UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOW-FLOW CHARACTERISTICS AND MEAN ANNUAL DISCHARGE OF NORTH BRANCH MANITOWOC RIVER AT POTTER, WISCONSIN

Open-File Report 76-204

Prepared in cooperation with the

Wisconsin Department of Natural Resources

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOW-FLOW CHARACTERISTICS AND MEAN ANNUAL DISCHARGE OF NORTH BRANCH MANITOWOC RIVER AT POTTER, WISCONSIN

By B. K. Holmstrom

Open-File Report 76-204

Prepared in cooperation with the
Wisconsin Department of Natural Resources

Madison, Wisconsin

April 1976

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For readers who prefer to use metric units rather than English units, the conversion factors for terms used in this report are listed below:

Multiply English unit	By	To obtain metric unit
square miles (mi^2)	2.590	square kilometres (km^2)
cubic feet per second (ft^3/s)	2.832×10^{-2}	cubic metres per second (m^3/s)
feet (ft)	.3048	metres (m)

LOW-FLOW CHARACTERISTICS AND MEAN ANNUAL DISCHARGE OF NORTH BRANCH MANITOWOC RIVER AT POTTER, WISCONSIN

By B. K. Holmstrom

ABSTRACT

The low-flow characteristics presented in this report are the annual minimum 7-day mean flows at the 2-year recurrence interval and 10-year recurrence interval. They were determined just downstream from the confluence of the three streams forming the North Branch Manitowoc River and, based on natural-flow conditions, are 0.0 cubic foot per second (0.0 cubic metre per second). Observations made in October 1974 showed that the natural discharge of the three streams forming the North Branch Manitowoc River was 0.0 cubic foot per second (0.0 cubic metre per second). A discharge of 0.30 cubic foot per second (0.008 cubic metre per second) was measured in the tributary from Hilbert but this was predominantly effluent from the sewage-treatment plant and a cheese factory in Hilbert.

The mean annual discharge for the North Branch Manitowoc River at Potter is 27 cubic feet per second (0.76 cubic metre per second). This was based on the estimated and recorded discharge for June 1, 1974, to May 31, 1975, for the North Branch Manitowoc River at Potter site and an adjustment based on the long-term mean annual discharge at gaging station 04086000, Sheboygan River at Sheboygan.

INTRODUCTION

The purpose of the study was to estimate the low-flow characteristics and mean annual discharge for the North Branch Manitowoc River at Potter. These estimates will help the Wisconsin Department of Natural Resources evaluate a proposed impoundment for wildlife on the North Branch Manitowoc River at Potter (fig. 1). The study was done in cooperation with the Wisconsin Department of Natural Resources.

Discharge measurements based on stage-discharge relationships were obtained at three sites during the study. Miscellaneous discharge measurements also were made upstream from the proposed impoundment.

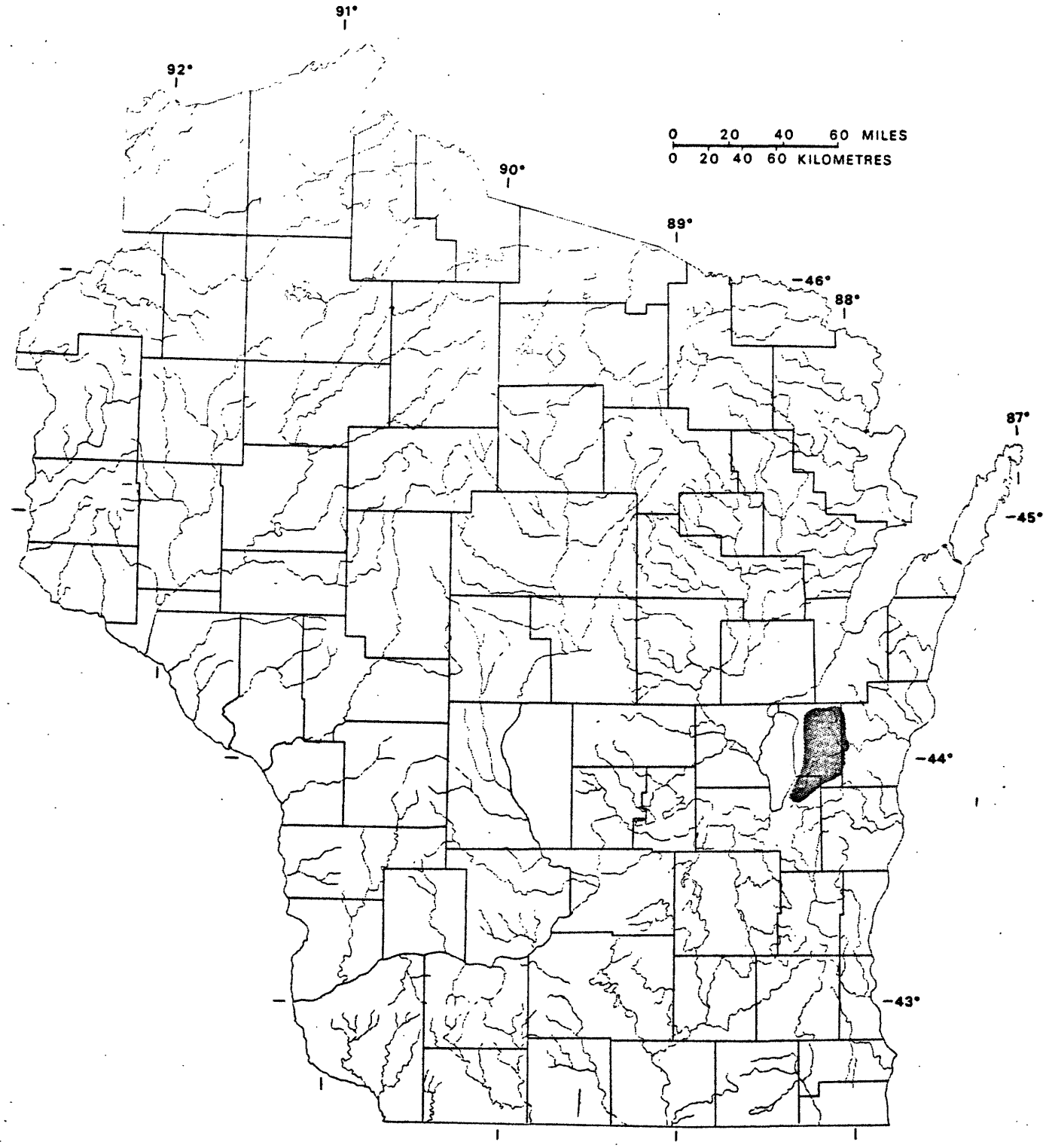

Figure 1.--Location of study area in Wisconsin.

STREAMFLOW-DATA COLLECTION

A reconnaissance trip made June 25, 1974, showed no accessible discharge-measuring sites on the North Branch Manitowoc River. Heavy weed growth and very low velocities prevented discharge measurements on the North Branch Manitowoc River during the summer and fall of 1974.

In an attempt to establish drainage area-discharge relationships for the basin, daily gage-height observations and twice-a-month discharge measurements (table 1) were made on the South Branch Manitowoc River, site M 1 (pl. 1), and Manitowoc River, site M 10, from June 25 to October 31, 1974. Tables 2 and 3 give the daily discharges for sites M 1 and M 10.

However, drainage area-discharge relationships for the basin were not adequate to define the flow characteristics for the North Branch Manitowoc River. Discharge measurements made in the basin on October 3-4, 1974, showed losing reaches between sites M 4 and M 10 on the Manitowoc River and between sites M 2 and M 3 on the Killsnake River. Discharge measurements made October 18, 1974, again showed a losing reach between sites M 4 and M 10. Possible explanations for these losing reaches could be evapotranspiration from marshes in the area and low ground-water inflow to the stream during extended dry periods because of low soil permeability (Skinner and Borman, 1973). Although this loss of discharge between sites M 4 and M 10 makes it impossible to establish meaningful drainage area-discharge relationships for low-flow conditions, it does indicate low or zero discharge from the North Branch Manitowoc River during low-flow conditions.

Discharge-measuring conditions on the North Branch Manitowoc River, site M 9, improved during the spring of 1975. Once-daily gage-height observations and three-a-month discharge measurements provided the mean daily discharges for site M 9 for April 5 to May 31, 1975 (table 4). Table 1 gives six discharge measurements made at sites M 9 and M 9A during this period. The discharge at site M 9A is approximately the same as the discharge at site M 9 because the drainage area increased only 5.5 percent, and there is no observed tributary inflow between the two sites.

Miscellaneous discharge measurements also were made for the project at sites M 3 to M 8 at various times during the investigation. Site M 7 also has discharge information available that was collected for another project (table 1).

LOW-FLOW CHARACTERISTICS

The low-flow characteristics determined on the North Branch Manitowoc River are the annual minimum 7-day mean flows at the 2-year recurrence interval ($Q_{7,2}$ and 10-year recurrence interval ($Q_{7,10}$).

Table 1.--Discharge measurements

Stream name	Site number	Drainage area (mi^2)	Date	Discharge (ft^3/s)
South Branch Manitowoc River	M 1	112	Oct. 5, 1968	5.28
			June 25, 1974	66.8
			July 3, 1974	55.4
			July 16, 1974	23.7
			July 25, 1974	12.1
			Aug. 7, 1974	35.4
			Aug. 22, 1974	15.5
			Sept. 4, 1974	8.22
			Sept. 25, 1974	7.55
			Oct. 3, 1974	7.89
			Oct. 18, 1974	10.0
			Oct. 28, 1974	10.3
			Apr. 5, 1975	135
Killsnake River	M 2	33.6	Oct. 3, 1974	1.95
Killsnake River	M 3	46.4	Oct. 4, 1974	1.41
South Branch Manitowoc River	M 4	187	Oct. 4, 1974	12.5
			Oct. 18, 1974	15.5
			Oct. 28, 1974	14.1
North Branch Manitowoc River	M 5	35.5	Oct. 28, 1974	.0
Spring Creek	M 6	22.3	Oct. 28, 1974	.0
North Branch Manitowoc River tributary	M 7A	4.16	Aug. 12, 1975	.12
North Branch Manitowoc River tributary	M 7	4.16	July 17, 1972	.33
			Oct. 11, 1972	.68
			July 31, 1973	.17
			Sept. 5, 1974	.32
			Aug. 12, 1975	.47

Table 1.--Discharge measurements (continued)

Stream name	Site number	Drainage area (mi^2)	Date	Discharge (ft^3/s)
North Branch Manitowoc River tributary	M 8	11.8	Oct. 28, 1974	0.30
North Branch Manitowoc River	M 9A	70.8	May 9, 1975	47.6
			May 16, 1975	20.1
			May 28, 1975	2.12
North Branch Manitowoc River	M 9	74.7	Apr. 5, 1975	301
			Apr. 16, 1975	161
			Apr. 22, 1975	74.3
Manitowoc River	M 10	285	June 24, 1974	211
			July 3, 1974	122
			July 16, 1974	60.7
			July 25, 1974	37.5
			Aug. 7, 1974	56.8
			Aug. 22, 1974	30.3
			Sept. 4, 1974	16.7
			Sept. 25, 1974	11.8
			Oct. 3, 1974	10.6
			Oct. 18, 1974	13.7
			Oct. 28, 1974	17.3

9-230
(Rev. 9-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. .....

Table 2 -- Daily discharges, in cubic feet per second, on the South Branch Manistee River (site M1)

DAY	June 1974	July 1974	Aug. 1974	Sept. 1974	Oct. 1974							
1		48	17	8.2	7.2							
2		50	29	8.2	7.4							
3		55	47	8.2	7.4							
4		58	50	8.2	7.6							
5		60	47	7.9	7.4							
6		58	43	7.6	6.9							
7		54	35	7.6	8.1							
8		49	26	7.2	11							
9		44	21	6.6	8.9							
10		43	17	6.9	7.6							
11		39	17	6.6	8.1							
12		38	15	6.4	7.9							
13		36	17	11	7.4							
14		33	16	9.8	9.2							
15		29	16	10	7.9							
16		27	15	9.8	7.4							
17		24	23	9.2	8.9							
18		21	19	8.9	10							
19		19	18	7.9	9.8							
20		16	16	7.4	9.5							
21		14	15	7.2	9.2							
22		14	15	6.9	8.9							
23		15	14	6.4	8.4							
24		14	12	6.4	8.9							
25	67	12	11	7.5	8.9							
26	65	30	8.4	6.9	16							
27	62	28	12	6.9	9.2							
28	58	32	11	6.6	10							
29	55	25	10	7.2	11							
30	50	22	8.9	7.2	12							
31		19	8.4		12							
Total		1026	631.7	232.8	283.9							
Mean		33.1	20.4	7.8	9.2							

U.S. GOVERNMENT PRINTING OFFICE : 1967—O-274-786

9-230
(Rev. 9-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. .....

Table 3.-- Daily discharges, in cubic feet per second, on the Manitou River (site H10)

DAY	June 1974	July 1974	Aug. 1974	Sept. 1974	Oct. 1974							
1		147	39	15	17							
2		134	39	19	17							
3		124	41	18	11							
4		112	42	17	15							
5		102	48	13	13							
6		92	53	13	34							
7		85	56	13	21							
8		82	57	11	17							
9		76	54	11	19							
10		72	54	11	17							
11		68	46	11	21							
12		65	44	11	21							
13		65	39	11	21							
14		63	37	11	30							
15		66	35	11	21							
16		61	34	17	23							
17		58	32	21	19							
18		56	30	17	14							
19		53	30	17	15							
20		44	30	17	19							
21		35	30	17	19							
22		39	30	17	15							
23		37	28	11	15							
24		37	28	21	15							
25	212	37	19	12	11							
26	201	37	23	17	17							
27	187	37	19	15	17							
28	176	37	19	11	17							
29	162	37	19	12	15							
30	151	37	19	14	28							
31		34	17		19							
Total		2029	1091	432	579							
Mean		65.4	35.2	14.4	18.7							

U.S. GOVERNMENT PRINTING OFFICE : 1967—O-274-786

9-230
(Rev. 9-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. ----------

Tou.. 4.-- Daily discharges in cubic feet per second, on the North Branch Manitowoc River (Site A

Day	June 1974	July 1974	Aug. 1974	Sept. 1974	Oct. 1974	Nov. 1974	Dec. 1974	Jan. 1975	Feb. 1975	Mar. 1975	Apr. 1975	May 1975
1	16	9.3	0.9	0.3	0.2	0.4	0.7	1.0	0.4	0.4	390	69
2	13	8.5	9	.3	.2	.4	.6	1.0	.4	.4	370	62
3	10	7.8	8	.2	2	.4	.3	.9	.4	.4	290	63
4	9.8	7.0	8	.2	.2	.4	1.1	.9	.4	.4	310	64
5	9.0	6.0	7	.2	.2	.4	1.2	.8	.3	.4	301	57
6	8.4	5.4	.7	.2	.2	.4	.9	.8	.3	.4	290	53
7	7.7	4.6	.7	.2	.3	.4	.9	.8	.3	.4	265	55
8	7.3	4.4	.7	.2	.3	.4	.9	.8	.3	.4	260	53
9	42	3.9	.8	.2	.3	.4	1.6	.8	.2	.5	238	48
10	78	3.5	.9	.2	.3	.4	2.1	.9	.2	.5	229	45
11	78.	3.0	1.2	.2	.3	.9	2.1	.8	.2	.5	215	38
12	85	2.8	1.0	.2	3	.8	2.1	.9	.2	.5	207	34
13	66	2.5	1.0	.2	.3	.9	1.8	.8	.2	.5	193	31
14	55	2.4	.8	.2	.4	1.0	1.7	.7	.2	.5	183	25
15	54	2.0	.6	.2	.3	.9	1.7	.7	.2	.6	168	23
16	56	1.8	.6	.2	.4	.9	1.7	.7	.2	.9	161	20
17	58	1.7	.6	.2	.4	1.0	1.7	.6	.2	1.5	140	15
18	60	1.5	.6	.2	.3	.9	1.7	.6	.2	3.8	125	13
19	63	1.3	.5	.2	.3	.9	1.8	.5	.2	9.7	100	14
20	58	1.2	.5	.2	.3	.9	2.1	.5	.3	83	93	13
21	48	1.0	.5	.2	.3	.8	1.8	.5	.3	260	90	11
22	40	1.0	.4	.2	.3	1.0	1.7	.5	.3	450	74	10
23	33	.9	.4	.2	.3	.8	1.6	.5	.3	540	73	7.8
24	29	.8	.4	.2	.3	.8	1.6	.5	.3	700	60	5.7
25	25	1.1	.4	.2	.3	.8	1.5	.5	.5	630	59	4.5
26	20	1.4	.3	.2	.3	1.4	1.4	.4	.4	540	56	3.8
27	16	1.2	.4	.2	.3	.9	1.4	.4	.4	540	54	3.1
28	14	1.1	.3	.2	.3	.8	1.3	.4	.4	520	64	2.1
29	12	1.0	.3	.2	.3	1.1	1.3	.4	—	560	62	2.3
30	11	1.0	.3	.2	.4	.8	1.3	.3	—	500	63	3.2
31	—	.9	.3	.2	.4	—	1.2	.3	—	450	—	4.9
Total	1082.2	72.0	19.2	6.2	7.2	22.1	45.3	20.1	8.2	5795.7	5166	364.4
Mean	36.1	3.0	.6	.2	.3	.7	1.5	.6	.3	187	172	27.9

Mean discharge for June 1, 1974 to May 31, 1975 = ~~13130.6~~ / 365 = 36.0 ft³/s (1.02 m³/s)

U.S. GOVERNMENT PRINTING OFFICE : 1967—O-274-786

The low-flow characteristics were determined just downstream from the confluence of the three streams forming the North Branch Manitowoc River. It was not possible to make discharge measurements on the North Branch Manitowoc River (sites M 9A and M 9) during low-flow conditions due to heavy weed growth and very low velocities. Therefore, discharge measurements were made on the three streams forming the North Branch Manitowoc River on October 28, 1974 (table 1). Streamflow data from an adjacent basin indicate that natural flows for the basin were about the 50 percent flow-duration point at this time. This indicates high base-flow conditions for the basin. There was no flow at sites M 5 and M 6 and a discharge of 0.30 ft^3/s (0.008 m^3/s) was measured at site M 8. The natural flow upstream from the sewage-treatment plant in Hilbert and in the intermittent tributaries between the sewage-treatment plant and site M 8 was also 0.0 ft^3/s (0.0 m^3/s). The discharge measured at site M 8 is predominantly effluent from the sewage-treatment plant and cheese factory upstream from site M 7. The sewage-treatment plant in Hilbert discharges about 0.16 ft^3/s (0.005 m^3/s) of effluent to the North Branch Manitowoc River tributary (Wisconsin Department of Natural Resources, 1969), and effluent from the cheese factory also is discharged to the tributary upstream from site M 7.

Based on these measurements and observations, the natural low flow for the $Q_{7,2}$ and $Q_{7,10}$ condition would be 0.0 ft^3/s (0.0 m^3/s) for the North Branch Manitowoc River below the confluence of the three streams.

The regulated or actual $Q_{7,2}$ and $Q_{7,10}$ discharge cannot be determined by graphical regression techniques and would depend on the combined effluent from the sewage-treatment plant and the cheese factory. An example of the effect of the combined effluent on streamflow during low-flow conditions was observed on August 12, 1975. The flow of the North Branch Manitowoc River tributary upstream from the sewage-treatment plant in Hilbert was 0.0 ft^3/s (0.0 m^3/s). At site M 7A, just upstream from the cheese factory outfall, the discharge measured was 0.12 ft^3/s (0.003 m^3/s) and at site M 7, 100 ft (30.5 m) downstream from the cheese factory outfall, the discharge was 0.47 ft^3/s (0.01 m^3/s).

The $Q_{7,2}$ and $Q_{7,10}$ discharge at Potter would appear to be the same as that estimated below the confluence of the three tributaries during the natural and regulated conditions. This is due to a slight increase in drainage area, 69.6 mi^2 (180 km^2) at the confluence of the three tributaries as compared to 74.7 mi^2 (193 km^2) at Potter, and no observed increase in tributary flow between the two sites.

MEAN ANNUAL DISCHARGE

The estimated mean annual discharge for the North Branch Manitowoc River at Potter (site M 9) is 27 ft^3/s (0.76 m3/s). This estimate is based on the recorded discharge of April 5 to May 31, 1975, and an estimated daily discharge for the preceding 10 months (table 4). The

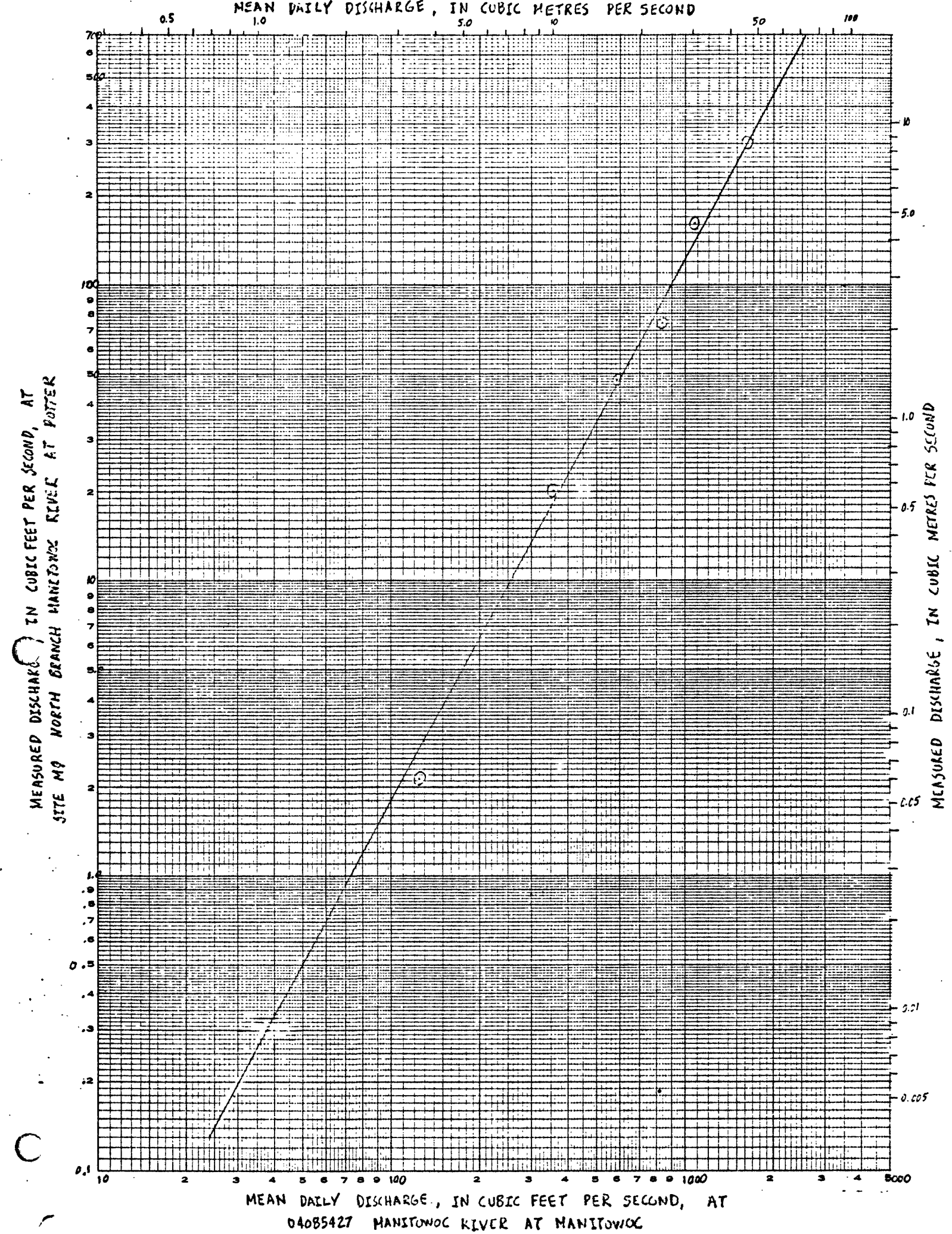

Figure 2... Relationship used to estimate mean daily discharge at site M9 North Branch Manitowoc River at Potter.

estimated daily discharge for the preceding 10 months was determined from a relationship (fig. 2) developed from the measured discharge at site M 9 and the recorded discharge at the gaging station 04085427, Manitowoc River at Manitowoc (not shown on map). The daily discharge at this gaging station (04085427) was transferred through the relation line in figure 2 to estimate the daily discharge at site M 9 for the 10-month period. The discharge at gaging station 04086000, Sheboygan River at Sheboygan (not shown on map) for June 1, 1974, to May 31, 1975, was 313 ft^3/s (8.86 m^3/s) compared to its long-term mean annual discharge of 234 ft^3/s (6.63 m^3/s). The mean discharge at site M 9 for June 1, 1974, to May 31, 1975, (table 4) was adjusted by the ratio of the long-term mean annual discharge to the June 1, 1974, to May 31, 1975, discharge at station 04086000. Station 04086000 (33 years of record) was used to make this adjustment because of the short period of record at station 04085427 (3 years of record). Using this method, the long-term mean annual discharge at site M 9 is estimated to be 27 ft^3/s (0.76 m^3/s).

REFERENCES

Skinner, E. L., and Borman, R. G., 1973, Water resources of Wisconsin--Lake Michigan basin: U.S. Geol. Survey Hydrol. Inv. Atlas HA-432.

Wisconsin Department of Natural Resources, 1969, Report on an investigation of the pollution in the Manitowoc River drainage basin made during 1968: Madison, Wis., 16 p., 1 fig., 4 tables.