U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT
ON
BELLEVILLE LAKE
WAYNE COUNTY
MICHIGAN
EPA REGION V
WORKING PAPER No. 184

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

☆ GPO—697-032

REPORT
ON
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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.

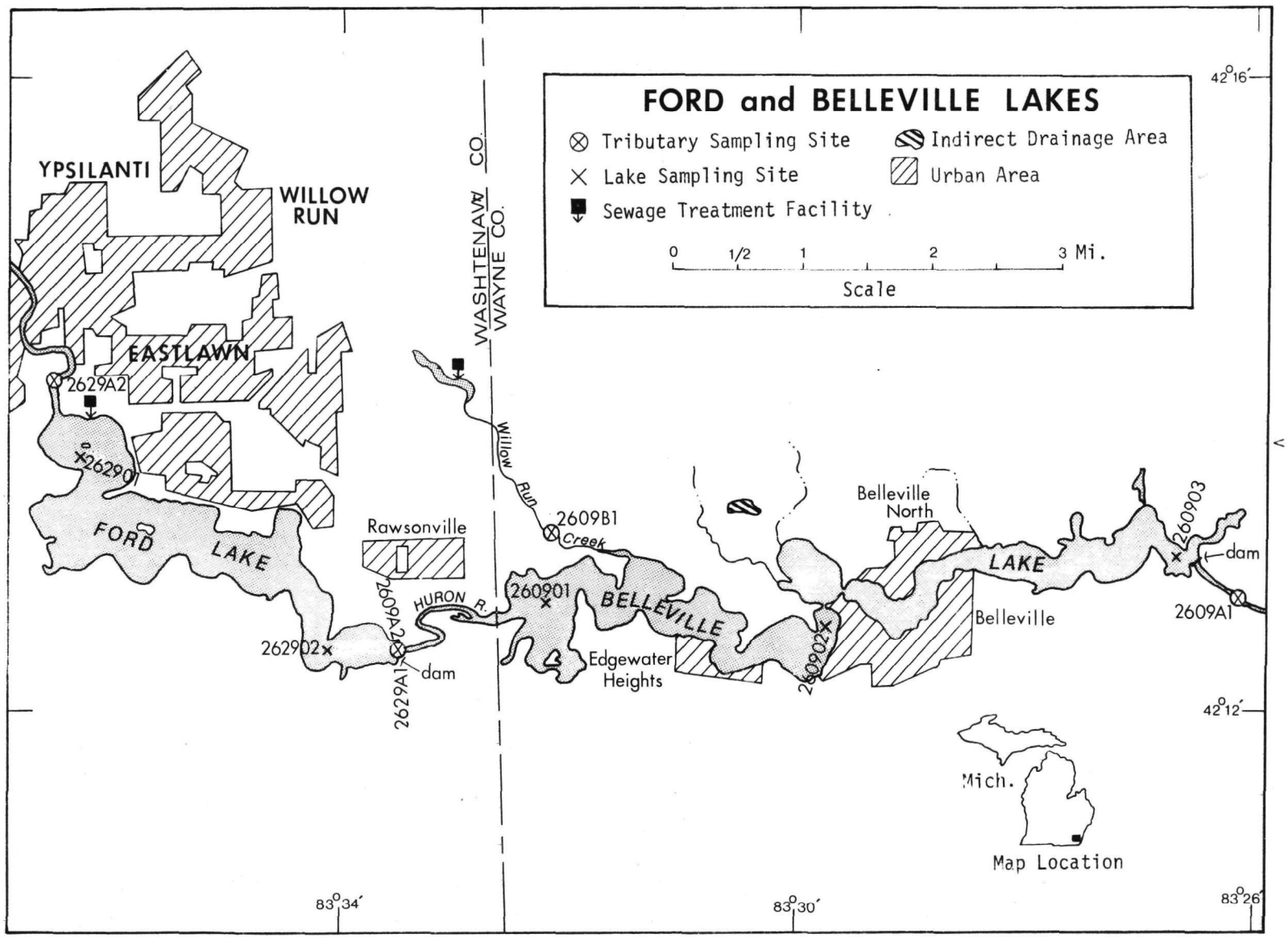
Major General Clarence A. Schnipke (Retired), then the Adjutant General of Michigan, and Project Officer Colonel Albert W. Lesky, who directed the volunteer efforts of the Michigan National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

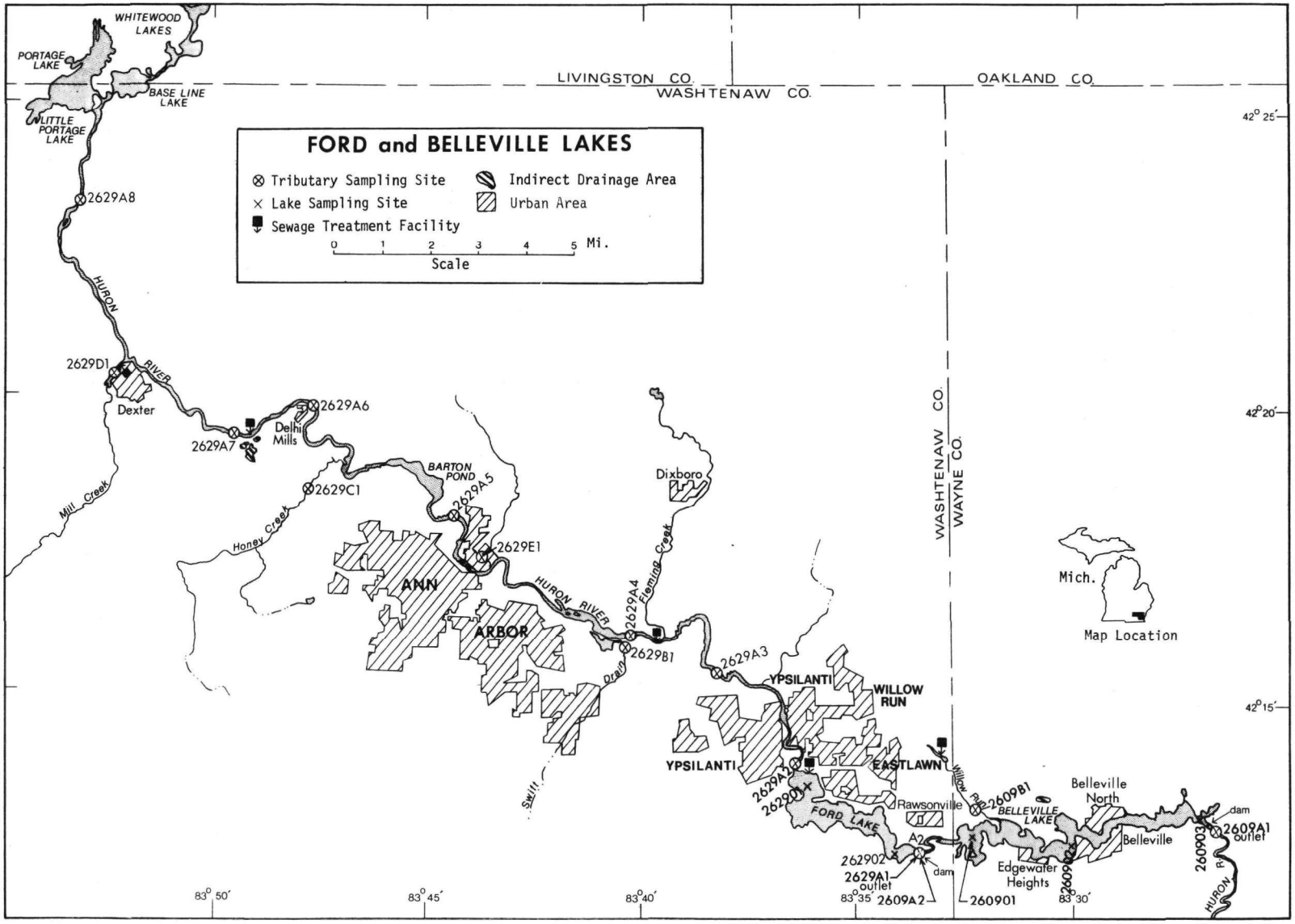
NATIONAL EUTROPHICATION SURVEY

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


FORD and BELLEVILLE LAKES
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Indirect Drainage Area
Urban Area
0 1/2 1 2 3 Mi.
Scale
YPSILANTI
WILLOW RUN
EASTLAWN
WASHTENAW CO.
WAYNE CO.
2629A2
2629O1
FORD LAKE
Rawsonville
2609A2
HURON R.
2629A1
dam
262902
Willow Run
2609B1
Creek
260901
BELLEVILLE LAKE
Edgewater Heights
260902
Belleville North
Belleville
260903
dam
2609A1
42°16'
42°12'
83°34'
83°30'
83°26'
Mich.
Map Location


FORD and BELLEVILLE LAKES
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Indirect Drainage Area
Urban Area
0 1 2 3 4 5 Mi.
Scale
WHITEWOOD LAKES
PORTAGE LAKE
BASE LINE LAKE
LITTLE PORTAGE LAKE
LIVINGSTON CO.
WASHTENAW CO.
OAKLAND CO.
WAYNE CO.
2629A8
HURON RIVER
2629D1
Dexter
Mill Creek
2629A7
Delhi Mills
2629A6
BARTON POND
2629A5
2629C1
Honey Creek
2629E1
ANN ARBOR
Dixboro
Fleming Creek
2629A4
HURON RIVER
2629B1
2629A3
Swift Run Drain
YPSILANTI
WILLOW RUN
EASTLAWN
YPSILANTI
2629A2
2629D2
FORD LAKE
Rawsonville
Willow Run
2609B1
BELLEVILLE LAKE
Belleville North
Belleville
dam
2609A1 outlet
2609C1
2609D1
HURON R.
Edgewater Heights
A2
dam
262902
2629A1 outlet
2609A2
260901
Mich.
Map Location
42° 25′
42° 20′
42° 15′
83° 50′
83° 45′
83° 40′
83° 35′
83° 30′

BELLEVILLE LAKE

STORET NO. 2609

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Belleville Lake is eutrophic. Of the 35 Michigan lakes sampled in November when essentially all were well-mixed, 25 had less mean total phosphorus, 21 had less mean dissolved phosphorus, and 27 had less mean inorganic nitrogen; of all 41 Michigan lakes sampled, 30 had less mean chlorophyll a, and 30 had greater Secchi disc transparency*.

Survey limnologists indicated overall poor water appearance during the September sampling period. The water was quite turbid, and an algal bloom was in progress.

B. Rate-Limiting Nutrient:

The results of the algal assay show that the lake was nitrogen limited at the time the sample was collected (09/19/72).

The lake data indicate that Belleville Lake was nitrogen limited in June also but phosphorus limited in November.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Belleville Lake received a total phosphorus load at a rate nearly nine times the rate proposed by Vollenweider (in press) as "dangerous";

* See Appendix A.

i.e., a eutrophic rate (see page 14). Now, Belleville Lake has a relatively short hydraulic retention time of 25 days, and Vollenweider's model may not be applicable. However, the existing trophic condition of the lake is evidence of excessive nutrient loads.

It is calculated that the municipal waste treatment plants considered in this study, including four plants impacting upstream Ford Lake*, contributed nearly 94% of the total phosphorus load. Removal of 85% of the phosphorus at the four municipal point sources now without phosphorus removal (the Ann Arbor plant has P removal) would reduce the loading to 7 $g/m^2/yr$ or about four times the eutrophic rate. However, in view of the questionable application of Vollenweider's model, it is believed that this degree of reduction of the phosphorus load would improve the trophic condition of Belleville Lake and, in particular, would reduce the incidence and severity of nuisance algal blooms.

2. Non-point sources--It is estimated that non-point sources, including precipitation, contributed about 6% of the total phosphorus load to Belleville Lake during the sampling year.

* Working Paper No. 193.

The phosphorus export of the Huron River was quite low as compared to the other Michigan streams sampled during the Survey (see page 13).

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 1,270 acres.
2. Mean depth: 20 feet.
3. Maximum depth: 30 feet.
4. Volume: 25,400 acre-feet.
5. Mean hydraulic retention time: 25 days.

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

1. Tributaries -

Name	Drainage area*	Mean flow*
Huron River	814.0 mi^2	497.7 cfs
Willow Run Creek	6.3 mi^2	3.8 cfs
Minor tributaries & immediate drainage -	10.7 mi^2	7.7 cfs
Totals	831.0 mi^2	509.2 cfs

2. Outlet -

Huron River	833.0 mi^2**	509.2 cfs**

C. Precipitation***:

1. Year of sampling: 40.6 inches.
2. Mean annual: 39.9 inches.

† MI Cons. Dept. lake inventory map (1943).
* Drainage areas are accurate within ±5%; mean daily flows for 74% of the sampling sites are accurate within ±35% 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; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 1, "Survey Methods, 1972".

III. LAKE WATER QUALITY SUMMARY

Belleville 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 (two stations in June) and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the three stations for phytoplankton identification and enumeration; and during the second visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analyses. The maximum depths sampled were 4 feet at station 1, 15 feet at station 2, and 15 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 was essentially 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:

FALL VALUES

(11/13/72)

Parameter	Mimimum	Mean	Median	Maximum
Temperature (Cent.)	7.5	7.6	7.6	7.8
Dissolved oxygen (mg/l)	9.9	10.1	10.0	10.2
Conductivity (μmhos)	520	536	540	540
pH (units)	8.2	8.3	8.3	8.4
Alkalinity (mg/l)	170	185	188	196
Total P (mg/l)	0.098	0.118	0.114	0.139
Dissolved P (mg/l)	0.037	0.048	0.049	0.062
NO_2 + NO_3 (mg/l)	0.520	0.537	0.540	0.560
Ammonia (mg/l)	0.770	0.882	0.890	0.990
		ALL VALUES		
Secci disc (inches)	27	35	32	58

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/16/72	1. Scenedesmus	1,222
	2. Melosira	1,131
	3. Cyclotella	1,086
	4. Anabaena	656
	5. Gloeocapsa	452
	Other genera	7,444
	Total	11,991
09/19/72	1. Melosira	4,525
	2. Scenedesmus	1,719
	3. Polycystis	1,086
	4. Oscillatoria	995
	5. Stephanodiscus	950
	Other genera	2,716
	Total	11,991
11/13/72	1. Anabaena	1,105
	2. Chroococcus	704
	3. Stepanodiscus	704
	4. Cyclotella	578
	5. Synedra	578
	Other genera	3,065
	Total	6,734

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	65.6
	02	31.0
09/19/72	01	30.2
	02	30.0
	03	14.2
11/13/72	01	9.6
	02	25.9
	03	19.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.073	0.830	21.5
0.010 P	0.083	0.830	19.4
0.020 P	0.093	0.830	20.3
0.050 P	0.123	0.830	20.5
0.050 P + 10.0 N	0.123	10.830	48.9
10.0 N	0.073	10.830	40.0

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Belleville Lake was very high at the time the sample was collected (09/19/72). Also, the lack of yield response with increased levels of orthophosphorus and the increase in

yield when only nitrogen was added indicate the lake was nitrogen limited at that time.

The lake data indicate nitrogen limitation in June as well (N/P = 7/1) but phosphorus limitation in November (N/P = 30/1).

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 vi), except for the high runoff months of March and April when two samples were collected. Also, an additional sample was collected from station A-1 in December and from station A-2 in February. Sampling was begun in October, 1972, and was completed in September, 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 the Huron River were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. However, the nutrient loads calculated for Willow Run Creek were less than the Ypsilanti Township waste treatment plant loads, and the nutrient loadings for this stream and the loadings for the unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient concentrations in unimpacted Mill Creek, tributary to nearby Ford Lake, at station D-1 and multiplying by the mean ZZ flow.

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* See Working Paper No. 1.

The operator of the Ypsilanti Township wastewater treatment plant provided monthly effluent samples and corresponding flow data.

Also, the Ann Arbor, Ypsilanti, Scio Webster, and Dexter treatment plants are indirect point sources impacting Belleville Lake. These plants directly affect Ford Lake just upstream; but Ford Lake only retained 19% of the applied phosphorus load and 12% of the nitrogen load. Therefore, the nutrient loads given for these four plants in the following loading tables were adjusted for the Ford Lake retention.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Ypsilanti Township	43,000	act. sludge + P-removal	6.594	Tyler Pond to Willow Run Creek
Ann Arbor**	100,000	act. sludge + P-removal	16.477	Huron River
Ypsilanti**	21,000	act. sludge	7.120	Ford Lake
Scio-Webster**	500	trickling filter	0.088	Huron River
Dexter**	1,700	prim. clarifier	0.235	Mill Creek

2. Industrial - Unknown

* Sprow, 1974.
** Indirect sources; see Working Paper No. 193, "Report on Ford Lake".

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Huron River	9,410	5.3
Willow Run Creek	290	0.2
b. Minor tributaries & immediate drainage (non-point load) -	1,080	0.6
c. Known municipal STP's -		
Ypsilanti Township	53,870	30.2
Ann Arbor*	51,670	29.0
Ypsilanti*	55,020	30.8
Scio-Webster*	940	0.5
Dexter*	5,740	3.2
d. Septic tanks** -	220	0.1
e. Known industrial - Unknown	-	-
f. Direct precipitation*** -	200	0.1
Total	178,440	100.0

2. Outputs -

Lake outlet - Huron River 134,080

3. Net annual P accumulation - 44,360 pounds

* Indirect sources.
** Estimate based on 344 seasonal dwellings and 2 campgrounds on shoreline; 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) -		
Huron River	1,321,170	53.5
Willow Run Creek	12,460	0.5
b. Minor tributaries & immediate drainage (non-point load) -	44,990	1.8
c. Known municipal STP's -		
Ypsilanti Township	224,690	9.1
Ann Arbor*	686,730	27.8
Ypsilanti*	23,500	1.0
Scio-Webster*	2,870	0.1
Dexter*	133,310	5.4
d. Septic tanks** -	8,010	0.3
e. Known industrial - Unknown	-	-
f. Direct precipitation*** -	12,240	0.5
Total	2,469,970	100.0

2. Outputs -

Lake outlet - Huron River 2,726,090

3. Net annual N loss - 256,120 pounds

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

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
Huron River	12	1,623

* Indirect sources.
** Estimate based on 344 seasonal dwellings and 2 campgrounds on shoreline; see Working Paper No. 1.
*** See Working Paper No. 1.

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	140.5	34.9	1,944.9	loss*
grams/m^2/yr	15.75	3.91	218.0	-

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

"Dangerous" (eutrophic rate)	1.76
"Permissible" (oligotrophic rate)	0.88

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, unknown and unsampled point sources discharging directly to the lake, or the limits of accuracy of the flow estimates provided by the U.S.G.S. (page 4). Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's National Eutrophication and Lake Restoration Branch.

V. LITERATURE REVIEWED

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

Sprow, David, 1974. Personal communication (Ypsilanti Twp. wastewater treatment plant). MI Dept. Public Health, 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 2609 BELLEVILLE LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 833.00

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2609A1	833.00	549.00	643.00	985.00	999.00	694.00	395.00	258.00	190.00	210.00	292.00	416.00	493.00	509.30
2609A2	814.00	537.00	629.00	963.00	977.00	678.00	386.00	252.00	185.00	205.00	285.00	406.00	482.00	497.74
2609B1	6.30	4.00	5.00	7.00	8.00	5.00	3.00	2.00	1.00	2.00	2.00	3.00	4.00	3.82
2609ZZ	12.70	8.00	10.00	15.00	15.00	11.00	6.00	4.00	3.00	3.00	4.00	6.00	8.00	7.73

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 833.00
SUM OF SUB-DRAINAGE AREAS = 833.00
TOTAL FLOW IN = 6124.00
TOTAL FLOW OUT = 6124.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2609A1	10	72	331.00	28	613.00				
	11	72	704.00	24	718.00				
	12	72	750.00	16	739.00				
	1	73	1150.00	12	980.00				
	2	73	662.00	10	811.00				
	3	73	1580.00	11	1520.00	25	2070.00		
	4	73	1180.00	15	902.00	30	539.00		
	5	73	886.00	31	1290.00				
	6	73	826.00	26	526.00				
	7	73	615.00	24	371.00				
	8	73	519.00	28	288.00				
	9	73	243.00	27	170.00				
2609A2	10	72	323.00	28	597.00				
	11	72	686.00						
	12	72	731.00	2	630.00	16	720.00		
	1	73	1120.00	12	955.00				
	2	73	645.00	10	790.00				
	3	73	1540.00	11	1480.00	25	2020.00		
	4	73	1150.00	15	879.00	30	526.00		
	5	73	863.00	31	1250.00				
	6	73	805.00	26	513.00				
	7	73	600.00	24	361.00				
	8	73	506.00	28	280.00				
	9	73	237.00	27	165.00				

LAKE CODE 2609 BELLEVILLE LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
260981	10	72	2.60	28	4.70				
	11	72	5.40	24	5.50				
	12	72	5.80	16	5.70				
	1	73	8.80						
	2	73	5.10	3	7.80	10	6.20		
	3	73	12.00	11	12.00	25	16.00		
	4	73	9.10	15	6.90	30	4.20		
	5	73	6.80	31	9.90				
	6	73	6.40	26	4.00				
	7	73	4.70	24	2.80				
	8	73	4.00	28	2.20				
	9	73	1.90	27	1.30				
260922	10	72	5.10						
	11	72	11.00						
	12	72	12.00						
	1	73	18.00						
	2	73	10.00						
	3	73	24.00						
	4	73	18.00						
	5	73	14.00						
	6	73	13.00						
	7	73	9.50						
	8	73	8.00						
	9	73	3.70						

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/04

260901
42 12 30.0 083 31 00.0
BELLEVILLE LAKE
26 MICHIGAN

11EPALES
4

2111202
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	18	45 0000	22.5	11.6	30	520	8.33	177	0.260	0.580	0.180	0.124
72/09/19	10	30 0000			27	540	8.10	138	0.300	0.440	0.117	0.057
	10	30 0004	21.7	8.0		545	8.10	137	0.280	0.430	0.088	0.052
72/11/13	11	45 0000			31	530	8.20	192	0.560	0.880	0.115	0.056
	11	45 0004	7.6	9.9		520	8.20	193	0.550	0.900	0.114	0.062

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/16	18	45 0000	65.6J
72/09/19	10	30 0000	30.2J
72/11/13	11	45 0000	9.6J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

260902
42 12 30.0 083 30 00.0
BELLEVILLE LAKE
26 MICHIGAN

11EPALES 2111202
4 0016 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	19 00	0000	22.3	10.6	32	505	8.40	178	0.200	0.270	0.116	0.060
	19 00	0015	21.4	6.8		510	7.95	176	0.180	0.620	0.157	0.110
72/09/19	10 45	0000			32	550	8.30	138	0.250	0.400	0.118	0.072
	10 45	0004	21.9	8.8		545	8.30	136	0.250	0.400	0.122	0.075
	10 45	0015	21.8	8.1		550	8.30	135	0.250	0.400	0.160	0.070
72/11/13	11 35	0000			32	540	8.30	196	0.540	0.920	0.132	0.051
	11 35	0004	7.5	10.0		535	8.30	172	0.520	0.990	0.128	0.050
	11 35	0012	7.5	10.0		540	8.30	170	0.520	0.960	0.139	0.049

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/16	19 00	0000	31.00
72/09/19	10 45	0000	30.00
72/11/13	11 35	0000	25.90

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

260903
42 12 00.0 083 30 00.0
BELLEVILLE LAKE
26163 MICHIGAN

11EPALES 2111202
6 0000 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
72/09/19	11 15	0000			58	560	8.15	135	0.170	0.930	0.209	0.188
	11 15	0004	21.9	7.3		540	8.10	134	0.180	0.940	0.205	0.177
	11 15	0008	21.9	6.8		540	8.10	134	0.180	0.930	0.199	0.177
72/11/13	11 13	0000			36	540	8.40	189	0.540	0.840	0.113	0.041
	11 13	0004	7.8	10.2		540	8.40	186	0.540	0.800	0.106	0.037
	11 13	0015	7.8	10.2		540	8.40	179	0.530	0.770	0.098	0.038

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/09/19	11 15	0000	14.2J
72/11/13	11 13	0000	19.6J

J VALUE KNOWN TO BE IN ERROR

APPENDIX D

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/04

260941 LS2609A1
42 12 30.0 083 26 00.0
HURON RIVER
26 7.5 BELLEVILLE
O/BELLEVILLE LAKE
HURON RV DR BRDG BELO DAM E BELLEVILLE
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
72/10/28	15 50		0.362	1.500	0.430	0.039	0.100
72/11/24	12 00		0.541	5.200	0.722	0.046	0.154
72/12/16	13 45		1.060	1.400	0.710	0.115	0.160
73/01/12	13 30		1.550	2.730	1.100	0.058	0.135
73/02/10	14 15		0.870	1.380	0.520	0.081	0.126
73/03/11	11 00		0.730	4.800	0.300	0.091	0.170
73/03/25	16 14		0.900	1.100	0.260	0.044	0.090
73/04/15	13 15		0.700	1.410	0.340	0.033	0.080
73/04/30	12 21		0.430	1.260	0.200	0.018	0.108
73/05/31	11 49		0.231	1.320	0.190	0.042	0.095
73/06/26	13 20		0.220	1.500	0.315	0.150	0.160
73/07/24	19 14		0.088	1.600	0.260	0.063	0.165
73/08/28	19 30		0.026	2.200	0.100	0.026	0.135
73/09/27	10 28		0.080	1.500	0.180	0.031	0.125

STORET RETRIEVAL DATE 75/02/04

2626A2 2629A1
42 12 30.0 083 33 30.0
HURON RIVER
26 7.5 YPSILANTI E
W/BELLEVILLE LAKE
BRDG RD XING FORD DAM
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
72/10/28	14	20	0.530	1.550	0.300	0.014	0.131
72/12/16	14	30	0.450	1.900	0.590	0.100	0.147
73/01/12	14	20	1.200	2.520	1.470	0.046	0.075
73/02/10	13	45	0.900	1.300	0.410	0.053	0.115
73/03/11	10	15	0.770	2.200	0.460	0.063	0.110
73/03/25	15	59	0.750	1.320	0.231	0.035	0.070
73/04/15	12	45	0.520	1.200	0.350	0.042	0.075
73/04/30	11	42	0.399	1.200	0.294	0.024	0.090
73/05/31	11	13	0.450	1.470	0.280	0.056	0.075
73/06/26	11	49	0.310	1.540	0.490	0.210	0.290
73/07/24	13	58	0.088	1.320	0.252	0.130	0.185
73/08/28	14	00	0.008	1.400	0.132	0.025	0.100
73/09/27	09	47	0.160	1.470	0.350	0.063	0.115

STORET RETRIEVAL DATE 75/02/04

250981 LS2609B1
42 13 00.0 083 32 00.0
WILLOW RUN (CREEK)
26 15 YPSILANTI E
T/BELLEVILLE LAKE
BRDG RD S WILLOW RUN AIRPORT BELO STP
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
72/10/28	15 00		0.970	7.100	1.130	0.285	0.550
72/11/24	12 15		0.905	6.400	4.900	0.740	1.160
73/02/03	14 00		1.260	7.400	5.200	0.920	1.300
73/02/10	15 00		1.000	7.600	6.000	1.160	1.700
73/03/11	11 30		0.860	9.300	0.723	0.820	1.650
73/03/25	16 28		1.460	5.300	3.000	0.890	1.250
73/04/15	14 30		1.100	6.300	4.700	1.160	1.570
73/04/30	12 35		1.100	6.900	5.100	1.300	1.600
73/05/31	12 00		0.700	7.600	4.400	1.000	1.450
73/06/25	13 52		0.500	9.200	6.800	1.700	2.200
73/07/24	19 29		0.860	7.300	4.300	1.500	1.880

STORET RETRIEVAL DATE 75/02/04

260954 P0262954 P043000
42 16 00.0 083 40 00.0
YPSILANTI TOWNSHIP
26 7.5 ANN ARBOR E.
T/BELLEVILLE LAKE
HURON RIVER
11EPALES 2141204
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	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/29	00 00								
CP(T)-			0.960	12.000	1.890	1.260	1.900	6.470	6.390
73/01/29	24 00								
73/02/14	00 00								
CP(T)-			0.250	12.300	4.300	1.500	2.400	6.450	6.610
73/02/14	24 00								
73/03/06	00 00								
CP(T)-			0.300	10.500	3.300	2.800	3.400	6.700	6.170
73/03/06	24 00								
73/04/27	00 00								
CP(T)-			0.110	10.500	3.000	1.470	1.950	6.760	5.960
73/04/27	24 00								
73/05/27	00 00								
CP(T)-			0.240	11.500	5.700	2.100	3.020	4.920	6.070
73/05/27	24 00								
73/06/02	00 00								
CP(T)-			0.115	11.300	4.900	2.700	3.750	7.190	6.750
73/06/02	24 00								
73/07/27	00 00								
CP(T)-			0.200	9.000	2.700	1.700	2.200	7.820	6.720
73/07/27	24 00								
73/08/06	00 00								
CP(T)-			0.290	10.500	2.510	1.380	2.000	6.820	6.900
73/08/06	24 00								
73/09/19	00 00								
CP(T)-			0.080	8.550	2.900	0.840	1.370	5.880	5.720
73/09/19	24 00								
73/10/31	00 00								
CP(T)-			1.540	10.000	0.340	4.300	5.750	8.560	8.410
73/10/31	24 00								
73/11/11	00 00								
CP(T)-			0.090	14.000	2.500	2.000	3.300	4.860	5.900
73/11/11	24 00								
73/12/13	00 00								
CP(T)-			0.160	12.500	1.470	0.960	2.500	7.280	6.410
73/12/13	24 00								

STORET RETRIEVAL DATE 75/02/04

260954 P0262954 P043000
42 16 00.0 083 40 00.0
YPSILANTI TOWNSHIP
26 7.5 ANN ARBOR E.
1/BELLEVILLE LAKE
HURON RIVER
11EPALES 2141204
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	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/01/11	00 00								
CP(T)-			0.400	9.200	3.000	0.640	0.950	8.240	7.710
74/01/11	24 00								