U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

BASS LAKE

STARKE COUNTY

INDIANA

EPA REGION V

WORKING PAPER No. 323

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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REPORT
ON
BASS LAKE
STARKE COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 323

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
MARCH, 1976

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 nationwide 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 Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

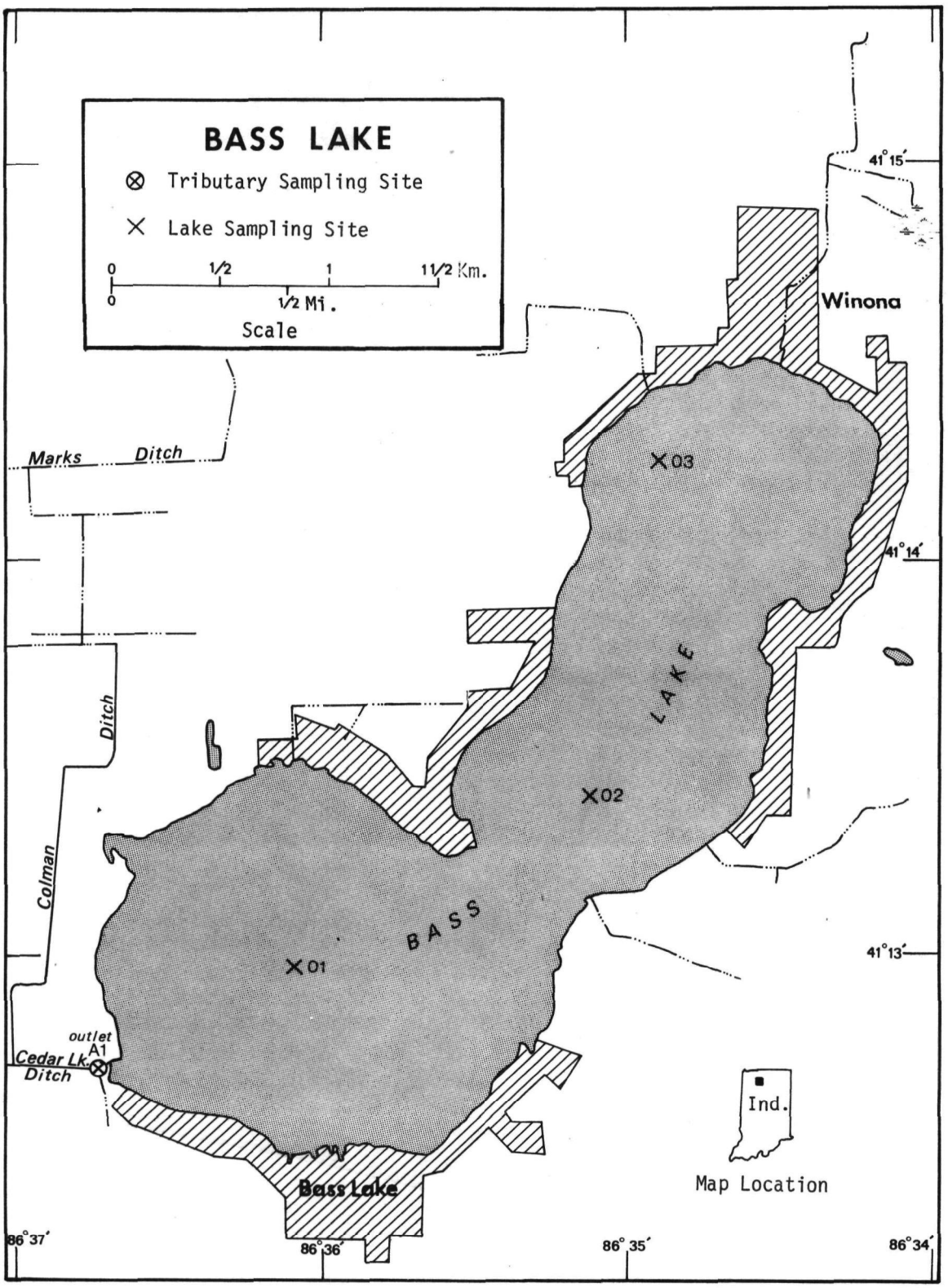
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


BASS LAKE
Tributary Sampling Site
Lake Sampling Site
0 1/2 1 1 1/2 Km.
0 1/2 Mi.
Scale
Winona
41°15′
41°14′
41°13′
Marks Ditch
Ditch
Colman
outlet
A1
Cedar Lk. Ditch
X01
X02
X03
BASS LAKE
Bass Lake
Ind.
Map Location
86°37′
86°36′
86°35′
86°34′

BASS LAKE

STORET NO. 1851

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Bass Lake is eutrophic. It ranked twelfth in overall trophic condition when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. Fifteen of the lakes had less median total phosphorus, 14 had less and one had the same median dissolved phosphorus, six had less median inorganic nitrogen, 20 had less mean chlorophyll a, and 21 had greater mean Secchi disc transparency.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Bass Lake was phosphorus limited at the time the sample was collected (05/02/73). The lake data indicate phosphorus limitation in August as well but marginal nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources impacted Bass Lake during the sampling year. Lakeshore septic tanks were estimated to have contributed 23.7% of the total load reaching the lake, but a shoreline survey would be necessary to determine the significance of those sources.

* See Appendix A.

The present phosphorus loading of 0.09 $g/m^2/yr$ is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11).

The trophic condition of the lake at this time may be the result of greater nutrient loadings in the past. For example, since the phosphorus ban was instituted in January, 1972, there was an estimated decrease in domestic wastewater phosphorus of about 50%. In other words, the 115 kg P/yr now estimated to have come from septic tanks (see page 9) would have been about 230 kg P/yr before the ban. The total phosphorus loading rate prior to the 1972 ban (assuming no other changes have taken place in phosphorus loading) is estimated at 600 kg P/yr (0.11 $g/m^2/yr$); i.e., 19% greater than the present load.

With a mean hydraulic retention time of three years, a lag time of several years would be expected before improvement in the quality of the lake becomes apparent.

2. Non-point sources--The phosphorus load from non-point sources was estimated to have been 76.3% of the total load during the sampling year. No gaged tributaries were sampled during the year; the ungaged tributaries were estimated to have contributed 55.7% of the total phosphorus load.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 5.69 kilometers^2.
2. Mean depth: 1.8 meters.
3. Maximum depth: 9.8 meters.
4. Volume: 10.242 x 10^6 m^3.
5. Mean hydraulic retention time: 3.2 years.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
None sampled	-	-
Minor tributaries & immediate drainage -	7.7	0.10
Totals	7.7	0.10

2. Outlet -

Cedar Lake Ditch	13.4**	0.10

C. Precipitation***:

1. Year of sampling: 104.3 centimeters.
2. Mean annual: 92.6 centimeters.

† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Bass Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters usually were collected from two or more depths at three stations on the lake (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter 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 analysis. The maximum depths sampled were 0.6 meters at station 1, 4.9 meters at station 2, and 2.1 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR BASS LAKE
STORET CODE 1851

	1ST SAMPLING (5/ 2/73) 3 SITES			2ND SAMPLING (8/ 3/73) 3 SITES			3RD SAMPLING (10/13/73) 3 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	16.3 - 16.4	16.3	16.3	23.4 - 24.4	24.1	24.2	19.7 - 20.2	20.1	20.2
DISS OXY (MG/L)	8.0 - 9.0	8.5	8.5	8.2 - 9.5	8.8	8.8	8.0 - 8.2	8.1	8.1
CNDCTVY (MCROMO)	280. - 290.	281.	280.	212. - 234.	218.	216.	193. - 200.	196.	196.
PH (STAND UNITS)	8.1 - 8.2	8.1	8.1	8.6 - 8.8	8.7	8.7	8.5 - 8.6	8.6	8.6
TOT ALK (MG/L)	105. - 108.	106.	106.	86. - 90.	89.	89.	77. - 80.	79.	79.
TOT P (MG/L)	0.095 - 0.136	0.115	0.118	0.031 - 0.038	0.036	0.037	0.034 - 0.049	0.039	0.038
ORTHO P (MG/L)	0.011 - 0.014	0.013	0.013	0.006 - 0.013	0.008	0.008	0.010 - 0.015	0.012	0.011
NO2+NO3 (MG/L)	0.190 - 0.270	0.211	0.200	0.120 - 0.160	0.138	0.140	0.060 - 0.080	0.063	0.060
AMMONIA (MG/L)	0.540 - 0.580	0.557	0.560	0.110 - 0.130	0.115	0.110	0.070 - 0.120	0.087	0.085
KJEL N (MG/L)	2.300 - 2.600	2.457	2.500	1.000 - 1.800	1.317	1.250	1.600 - 2.100	1.817	1.800
INORG N (MG/L)	0.740 - 0.810	0.769	0.760	0.230 - 0.290	0.253	0.250	0.130 - 0.180	0.150	0.145
TOTAL N (MG/L)	2.500 - 2.790	2.669	2.700	1.130 - 1.960	1.455	1.380	1.660 - 2.180	1.880	1.860
CHLRPYL A (UG/L)	26.3 - 27.7	27.0	27.0	25.5 - 39.9	33.0	33.7	26.8 - 29.1	28.1	28.3
SECCHI (METERS)	0.4 - 0.5	0.4	0.4	0.8 - 0.9	0.8	0.9	0.7 - 0.9	0.8	0.8

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/02/73	1. *Scenedesmus sp.*	2,063
	2. *Lyngbya sp.*	1,826
	3. *Synedra sp.*	1,420
	4. Flagellates	676
	5. *Aphanocapsa sp.*	304
	Other genera	2,065
	Total	8,354
08/03/73	1. *Lyngbya sp.*	6,229
	2. *Synedra sp.*	1,126
	3. Blue-green filaments	1,091
	4. Flagellates	528
	5. *Aphanothece sp.*	353
	Other genera	2,216
	Total	11,543
10/13/73	1. *Oscillatoria sp.*	24,890
	2. *Lyngbya sp.*	9,186
	3. *Synedra sp.*	4,004
	4. *Anabaena sp.*	303
	5. *Chroococcus sp.*	235
	Other genera	1,426
	Total	40,044

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
05/02/73	1	27.0
	2	27.7
	3	26.3
08/03/73	1	25.5
	2	33.7
	3	39.9
10/13/73	1	28.3
	2	26.8
	3	29.1

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	0.030	0.856	8.3
0.050 P	0.080	0.856	21.6
0.050 P + 1.0 N	0.080	1.856	26.4
1.0 N	0.030	1.856	10.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Bass Lake was high at the time the sample was collected (05/02/73). The results also indicate that Bass Lake was phosphorus limited at that time. Note that with the addition of nitrogen alone, the yield was not significantly greater than the control yield; however, with the addition of orthophosphorus, a marked increase in yield occurred.

The lake data indicate phosphorus limitation in August as well (the mean inorganic nitrogen/orthophosphorus ratio was 32/1) but marginal nitrogen limitation in October (the mean N/P ratio was nearly 13/1).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from the outlet site indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the outlet and minor tributaries and immediate drainage.

In this report, outlet nutrient loads 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 using the means of the nutrient loads, in $kg/km^2/year$, at stations A-2, B-1, and C-1 of nearby Lake Maxinkuckee** and multiplying the means by the Bass Lake ZZ area in km^2.

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* See Working Paper No. 175.
** Working Paper No. 335.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
None sampled	-	-
b. Minor tributaries & immediate drainage (non-point load) -	270	55.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	115	23.7
e. Known industrial - None	-	-
f. Direct precipitation** -	100	20.6
Total	485	100.0

2. Outputs -

Lake outlet - Cedar Lake Ditch 245

3. Net annual P accumulation - 240 kg.

* Estimate based on 398 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
None sampled	-	-
b. Minor tributaries & immediate drainage (non-point load) -	8,495	45.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	4,240	22.5
e. Known industrial - None	-	-
f. Direct precipitation** -	6,145	32.5
Total	18,880	100.0

2. Outputs -

Lake outlet - Cedar Lake Ditch 10,725

3. Net annual N accumulation - 8,155 kg.

* Estimate based on 398 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

D. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

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

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.09	0.04	3.3	1.4

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Bass Lake:	
"Dangerous" (eutrophic loading)	0.14
"Permissible" (oligotrophic loading)	0.07

V. LITERATURE REVIEWED

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATARACT LAKE	0.058	1.660	466.667	19.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

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

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1851 BASS LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 13.4

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1851A1	13.4	0.153	0.190	0.278	0.258	0.164	0.127	0.074	0.022	0.023	0.023	0.065	0.125	0.125
1851ZZ	7.7	0.085	0.110	0.161	0.147	0.093	0.074	0.042	0.012	0.013	0.013	0.037	0.074	0.072

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 13.4
SUM OF SUB-DRAINAGE AREAS = 7.7
TOTAL FLOW IN = 0.86
TOTAL FLOW OUT = 1.50

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1851A1	6	73	0.076	10	0.093				
	7	73	0.025	17	0.007				
	8	73	0.028	20	0.019				
	9	73	0.004	10	0.006				
	10	73	0.001	17	0.001				
	11	73	0.000	16	0.0				
	12	73	0.002	27	0.008				
	1	74	0.025	22	0.024				
	2	74	0.065	12	0.054	26	0.099		
	3	74	0.108	14	0.125	25	0.093		
	4	74	0.070	16	0.065				
	5	74	0.070	14	0.054				
1851ZZ	6	73	0.044	10	0.054				
	7	73	0.014	17	0.004				
	8	73	0.016	20	0.011				
	9	73	0.002	10	0.003				
	10	73	0.001	17	0.000				
	11	73	0.000	16	0.0				
	12	73	0.001	27	0.004				
	1	74	0.014	22	0.014				
	2	74	0.038	12	0.031	26	0.057		
	3	74	0.063	14	0.071	25	0.054		
	4	74	0.040	16	0.037				
	5	74	0.040	14	0.031				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

185101
41 13 00.0 086 36 05.0 4
BASS LAKE
18149 INDIANA
051792

11EPALES 2111202
0003 FEET DEPTH CLASS 00

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	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	10 45	0000	16.3		15	290	8.20	106	0.540	2.300	0.200	0.013
	10 45	0002	16.3	9.0		280	8.20	106	0.540	2.300	0.270	0.012
73/08/03	14 00	0000	24.3	9.5	30	212	8.80	90	0.130	1.800	0.160	0.007
73/10/13	09 45	0000	19.7	8.2	28	193	8.60	80	0.090	2.100	0.080	0.011

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	10 45	0000	0.095	27.0
	10 45	0002	0.096	
73/08/03	14 00	0000	0.038	25.5
73/10/13	09 45	0000	0.040	28.3

STORET RETRIEVAL DATE 76/03/30

185102
41 13 25.0 086 35 05.0 3
BASS LAKE
18149 INDIANA

051792

11EPALES 2111202
0020 FEET DEPTH CLASS 00

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	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	11	30 0000	16.3		18	280	8.10	106	0.550	2.600	0.190	0.011
	11	30 0004	16.3	8.0		280	8.10	105	0.570	2.500	0.210	0.013
	11	30 0016	16.3	8.4		280	8.10	107	0.580	2.400	0.220	0.014
73/08/03	14	15 0000	24.3		35	216	8.70	89	0.120	1.500	0.140	0.009
	14	15 0005	24.1	8.9		215	8.70	88	0.110	1.200	0.140	0.013
	14	15 0010	23.9	8.8		215	8.60	86	0.110	1.300	0.120	0.008
73/10/13	09	55 0000	20.2		33	196	8.60	79	0.090	1.800	0.060	0.012
	09	55 0005	20.2	8.0		198	8.60	79	0.120	1.600	0.060	0.015
	09	55 0014	20.2	8.0		200	8.50	77	0.070	2.000	0.060	0.012

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	11	30 0000	0.118	27.7
	11	30 0004	0.136	
	11	30 0016	0.132	
73/08/03	14	15 0000	0.034	33.7
	14	15 0005	0.038	
	14	15 0010	0.038	
73/10/13	09	55 0000	0.037	26.8
	09	55 0005	0.040	
	09	55 0014	0.049	

STORET RETRIEVAL DATE 76/03/30

185103
41 14 15.0 086 34 55.0 3
BASS LAKE
18149 INDIANA

051792

11EPALES 2111202
0007 FEET DEPTH CLASS 00

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	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	12 00	0000	16.4			280	8.10	108	0.560	2.600	0.190	0.013
	12 00	0005	16.4	8.7		280	8.10	106	0.560	2.500	0.200	0.013
73/08/03	14 40	0000	24.4	8.7	35	218	8.60	89	0.110	1.100	0.140	0.006
	14 40	0007	23.4	8.2		234	8.70	89	0.110	1.000	0.130	0.008
73/10/13	10 05	0000	20.2		35	194	8.60	79	0.080	1.800	0.060	0.011
	10 05	0005	20.2	8.2		195	8.60	78	0.070	1.600	0.060	0.010

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	12 00	0000	0.100	26.3
	12 00	0005	0.127	
73/08/03	14 40	0000	0.031	39.9
	14 40	0007	0.037	
73/10/13	10 05	0000	0.034	29.1
	10 05	0005	0.035	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/30

1851A1
41 12 44.0 086 36 44.0 4
CEDAR LAKE DITCH
18 7.5 BASS LAKE
0/BASS LAKE 051792
US HWY 35 BRDG AT SW EDGE OF LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

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
73/06/10	09 30		0.072	1.600	0.370	0.021	0.075
73/07/17	17 15		0.032	4.650	1.580	0.014	0.135
73/08/20	14 55		0.026	1.700	0.024	0.025	0.105
73/09/10	11 45		0.010K	1.320	0.180	0.009	0.065
73/10/17	14 30		0.010K	1.450	0.170	0.007	0.045
73/11/16	10 35		0.019	1.200	0.210	0.008	0.060
73/12/27	11 20		0.480	1.300	0.330	0.152	0.168
74/01/22	15 15		0.500	0.800	0.216	0.015	0.045
74/02/12	10 55		0.112	1.400	0.320	0.005K	0.010
74/02/26	11 50		0.104	1.500	0.340	0.005K	0.030
74/03/14	14 15		0.124	1.500	0.250	0.005K	0.025
74/03/25	09 55		0.108	1.600	0.420	0.005	0.025
74/04/16	12 20		0.144	2.000	0.380	0.005	0.005
74/05/14	14 10		0.124	1.600	0.400	0.010	0.050

K VALUE KNOWN TO BE
LESS THAN INDICATED