U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

THOMPSON LAKE

LIVINGSTON COUNTY

MICHIGAN

EPA REGION V

WORKING PAPER No. 214

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

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REPORT
ON
THOMPSON LAKE
LIVINGSTON COUNTY
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EPA REGION V

WORKING PAPER NO. 214

WITH THE COOPERATION OF THE

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

AND THE

MICHIGAN NATIONAL GUARD

FEBRUARY, 1975

CONTENTS

F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nation-wide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Michigan Department of Natural Resources for professional involvement and to the Michigan National Guard for conducting the tributary sampling phase of the Survey.

A. Gene Gazlay, former Director, and David H. Jenkins, Acting Director, Michigan Department of Natural Resources; and Carlos Fetterolf, Chief Environmental Scientist, and Dennis Tierney, Aquatic Biologist, Bureau of Water Management, Department of Natural Resources, provided invaluable lake documentation and counsel during the course of the Survey. John Vogt, Chief of the Bureau of Environmental Health, Michigan Department of Public Health, and his staff were most helpful in identfying point sources and soliciting municipal participation in the Survey.

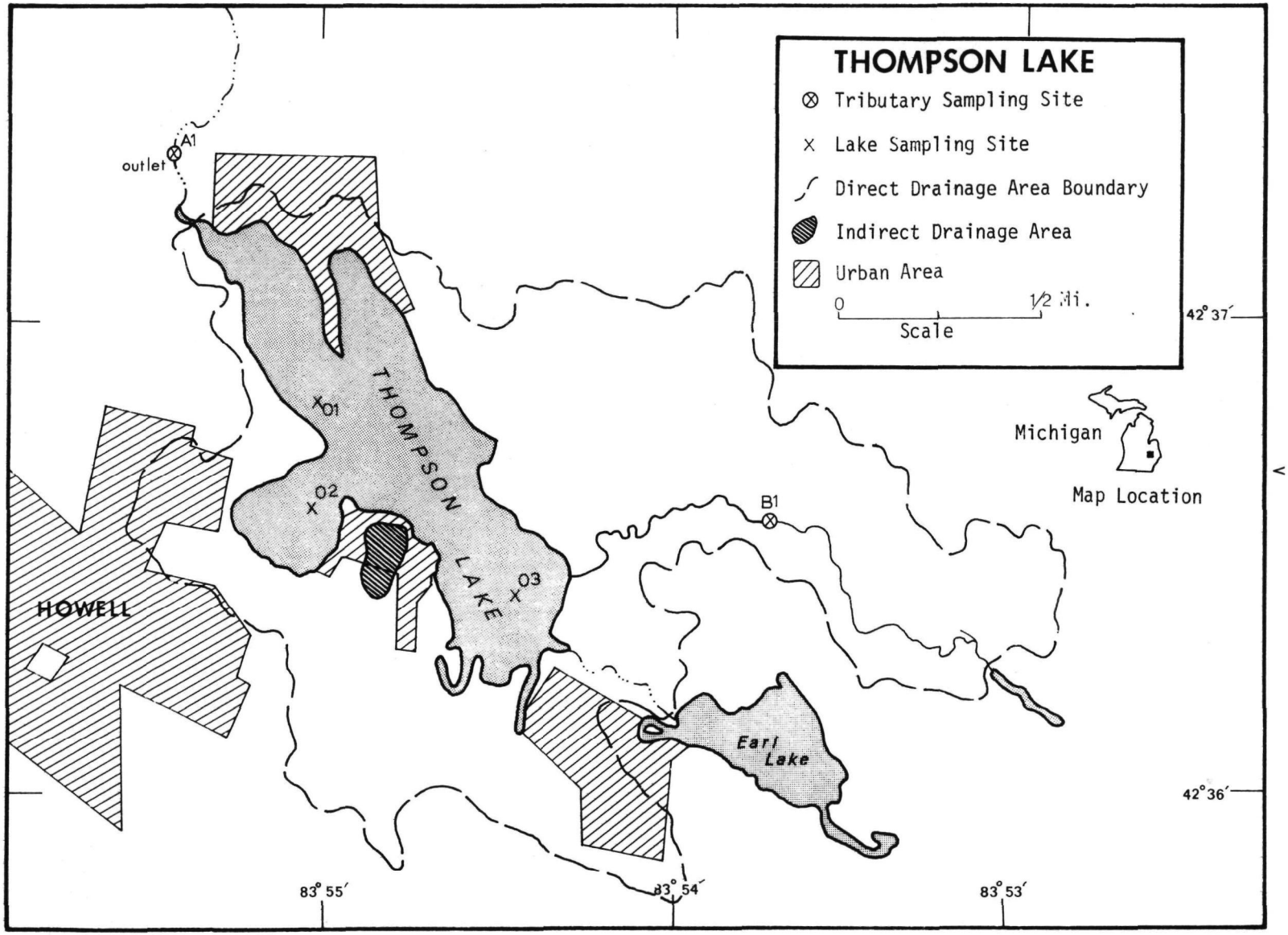
Major General Clarence A. Schnipke (Retired), then the Adjutant General of Michigan, and Project Officer Colonel Albert W. Lesky, who directed the volunteer efforts of the Michigan National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MICHIGAN

LAKE NAME	COUNTY
Allegan Res.	Allegan
Barton	Kalamazoo
Belleville	Wayne
Betsie	Benzie
Brighton	Livingston
Caro Res.	Tuscola
Charlevoix	Charlevoix
Chemung	Livingston
Constantine Res.	St. Joseph
Crystal	Montcalm
Deer	Marquette
Ford	Washtenaw
Fremont	Newago
Higgins	Roscommon
Holloway Res.	Genesee, Lapeer
Houghton	Roscommon
Jordon	Ionia, Barry
Kent	Oakland
Long	St. Joseph
Macatawa	Ottawa
Manistee	Manistee
Mona	Muskegon
Muskegon	Muskegon
Pentwater	Oceana
Pere Marquette	Mason
Portage	Houghton
Randall	Branch
Rogers Pond	Mecosta
Ross	Gladwin
St. Louis Res.	Gratiot
Sanford	Midland
Strawberry	Livingston
Thompson	Livingston
Thornapple	Barry
Union	Branch
White	Muskegon


THOMPSON LAKE
Tributary Sampling Site
Lake Sampling Site
Direct Drainage Area Boundary
Indirect Drainage Area
Urban Area
0
1/2 Mi.
Scale
outlet
A1
B1
01
02
03
THOMPSON LAKE
HOWELL
Earl Lake
Michigan
Map Location
42° 37′
42° 36′
83° 55′
83° 54′
83° 53′

THOMPSON LAKE

STORET NO. 2697

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Thompson Lake is eutrophic. Of the 35 Michigan lakes sampled in November when essentially all were well-mixed, 15 had less mean total phosphorus, 17 had less mean dissolved phosphorus, and nine had less mean inorganic nitrogen; of all 41 lakes sampled, 21 had less mean chlorophyll a, but only six had greater Secchi disc transparency*.

Near depletion of dissolved oxygen at the 21-foot depth was noted at station 1 in September, 1972, and Survey limnologists observed a heavy algal bloom at that time.

B. Rate-Limiting Nutrient:

A significant change in nutrients occurred in the algal assay sample, and the results are not representative of conditions in the lake at the time the sample was collected (09/19/72).

The lake data indicate marginal nitrogen limitation in June and September but phosphorus limitation in November.

C. Nutrient Controllability:

1. Point sources--Other than septic tanks, there were no known point sources contributing phosphorus to Thompson Lake; and, during the sampling year, the lake received a total

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* See Appendix A.

phosphorus load at a rate somewhat less than that proposed by Vollenweider (in press) as "dangerous" but more than his suggested "permissible" rate (i.e., a mesotrophic rate; see page 13). However, the existing trophic condition indicates that either the phosphorus loading rate was higher in the past or the Survey sampling did not reveal the actual loading rate.

In this regard, it is noted that there was an apparent loss of phosphorus during the sampling year; that is, more phosphorus was measured leaving the lake than was estimated or measured entering the lake (see page 11). While it is possible that such a phosphorus wash-out could have occurred, it is more likely that the "loss" resulted from unknown and unmeasured sources discharging directly to the lake (e.g., urban drainage), underestimation of septic tank contributions, or the limits of accuracy of the flow estimates provided by the U.S. Geological Survey (see footnote, page 4).

2. Non-point sources (see page 13)--During the sampling year, the phosphorus export of the unnamed stream (B-1) was somewhat higher than the exports of the tributaries to other lakes studied in Livingston County (e.g., Ore Creek to Brighton Lake* at 32 lbs/mi^2/yr and the unnamed tributary to Lake Chemung**

* Working Paper No. 187.
** Working Paper No. 189.

at 50 lbs/mi^2/yr). Whether the greater export is due to differences in cultural practices in the drainages or to the limits of sampling accuracy is not known.

In all, it is estimated that non-point sources, including precipitation, contributed about 87% of the total phosphorus load to Thompson Lake during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 262 acres.
2. Mean depth: 9 feet.
3. Maximum depth: 52 feet.
4. Volume: 2,358 acre-feet.
5. Mean hydraulic retention time: 152 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Unnamed stream (B-1)	7.6 mi^2	5.0 cfs
Minor tributaries & immediate drainage -	3.9 mi^2	2.8 cfs
Totals	11.5 mi^2	7.8 cfs

2. Outlet -

Unnamed stream (A-1)	11.9 mi^2**	7.8 cfs

C. Precipitation***:

1. Year of sampling: 32.6 inches.
2. Mean annual: 33.1 inches.

† MI Dept. Cons. lake inventory map (1952); mean depth from Fetterolf (1973).
* Drainage areas are accurate within ±5%; mean daily flows for 74% of the sampling sites are accurate within ±25% and the remaining sites up to ±40%; and mean monthly flows, normalized mean monthly flows, and mean annual flows are slightly more accurate than mean daily flows.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods, 1972".

III. LAKE WATER QUALITY SUMMARY

Thompson Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and usually from two or more depths at each station (see map, page v). During each visit a single depth-integrated (15 feet or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the second visit, a single five-gallon depth-integrated sample was composited for algal assay. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analyses. The maximum depths sampled were 41 feet at station 1, 16 feet at station 2, and 4 feet at station 3.

The results obtained are presented in full in Appendix C, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix C.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/15/72)		
Temperature (Cent.)	3.0	4.7	5.2	5.5
Dissolved oxygen (mg/l)	7.2	9.1	9.2	10.6
Conductivity (μmhos)	520	538	538	560
pH (units)	7.7	7.8	7.8	7.9
Alkalinity (mg/l)	175	179	177	185
Total P (mg/l)	0.033	0.043	0.042	0.052
Dissolved P (mg/l)	0.020	0.029	0.027	0.035
NO_2 + NO_3 (mg/l)	0.200	0.212	0.210	0.230
Ammonia (mg/l)	0.180	0.224	0.230	0.240
		ALL VALUES		
Secchi disc (inches)	42	92	96	152

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/16/72	1. Anabaena	702
	2. Oscillatoria	695
	3. Asterionella	29
	4. Characium	22
	5. Flagellates	14
	Other genera	7
	Total	1,469
09/19/72	1. Cyclotella	10,540
	2. Fragilaria	4,144
	3. Microcystis	2,703
	4. Micractinium	1,718
	5. Melosira	1,441
	Other genera	9,004
	Total	29,550
11/15/72 *	1. Fragilaria	597
	2. Dinobryon	443
	3. Kirchneriella	244
	4. Microcystis	136
	5. Synedra	81
	Other genera	343
	Total	1,844

* It is likely that these results are not representative; the chlorophyll a concentrations on this date (page 8) indicate that phytoplankton were much more numerous.

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/16/72	01	6.8
	02	3.6
	03	0.8
09/19/72	01	16.9
	02	14.9
	03	18.8
11/15/72	01	2.6
	02	12.9
	03	30.4

C. Limiting Nutrient Study:

There was an apparent gain in nutrients in the assay sample from the time of collection to the beginning of the assay. Inorganic nitrogen apparently increased by 110% and dissolved phosphorus apparently increased by 67%.

It is not known whether the apparent gain was due to sample contamination, analytical error, or decomposition of the large numbers of phytoplankton in the sample (see page 7) with a resulting release of nutrients. Whatever the cause, the differential change in the major nutrients resulted in a shift from nitrogen limitation in the lake (N/P ratio = 12/1) to phosphorus limitation in the sample (N/P = 17/1). Consequently, the assay results are not representative of conditions in the lake at the time the sample was collected.

The lake data indicate marginal nitrogen limitation in June (N/P = 13/1) but phosphorus limitation in November (N/P = 15/1).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Michigan National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of April when three samples were collected. Sampling was begun in October, 1972, and was completed in October, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Michigan District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the nutrient loads, in lbs/mi^2/year, at station B-1 and multiplying by the ZZ area in mi^2.

There are no known point sources impacting Thompson Lake.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

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* See Working Paper No. 1.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed stream (B-1)	520	54.7
b. Minor tributaries & immediate drainage (non-point load) -	270	28.4
c. Known municipal STP's - None	-	-
d. Septic tanks* -	120	12.6
e. Known industrial - None	-	-
f. Direct precipitation** -	40	4.2
Total	950	100.0

2. Outputs -

Lake outlet - Unnamed stream (A-1)	1,160

3. Net annual P loss - 210 pounds

* Estimated 190 dwellings on lakeshore; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/yr	% of total
a. Tributaries (non-point load) -		
Unnamed stream (B-1)	15,200	50.7
b. Minor tributaries & immediate drainage (non-point load) -	7,800	26.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	4,460	14.9
e. Known industrial - None	-	-
f. Direct precipitation** -	2,520	8.4
Total	29,980	100.0

2. Outputs -

Lake outlet - Unnamed stream (A-1)	20,800

3. Net annual N accumulation - 9,180 pounds

* Estimated 190 dwellings on lakeshore; see Working Paper No. 1.
** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Unnamed stream (B-1)	68	2,000

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with very short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	3.6	loss*	114.4	35.0
grams/m^2/yr	0.41	-	12.8	3.9

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time for Thompson Lake:

"Dangerous" (eutrophic rate)	0.54
"Permissible" (oligotrophic rate)	0.27

* See discussion, page 2.

V. LITERATURE REVIEWED

Fetterolf, Carlos, 1973. Personal communication (lake morphometry). MI Dept. of Nat. Resources, Lansing.

Vollenweider, Richard A. (in press). Input-output models. Schweiz. Z. Hydrol.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES MEAN TOTAL P	FALL VALUES MEAN DISS P	FALL VALUES MEAN INORG N	ALL VALUES 500- MEAN SEC	ALL VALUES MEAN CHLORA	ALL VALUES 15- MIN DO
26A0	HOLLOWAY RESERVOIR	0.062	0.043	1.461	439.375	10.678	9.200
26A1	CARO RESERVOIR	0.117	0.022	3.835	473.000	11.967	9.500
26A2	BOARDMAN HYDRO POND	0.006	0.005	0.358	363.500	1.267	6.600
2603	ALLEGAN LAKE	0.123	0.057	1.168	470.222	20.311	12.600
2606	BARTON LAKE	0.121	0.086	1.489	456.167	27.800	14.850
2609	BELLEVILLE LAKE	0.118	0.048	1.420	465.250	28.262	8.200
2610	BETSIE LAKE	0.025	0.008	0.273	461.667	4.567	7.400
2613	BRIGHTON LAKE	0.109	0.073	1.015	456.000	44.233	7.500
2617	LAKE CHARLEVOIX	0.007	0.006	0.230	351.250	3.008	9.240
2618	LAKE CHEMUNG	0.044	0.014	0.132	404.333	13.483	14.800
2621	CONSTANTINE RESERVOIR	0.027	0.008	0.910	456.167	39.317	7.500
2629	FORD LAKE	0.105	0.058	1.536	456.167	14.733	14.000
2631	FREMONT LAKE	0.372	0.342	1.406	441.667	28.500	14.800
2640	JORDAN LAKE	0.180	0.144	1.998	427.667	20.517	14.900
2643	KENT LAKE	0.040	0.015	0.417	455.000	33.944	13.000
2648	LAKE MACATAWA	0.197	0.120	2.358	477.600	25.600	12.200
2649	MANISTEE LAKE	0.018	0.010	0.304	451.333	6.317	11.380
2659	MUSKEGON LAKE	0.087	0.043	0.469	436.444	9.511	14.800
2665	PENTWATER LAKE	0.027	0.017	0.496	430.667	16.083	14.800
2671	RANDALL LAKE	0.246	0.183	0.818	457.333	27.217	8.020
2672	ROGERS POND	0.026	0.015	0.183	435.500	8.133	9.600
2673	ROSS RESERVOIR	0.034	0.021	0.460	465.333	10.383	8.200
2674	SANFORD LAKE	0.016	0.008	0.307	458.750	13.791	8.300
2683	THORNAPPLE LAKE	0.042	0.032	1.737	442.833	14.650	10.800
2685	UNION LAKE	0.083	0.064	1.252	455.500	15.667	8.200
2688	WHITE LAKE	0.027	0.019	0.367	417.778	9.211	13.400
2691	MONA LAKE	0.307	0.241	0.963	451.667	27.783	14.100
2692	LONG LAKE	0.163	0.148	0.749	418.400	10.067	13.600

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES MEAN TOTAL P	FALL VALUES MEAN DISS P	FALL VALUES MEAN INORG N	ALL VALUES 500- MEAN SEC	ALL VALUES MEAN CHLORA	ALL VALUES 15- MIN DO
2693	ST LOUIS RESERVOIR	0.134	0.093	1.227	462.667	5.583	8.420
2694	CRYSTAL LAKE	0.009	0.006	0.164	380.000	2.986	13.000
2695	HIGGINS LAKE	0.007	0.005	0.058	268.500	1.043	9.400
2696	HOUGHTON LAKE	0.018	0.008	0.136	420.833	9.217	8.200
2697	THOMPSON LAKE	0.043	0.029	0.436	407.889	11.967	14.800
2698	PERE MARQUETTE LAKE	0.032	0.024	0.346	448.667	11.833	8.600
2699	STRAWBERRY LAKE	0.069	0.050	0.567	419.800	11.117	13.600

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500- MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15- MIN DO	INDEX NO
26A0	HOLLOWAY RESERVOIR	46 (16)	43 (15)	17 (6)	57 (20)	60 (21)	63 (22)	286
26A1	CARO RESERVOIR	29 (10)	54 (19)	0 (0)	3 (1)	49 (17)	54 (19)	189
26A2	BOARDMAN HYDRO POND	97 (34)	97 (34)	69 (24)	91 (32)	94 (33)	97 (34)	545
2603	ALLEGAN LAKE	20 (7)	31 (11)	31 (11)	6 (2)	29 (10)	40 (14)	157
2606	BARTON LAKE	23 (8)	20 (7)	14 (5)	29 (9)	14 (5)	3 (1)	103
2609	BELLEVILLE LAKE	26 (9)	37 (13)	20 (7)	11 (4)	11 (4)	79 (26)	184
2610	BETSIE LAKE	77 (27)	77 (27)	80 (28)	17 (6)	86 (30)	94 (33)	431
2613	BRIGHTON LAKE	31 (11)	23 (8)	34 (12)	34 (12)	0 (0)	90 (31)	212
2617	LAKE CHARLEVOIX	91 (32)	91 (32)	83 (29)	94 (33)	89 (31)	60 (21)	508
2618	LAKE CHEMUNG	49 (17)	71 (25)	94 (33)	86 (30)	46 (16)	11 (2)	357
2621	CONSTANTINE RESERVOIR	71 (25)	83 (29)	40 (14)	29 (9)	3 (1)	90 (31)	316
2629	FORD LAKE	34 (12)	29 (10)	11 (4)	29 (9)	37 (13)	23 (8)	163
2631	FREMONT LAKE	0 (0)	0 (0)	23 (8)	54 (19)	9 (3)	11 (2)	97
2640	JORDAN LAKE	11 (4)	11 (4)	6 (2)	69 (24)	26 (9)	0 (0)	123
2643	KENT LAKE	57 (20)	69 (24)	63 (22)	40 (14)	6 (2)	36 (12)	271
2648	LAKE MACATAWA	9 (3)	14 (5)	3 (1)	0 (0)	23 (8)	43 (15)	92
2649	MANISTEE LAKE	80 (28)	74 (26)	77 (27)	46 (16)	80 (28)	46 (16)	403
2659	MUSKEGON LAKE	37 (13)	40 (14)	54 (19)	60 (21)	69 (24)	11 (2)	271
2665	PENTWATER LAKE	69 (24)	63 (22)	51 (18)	66 (23)	31 (11)	11 (2)	291
2671	RANDALL LAKE	6 (2)	6 (2)	43 (15)	23 (8)	20 (7)	86 (30)	184
2672	ROGERS POND	74 (26)	66 (23)	86 (30)	63 (22)	77 (27)	51 (18)	417
2673	ROSS RESERVOIR	60 (21)	57 (20)	57 (20)	9 (3)	63 (22)	79 (26)	325
2674	SANFORD LAKE	86 (30)	80 (28)	74 (26)	20 (7)	43 (15)	71 (25)	374
2683	THORNAPPLE LAKE	54 (19)	46 (16)	9 (3)	51 (18)	40 (14)	49 (17)	249
2685	UNION LAKE	40 (14)	26 (9)	26 (9)	37 (13)	34 (12)	79 (26)	242
2688	WHITE LAKE	66 (23)	60 (21)	66 (23)	80 (28)	74 (26)	31 (11)	377
2691	MONA LAKE	3 (1)	3 (1)	37 (13)	43 (15)	17 (6)	20 (7)	123
2692	LONG LAKE	14 (5)	9 (3)	46 (16)	77 (27)	66 (23)	27 (9)	239

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500-MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15-MIN DO	INDEX NO
2693	ST LOUIS RESERVOIR	17 (6)	17 (6)	29 (10)	14 (5)	83 (29)	69 (24)	229
2694	CRYSTAL LAKE	89 (31)	89 (31)	89 (31)	89 (31)	91 (32)	36 (12)	483
2695	HIGGINS LAKE	94 (33)	94 (33)	97 (34)	97 (34)	97 (34)	57 (20)	536
2696	HOUGHTON LAKE	83 (29)	86 (30)	91 (32)	71 (25)	71 (25)	79 (26)	481
2697	THOMPSON LAKE	51 (18)	49 (17)	60 (21)	83 (29)	51 (18)	11 (2)	305
2698	PERE MARQUETTE LAKE	63 (22)	51 (18)	71 (25)	49 (17)	54 (19)	66 (23)	354
2699	STRAWBERRY LAKE	43 (15)	34 (12)	49 (17)	74 (26)	57 (20)	27 (9)	284

APPENDIX B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MICHIGAN 2/3/75

LAKE CODE 2697 THOMPSON LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 11.90

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2697A1	11.90	6.77	11.00	12.20	14.60	8.56	5.58	6.46	3.34	2.83	5.30	7.90	8.94	7.76
2697B1	7.60	4.35	7.08	7.84	9.36	5.47	3.58	4.13	2.13	1.81	3.40	5.06	5.73	4.98
2697ZZ	4.30	2.46	4.01	4.44	5.30	3.10	2.01	2.32	1.20	1.01	1.91	2.87	3.24	2.81

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 11.90
SUM OF SUB-DRAINAGE AREAS = 11.90
TOTAL FLOW IN = 93.81
TOTAL FLOW OUT = 93.48

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2697A1	10	72	5.80	29	13.00				
	11	72	12.00						
	12	72	11.00	2	10.00				
	1	73	21.00	7	37.00				
	2	73	11.00	4	14.00				
	3	73	26.00	4	12.00				
	4	73	20.00	6	30.00	21	13.00	22	14.00
	5	73	11.00						
	6	73	8.70	2	13.00				
	7	73	7.10	7	13.00				
	8	73	3.90	4	2.80				
	9	73	2.30	8	1.30				
	10	73	4.40	13	4.20				
2697B1	10	72	3.70	29	8.50				
	11	72	7.80						
	12	72	7.00	2	6.60				
	1	73	14.00	7	24.00				
	2	73	6.90	4	8.80				
	3	73	17.00	4	7.40				
	4	73	13.00	6	19.00	21	8.50	22	8.70
	5	73	7.30	20	8.00				
	6	73	5.60	2	8.00				
	7	73	4.50	7	8.30				
	8	73	2.50	4	1.80				
	9	73	1.50	8	0.80				
	10	73	2.80	13	2.70				

TRIBUTARY FLOW INFORMATION FOR MICHIGAN 2/3/75

LAKE CODE 2697 THOMPSON LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2697ZZ	10	72	2.10						
	11	72	4.40						
	12	72	4.00						
	1	73	7.70						
	2	73	3.90						
	3	73	9.50						
	4	73	7.40						
	5	73	4.20						
	6	73	3.20						
	7	73	2.60						
	8	73	1.40						
	9	73	0.80						
	10	73	1.60						

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/04

269701
42 37 00.0 083 55 00.0
THOMPSON LAKE
26 MICHIGAN

11EPALES
4

2111202
0026 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/16	15 55	0000	22.5	5.4	152	410	7.87	160	0.020	0.420	0.046	0.042
	15 55	0020	9.9	10.2		440	8.20	185	0.010	0.010K	0.028	0.010
72/09/19	16 35	0000			72	480	8.60	165	0.040	0.080	0.023	0.014
	16 35	0004		9.1		460	8.60	165	0.050	0.070	0.021	0.014
	16 35	0015		6.6		460	8.28	165	0.040	0.070	0.024	0.013
	16 35	0021		0.2		480	7.61	168	0.030	0.470	0.019	0.009
72/11/15	10 35	0000			121	560	7.70	185	0.210	0.240	0.042	0.035
	10 35	0004	5.5	9.2		530	7.70	176	0.230	0.230	0.052	0.034
	10 35	0015	5.5	9.2		530	7.70	175	0.220	0.230	0.051	0.034
	10 35	0025	5.4	8.8		520	7.70	177	0.200	0.240	0.051	0.035
	10 35	0041	5.2	7.2		530	7.70	175	0.210	0.240	0.039	0.030

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/16	15 55	0000	6.8J
72/09/19	16 35	0000	16.9J
72/11/15	10 35	0000	2.6J

K VALUE KNOWN TO BE LESS THAN INDICATED

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

269702
42 36 30.0 083 55 00.0
THOMPSON LAKE
26 MICHIGAN.

11EPALES 2111202
4 0010 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/16	16 30	0000	22.3	4.8	120	420	7.70	164	0.030	0.530	0.068	0.058
	16 30	0010	20.0	4.0		425	7.58	164	0.660	0.800	0.073	0.073
72/09/19	16 25	0000			48	475	8.65	166	0.060	0.070	0.023	0.014
	16 25	0004	22.1	9.5		475	8.65	165	0.050	0.080	0.027	0.019
72/11/15	11 00	0000			118	540	7.90	179	0.210	0.230	0.036	0.025
	11 00	0004	4.3	9.5		540	7.90	176	0.210	0.230	0.048	0.024
	11 00	0016	4.3	9.0		535	7.90	177	0.200	0.230	0.041	0.025

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/16	16 30	0000	3.6J
72/09/19	16 25	0000	14.9J
72/11/15	11 00	0000	12.9J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

269703
42 36 00.0 083 54 30.0
THOMPSON LAKE
26 MICHIGAN

11EPALES 2111202
4 0008 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/16	16 55	0000	22.5	5.6	96	415	7.80	161	0.030	0.470	0.048	0.044
72/09/19	16 00	0000			42	480	8.55	170	0.060	0.100	0.034	0.018
	16 00	0004	21.8	9.1		470	8.55	167	0.050	0.090	0.060	0.018
72/11/15	11 20	0000			60	550	7.90	184	0.220	0.190	0.033	0.020
	11 20	0004	3.0	10.6		540	7.90	182	0.210	0.180	0.042	0.025

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/16	16 55	0000	0.8J
72/09/19	16 00	0000	18.8J
72/11/15	11 20	0000	30.4J

J VALUE KNOWN TO BE IN ERROR

APPENDIX D

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/04

2697A1 LS2697A1
42 37 30.0 083 55 30.0
UNNAMED OUTLET CREEK
26 7.5 HOWELL
0/THOMPSON LAKE
ST HWY 59 BRDG NW CORNER OF LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/29	09 45		0.610	4.550	0.310	0.040	0.126
72/12/02	09 55		0.010K	0.930	0.016	0.022	0.047
73/01/07	07 40		0.294	1.050	0.138	0.022	0.056
73/02/04	08 15		0.200	1.050	0.105	0.013	0.055
73/03/04	08 30		0.336	0.830	0.090	0.025	0.035
73/04/06	08 00		0.100	0.750	0.025	0.007	0.035
73/04/21	12 10		0.410	1.150	0.176	0.023	0.065
73/04/22	10 50		0.079	1.150	0.058	0.011	0.065
73/06/02	12 45		0.500	1.470	0.270	0.054	0.115
73/07/07	11 30		0.070	0.940	0.044	0.013	0.050
73/08/04	14 30		0.069	1.200	0.040	0.017	0.085
73/09/08	13 00		0.190	1.200	0.168	0.018	0.055
73/10/13	08 30		0.315	1.750	0.375	0.008	0.180

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2697B1 LS2697B1
42 36 30.0 083 53 30.0
UNNAMED INLET CREEK
26 7.5 HOWELL
I/THOMPSON LAKE
EAGER RD BRDG N OF EARL LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/29	10 20		0.180	2.600	0.147	0.009	0.040
72/12/02	10 00		0.180	0.965	0.014	0.005K	0.038
73/01/07	08 00		0.176	0.940	0.030	0.005K	0.046
73/02/04	08 30		0.200	1.500	0.063	0.007	0.035
73/03/04	08 45		0.390	0.990	0.154	0.015	0.055
73/04/06	08 30		0.110	1.100	0.036	0.005	0.030
73/04/21	12 00		0.020	2.000	0.042	0.009	0.050
73/04/22	10 00		0.073	1.300	0.026	0.007	0.050
73/05/20	14 20		0.010K	1.260	0.027	0.008	0.050
73/06/02	12 30		0.023	1.760	0.054	0.010	0.045
73/07/07	11 40		0.048	1.550	0.077	0.018	0.055
73/08/04	13 50		0.060	1.680	0.070	0.025	0.060
73/09/08	12 45		0.034	1.150	0.042	0.021	0.105
73/10/13	08 40		0.031	1.050	0.085	0.006	0.070

K VALUE KNOWN TO BE
LESS THAN INDICATED