U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

HORSESHOE LAKE

MADISON COUNTY

ILLINOIS

EPA REGION V

WORKING PAPER No. 308

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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Report

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Working Paper No. 308

With the cooperation of the

Illinois Environmental Protection Agency

and the

Illinois National Guard

June, 1975

CONTENTS

	Page
Foreword	ii
List of Illinois Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	9
V. Literature Reviewed	14
VI. Appendices	15

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 Illinois Environmental Protection Agency for professional involvement and to the Illinois National Guard for conducting the tributary sampling phase of the Survey.

Dr. Richard H. Briceland, Director of the Illinois Environmental Protection Agency; and Ronald M. Barganz, State Survey Coordinator, and John J. Forneris, Manager of Region III, Field Operations Section of the Division of Water Pollution Control, 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 Harold R. Patton, the Adjutant General of Illinois, and Project Officer Colonel Daniel L. Fane, who directed the volunteer efforts of the Illinois National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ILLINOIS

LAKE NAME	COUNTY
Baldwin	Randolph
Bloomington	McLean
Carlyle	Bond, Clinton, Fayette
Cedar	Lake
Charleston	Coles
Coffeen	Montgomery
Crab Orchard	Jackson, Williamson
Decatur	Macon
DePue	Bureau
East Loon	Lake
Fox	Lake
Grass	Lake
Highland Silver	Madison
Holiday	LaSalle
Horseshoe	Madison
Long	Lake
Lou Yaeger	Montgomery
Marie	Lake
Old Ben Mine	Franklin
Pistakee	Lake, McHenry
Raccoon	Marion
Rend	Franklin, Jefferson
Sangchris	Christian
Shelbyville	Moultrie, Shelby
Slocum	Lake
Springfield	Sangamon
Storey	Knox
Vandalia	Fayette
Vermilion	Vermilion
Wee Ma Tuk	Fulton
Wonder	McHenry

HORSESHOE LAKE

STORET NO. 1766

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Horseshoe Lake is eutrophic. It ranked fourteenth in overall trophic quality when the 31 Illinois lakes sampled in 1973 were compared using a combination of six parameters*. Seventeen lakes had less median total phosphorus, six had less and one had the same median dissolved phosphorus, 13 had less median inorganic nitrogen, 29 had less mean chlorophyll a, and 19 had greater mean Secchi disc transparency.

Survey limnologists reported algal blooms and some macrophytes, and blue-green algae were present in large numbers and dominant in all phytoplankton samples (see page 7).

B. Rate-Limiting Nutrient:

The algal assay results indicate that Horseshoe Lake was phosphorus limited when the assay sample was collected (05/07/73). These results are substantiated by the lake data. At all sampling times, the mean N/P ratios were 17/1 or greater, and phosphorus limitation would be expected.

C. Nutrient Controllability:

1. Point sources--The only known point source discharging to Horseshoe Lake during the sampling year was the Granite City

* See Appendix A.

Steel Company mill. The Company declined participation in the Survey, and the nutrient content of the treated wastes from the steel mill is not known. However, such wastes ordinarily are of little significance as a source of phosphorus, although concentrations of ammonia and nitrates may be quite high depending on the mill process(es) being used (U.S. EPA, 1974).

Lakeshore septic tanks were estimated to have contributed only 0.6% of the total phosphorus input to Horseshoe Lake. However, the phosphorus exports of the two gaged tributaries were somewhat high, and it is likely that urban drainage in the surrounding metropolitan areas (e.g., East St. Louis, Granite City, and Madison) contributed significantly to the overall phosphorus load.

The present annual phosphorus loading rate of 0.51 g/m^2 is almost double that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic rate (see page 13). Because the lake is phosphorus limited, all phosphorus inputs should be minimized to the greatest practicable extent to slow the eutrophication of this water body.

2. Non-point sources--Over 99% of the total phosphorus input to Horseshoe Lake during the sampling year is attributed to non-point sources. The unnamed stream D-1 contributed 38.7%,

and the unnamed canal E-1 contributed 13.0%. Ungaged tributaries were estimated to have contributed 44.3% of the total.

As discussed above, a part of the phosphorus export of the unnamed stream D-1 and the unnamed canal E-1 probably should be attributed to urban drainage in the metropolitan areas rather than to non-point source contributions, since the export rates of these streams (see page 12) were significantly higher than the rates of unimpacted Illinois streams sampled elsewhere (e.g., the phosphorus export rate of Raccoon Creek, tributary to nearby Raccoon Lake*, was only 36 $kg/km^2/yr$).

* Working Paper No. 312.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 8.78 kilometers^2.
2. Mean depth: 2.1 meters.
3. Maximum depth: unknown.
4. Volume: 18.193 x 10^6 m^3.
5. Mean hydraulic retention time: 420 days.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Unnamed Stream D-1	30.8	0.2
Unnamed Canal E-1	9.6	<0.1
Minor tributaries & immediate drainage -	33.9	0.3
Totals	74.3	0.5

2. Outlet -

Unnamed Canal A-1	83.1**	0.5

C. Precipitation***:

1. Year of sampling: 127.8 centimeters.
2. Mean annual: 94.9 centimeters.

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† Table of metric conversions--Appendix B.
†† Forneris, 1973.
* 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

Horseshoe 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 were collected from two stations on the lake and from one or more depths at each station (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 depth sampled at both stations was 0.9 meters.

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

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR HORSESHOE LAKE
STORET CODE 1766

PARAMETER	1ST SAMPLING (5/ 7/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/10/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/17/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	15.8 - 16.0	15.9	15.9	27.9 - 28.6	28.3	28.3	17.1 - 17.6	17.3	17.3
DISS OXY (MG/L)	9.5 - 9.7	9.6	9.6	8.2 - 9.0	8.6	8.6	10.8 - 10.8	10.8	10.8
CNDCTVY (MCROMO)	470. - 560.	515.	515.	609. - 616.	613.	613.	536. - 559.	547.	547.
PH (STAND UNITS)	8.4 - 8.7	8.5	8.5	9.2 - 9.8	9.3	9.2	8.8 - 9.0	8.9	8.9
TOT ALK (MG/L)	78. - 196.	137.	137.	39. - 59.	49.	49.	73. - 111.	88.	84.
TOT P (MG/L)	0.083 - 0.145	0.114	0.114	0.137 - 0.453	0.256	0.216	0.086 - 0.117	0.098	0.094
ORTHO P (MG/L)	0.006 - 0.101	0.053	0.053	0.021 - 0.030	0.026	0.026	0.009 - 0.015	0.012	0.011
NO2+NO3 (MG/L)	2.180 - 6.600	4.390	4.390	0.200 - 0.270	0.252	0.270	0.130 - 0.810	0.455	0.440
AMMONIA (MG/L)	0.120 - 0.840	0.480	0.480	0.150 - 0.210	0.180	0.180	0.030 - 2.000	0.975	0.935
KJEL N (MG/L)	0.500 - 2.800	1.650	1.650	4.000 - 4.900	4.300	4.150	2.900 - 4.100	3.350	3.200
INORG N (MG/L)	3.020 - 6.720	4.870	4.870	0.350 - 0.480	0.432	0.450	0.160 - 2.440	1.430	1.560
TOTAL N (MG/L)	4.980 - 7.100	6.040	6.040	4.200 - 5.170	4.552	4.420	3.330 - 4.540	3.805	3.675
CHLRPYL A (UG/L)	132.9 - 244.2	188.5	188.5	226.9 - 290.5	258.7	258.7	84.8 - 114.2	99.5	99.5
SECCHI (METERS)	0.4 - 0.6	0.5	0.5	0.2 - 0.3	0.3	0.3	0.5 - 0.7	0.6	0.6

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal units per ml
05/07/73	1. *Oscillatoria sp.*	53,701
	2. *Synedra sp.*	40,977
	3. Flagellates	5,176
	4. *Merismopedia sp.*	4,745
	5. *Scenedesmus sp.*	4,313
	Other genera	12,939
	Total	121,851
08/10/73	1. *Raphidiopsis sp.*	51,017
	2. *Oscillatoria sp.*	26,167
	3. *Merismopedia sp.*	12,049
	4. *Lyngbya sp.*	11,107
	5. *Anabaenopsis sp.*	6,777
	Other genera	20,330
	Total	127,447
10/17/73	1. *Raphidiopsis sp.*	47,913
	2. *Lyngbya sp.*	10,629
	3. Flagellates	4,252
	4. *Merismopedia sp.*	4,252
	5. *Phormidium* (?) *sp.*	4,088
	Other genera	15,699
	Total	86,833

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (μg/l)
05/07/73	01	132.9
	02	244.2
08/10/73	01	226.9
	02	290.5
10/17/73	01	114.2
	02	84.8

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	0.020	2.610	20.7
0.050 P	0.070	2.610	30.1
0.050 P + 1.0 N	0.070	3.610	37.2
1.0 N	0.020	3.610	19.4

2. Discussion -

The control yield of the assay alga, *Selenastrum capricornutum*, indicates that the potential primary productivity of Horseshoe Lake was high at the time the sample was collected. Also, the significant increase in yield with the addition of phosphorus alone, and the lack of response with the addition of only nitrogen indicate the lake was phosphorus limited.

The lake data also indicate limitation by phosphorus; at all sampling times, the mean inorganic nitrogen/orthophosphorus ratios were 17/1 or greater.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Illinois 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 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 Illinois 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 loads 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 D-1 and E-1 and multiplying the means by the ZZ area in km^2.

As far as is known, the only point source discharging to Horseshoe Lake during the sampling year was the Granite City Steel Company mill, but the Company declined participation in the Survey.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial* -

Name	Product	Treatment	Mean Flow (cms)	Receiving Water
Granite City Steel Co.	steel	settling ponds + anaer. ponds	?	Unnamed Canal E-1

* Anonymous, 1972.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed Stream D-1	1,735	38.7
Unnamed Canal E-1	585	13.0
b. Minor tributaries & immediate drainage (non-point load) -	1,985	44.3
c. Known municipal STP's - None	-	-
d. Septic tanks* -	25	0.6
e. Known industrial -		
Granite City Steel Co.	?	-
f. Direct precipitation** -	155	3.4
Total	4,485	100.0

2. Outputs -

Lake outlet - Unnamed Canal A-1 3,740 •

3. Net annual P accumulation - 745 kg.

* Estimate based on 82 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) -		
Unnamed Stream D-1	8,255	26.5
Unnamed Canal E-1	2,895	9.3
b. Minor tributaries & immediate drainage (non-point load) -	9,660	31.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	875	2.8
e. Known industrial -		
Granite City Steel Co.	?	-
f. Direct precipitation** -	9,480	30.4
Total	31,165	100.0

2. Outputs -

Lake outlet - Unnamed Canal A-1 82,785

3. Net annual N loss - 51,620 kg.

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

Tributary	kg P/km^2/yr	kg N/km^2/yr
Unnamed Stream D-1	56	268
Unnamed Canal E-1	61	302

* Estimate based on 82 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" rate is the rate at which the receiving water 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 short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.51	0.08	3.5	loss*

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

"Dangerous" (eutrophic rate)	0.26
"Permissible" (oligotrophic rate)	0.13

* 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, or unknown and unsampled point sources discharging directly to the lake. 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 (Malueg et al., 1975).

V. LITERATURE REVIEWED

Anonymous, 1972. Waste water treatment works data book. IL Env. Prot. Agency, Springfield.

Forneris, John J., 1973. Personal communication (lake morphometry). IL Env. Prot. Agency, Springfield.

Malueg, Kenneth W., D. Phillips Larsen, Donald W. Schults, and Howard T. Mercier; 1975. A six-year water, phosphorus, and nitrogen budget for Shagawa Lake, Minnesota. Jour. Environ. Qual., vol. 4, no. 2, pp. 236-242.

U.S. EPA, 1974. Iron and steel manufacturing point source category. Effluent guidelines and standards. Federal Register 39, 126, 24114.

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.

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
1703	LAKE BLOOMINGTON	0.050	5.730	464.667	26.200	14.800	0.020
1706	LAKE CARLYLE	0.084	1.270	477.889	17.367	11.000	0.032
1708	LAKE CHARLESTON	0.160	4.680	490.667	12.000	8.400	0.065
1711	COFFEEN LAKE	0.032	0.260	456.222	7.700	14.900	0.012
1712	CRAB ORCHARD LAKE	0.082	0.200	482.222	59.867	13.800	0.013
1714	LAKE DECATUR	0.129	3.750	479.571	43.000	14.500	0.062
1725	LONG LAKE	0.704	1.190	482.667	49.333	8.800	0.398
1726	LAKE LOU YAEGER	0.186	1.600	489.583	10.662	11.400	0.076
1727	LAKE MARIE	0.098	0.370	467.667	39.533	14.700	0.057
1733	PISTAKEE LAKE	0.203	0.370	485.667	75.867	7.000	0.062
1735	REND LAKE	0.071	0.210	471.500	23.533	12.700	0.012
1739	LAKE SHELBYVILLE	0.062	3.290	461.333	17.161	14.800	0.019
1740	SILVER LAKE (HIGHLAND)	0.226	0.970	489.500	5.822	14.800	0.057
1742	LAKE SPRINGFIELD	0.108	3.265	483.385	13.013	10.800	0.059
1748	VERMILION LAKE	0.109	4.695	481.500	31.150	14.200	0.050
1750	WONDER LAKE	0.426	0.890	486.000	98.533	7.800	0.132
1751	LAKE STORY	0.072	2.510	459.333	17.250	14.800	0.021
1752	DEPUE LAKE	0.438	4.050	490.000	58.833	7.600	0.276
1753	LAKE SANGCHRIS	0.050	1.970	475.417	19.292	14.500	0.009
1754	LAKE HOLIDAY	0.167	3.135	485.167	51.217	7.200	0.046
1755	FOX LAKE	0.219	0.375	486.167	63.850	8.800	0.083
1756	GRASS LAKE	0.301	0.820	481.000	83.500	5.900	0.093
1757	EAST LOON LAKE	0.076	0.120	450.000	22.300	14.900	0.018
1758	SLOCUM LAKE	0.865	0.200	487.333	221.100	5.800	0.362
1759	CEDAR LAKE	0.029	0.170	400.333	5.767	12.800	0.013
1761	LAKE WEMATUK	0.069	1.770	466.333	7.967	14.500	0.031
1762	RACCOON LAKE	0.106	0.310	484.333	19.217	13.800	0.020
1763	BALDWIN LAKE	0.044	0.140	461.167	11.333	13.200	0.007

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
1764	LAKE VANDALIA	0.116	0.480	478.111	11.278	14.800	0.023
1765	OLD BEN MINE RESERVOIR	0.930	0.205	478.333	31.433	11.200	0.575
1766	HORSESHOE LAKE	0.127	0.705	482.833	182.250	6.800	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
1703	LAKE BLOOMINGTON	88 (26)	0 (0)	80 (24)	47 (14)	13 (2)	68 (20)	296
1706	LAKE CARLYLE	63 (19)	40 (12)	63 (19)	63 (19)	63 (19)	53 (16)	345
1708	LAKE CHARLESTON	37 (11)	7 (2)	0 (0)	77 (23)	77 (23)	27 (8)	225
1711	COFFEEN LAKE	97 (29)	77 (23)	93 (28)	93 (28)	2 (0)	92 (27)	454
1712	CRAB ORCHARD LAKE	67 (20)	90 (27)	43 (13)	20 (6)	42 (12)	85 (25)	347
1714	LAKE DECATUR	40 (12)	13 (4)	53 (16)	33 (10)	30 (8)	32 (9)	201
1725	LONG LAKE	7 (2)	43 (13)	40 (12)	30 (9)	72 (21)	3 (1)	195
1726	LAKE LOU YAEGER	30 (9)	37 (11)	7 (2)	87 (26)	57 (17)	23 (7)	241
1727	LAKE MARIE	60 (18)	68 (20)	73 (22)	37 (11)	23 (7)	42 (12)	303
1733	PISTAKEE LAKE	27 (8)	68 (20)	23 (7)	13 (4)	90 (27)	32 (9)	253
1735	REND LAKE	77 (23)	80 (24)	70 (21)	50 (15)	53 (16)	92 (27)	422
1739	LAKE SHELBYVILLE	83 (25)	17 (5)	83 (25)	70 (21)	13 (2)	73 (22)	339
1740	SILVER LAKE (HIGHLAND)	20 (6)	47 (14)	10 (3)	97 (29)	13 (2)	42 (12)	229
1742	LAKE SPRINGFIELD	53 (16)	20 (6)	33 (10)	73 (22)	67 (20)	37 (11)	283
1748	VERMILION LAKE	50 (15)	3 (1)	47 (14)	43 (13)	37 (11)	47 (14)	227
1750	WONDER LAKE	13 (4)	50 (15)	20 (6)	7 (2)	80 (24)	13 (4)	183
1751	LAKE STORY	73 (22)	27 (8)	90 (27)	67 (20)	13 (2)	63 (19)	333
1752	DEPUE LAKE	10 (3)	10 (3)	3 (1)	23 (7)	83 (25)	10 (3)	139
1753	LAKE SANGCHRIS	88 (26)	30 (9)	67 (20)	57 (17)	30 (8)	97 (29)	369
1754	LAKE HOLIDAY	33 (10)	23 (7)	27 (8)	27 (8)	87 (26)	50 (15)	247
1755	FOX LAKE	23 (7)	63 (19)	17 (5)	17 (5)	72 (21)	20 (6)	212
1756	GRASS LAKE	17 (5)	53 (16)	50 (15)	10 (3)	97 (29)	17 (5)	244
1757	EAST LOON LAKE	70 (21)	100 (30)	97 (29)	53 (16)	2 (0)	77 (23)	399
1758	SLOCUM LAKE	3 (1)	87 (26)	13 (4)	0 (0)	100 (30)	7 (2)	210
1759	CEDAR LAKE	100 (30)	93 (28)	100 (30)	100 (30)	50 (15)	85 (25)	528
1761	LAKE WEMATUK	80 (24)	33 (10)	77 (23)	90 (27)	30 (8)	57 (17)	367
1762	RACCOON LAKE	57 (17)	73 (22)	30 (9)	60 (18)	42 (12)	68 (20)	330
1763	BALDWIN LAKE	93 (28)	97 (29)	87 (26)	80 (24)	47 (14)	100 (30)	504

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

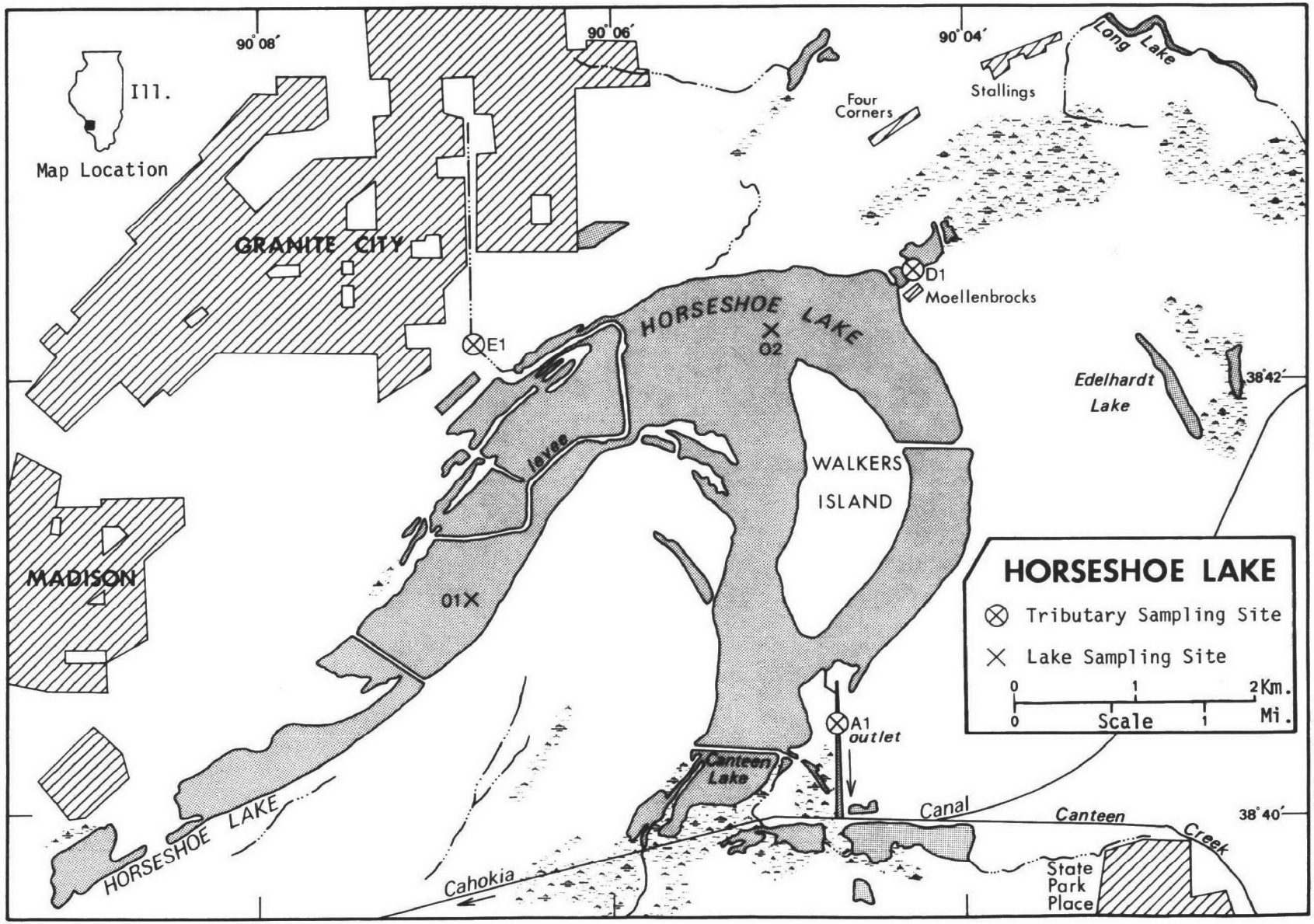
LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1764	LAKE VANDALIA	47 (14)	60 (18)	60 (18)	83 (25)	13 (2)	60 (18)	323
1765	OLD BEN MINE RESERVOIR	0 (0)	83 (25)	57 (17)	40 (12)	60 (18)	0 (0)	240
1766	HORSESHOE LAKE	43 (13)	57 (17)	37 (11)	3 (1)	93 (28)	80 (24)	313

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1759	CEDAR LAKE	528
2	1763	BALDWIN LAKE	504
3	1711	COFFEEN LAKE	454
4	1735	REND LAKE	422
5	1757	EAST LOON LAKE	399
6	1753	LAKE SANGCHRIS	369
7	1761	LAKE WEMATUK	367
8	1712	CRAB ORCHARD LAKE	347
9	1706	LAKE CARLYLE	345
10	1739	LAKE SHELBYVILLE	339
11	1751	LAKE STORY	333
12	1762	RACCOON LAKE	330
13	1764	LAKE VANDALIA	323
14	1766	HORSESHOE LAKE	313
15	1727	LAKE MARIE	303
16	1703	LAKE BLOOMINGTON	296
17	1742	LAKE SPRINGFIELD	283
18	1733	PISTAKEE LAKE	253
19	1754	LAKE HOLIDAY	247
20	1756	GRASS LAKE	244
21	1726	LAKE LOU YAEGER	241
22	1765	OLD BEN MINE RESERVOIR	240
23	1740	SILVER LAKE (HIGHLAND)	229
24	1748	VERMILION LAKE	227
25	1708	LAKE CHARLESTON	225
26	1755	FOX LAKE	212
27	1758	SLOCUM LAKE	210
28	1714	LAKE DECATUR	201

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	1725	LONG LAKE	195
30	1750	WONDER LAKE	183
31	1752	DEPUE LAKE	139


90°08′
90°06′
90°04′
Ill.
Map Location
GRANITE CITY
MADISON
Four Corners
Stallings
Long Lake
D1
Moellenbrocks
HORSESHOE LAKE
02
E1
levee
01
WALKERS ISLAND
Edelhardt Lake
38°42′
HORSESHOE LAKE
Canteen Lake
A1
outlet
Canal
Canteen
Creek
38°40′
Cahokia
State Park Place
HORSESHOE LAKE
Tributary Sampling Site
Lake Sampling Site
0
1
2 Km.
0
Scale
1
Mi.

APPENDIX B

CONVERSIONS 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 ILLINOIS 10/23/75

LAKE CODE 1766 HORSESHOE LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 83.1

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1766A1	83.1	0.53	0.81	1.00	1.03	0.80	0.68	0.40	0.21	0.15	0.16	0.24	0.28	0.52
1766D1	30.8	0.19	0.30	0.36	0.37	0.29	0.25	0.15	0.08	0.05	0.05	0.08	0.10	0.19
1766E1	9.6	0.06	0.09	0.11	0.11	0.09	0.08	0.04	0.02	0.01	0.01	0.02	0.03	0.06
1766ZZ	42.7	0.28	0.41	0.52	0.54	0.42	0.35	0.21	0.11	0.08	0.09	0.13	0.15	0.28

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 83.1 TOTAL FLOW IN = 6.28
SUM OF SUB-DRAINAGE AREAS = 83.1 TOTAL FLOW OUT = 6.28

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1766A1	6	73	1.56	3	0.93				
	7	73	0.26	7	0.23				
	8	73	0.14	5	0.05				
	9	73	0.09	1	0.03				
	10	73	0.09	13	0.25				
	11	73	0.15	4	0.08				
	12	73	0.82	1	0.25				
	1	74	1.70	5	0.48				
	2	74	1.90	16	0.54				
	3	74	1.78	2	1.22	16	1.47		
	4	74	1.13	6	0.88				
	5	74	1.39	4	0.57				
1766D1	8	73	0.05	5	0.02				
	9	73	0.03	1	0.01				
	10	73	0.03	13	0.08				
	11	73	0.05	4	0.03				
	12	73	0.28	1	0.09				
	1	74	0.62	5	0.18				
	2	74	0.71	16	0.20				
	3	74	0.65	2	0.45	16	0.54		
	4	74	0.40	6	0.31				
	5	74	0.51	4	0.21				
1766E1	8	73	0.01	5	0.01				
	9	73	0.01	1	0.00				
	10	73	0.01	13	0.02				
	11	73	0.01	4	0.01				
	12	73	0.08	1	0.03				
	1	74	0.18	5	0.05				
	2	74	0.22	16	0.06				
	3	74	0.20	2	0.14	16	0.16		
	4	74	0.12	6	0.10				
	5	74	0.15	4	0.06				

TRIBUTARY FLOW INFORMATION FOR ILLINOIS 10/23/75

LAKE CODE 1766 HORSESHOE LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1766ZZ	8	73	0.07	5	0.02				
	9	73	0.05	1	0.02				
	10	73	0.05	13	0.14				
	11	73	0.08	4	0.04				
	12	73	0.45	1	0.15				
	1	74	0.91	5	0.25				
	2	74	0.99	16	0.28				
	3	74	0.93	2	0.62	16	0.76		
	4	74	0.62	6	0.48				
	5	74	0.74	4	0.31				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/10/23

176601
38 41 01.0 090 06 48.0
HORSESHOE LAKE
17119 ILLINOIS

11EPALES 2111202
3 0003 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	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
73/05/07	12 45	0000	15.8	9.7	24	560	8.40	78	0.840	2.800	2.180	0.006
73/08/10	16 25	0000	28.1		8	610	9.80	39	0.150	4.000	0.200	0.021
	16 25	0003	27.9	8.2		609	9.20	40	0.210	4.100	0.270	0.023
73/10/17	13 55	0000	17.1		18	536	9.00	111	0.030	3.200	0.130	0.009
	13 55	0002	17.1	10.8		536	9.00	74	0.490	2.900	0.440	0.015

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/07	12 45	0000	0.083	132.9
73/08/10	16 25	0000	0.137	226.9
	16 25	0003	0.180	
73/10/17	13 55	0000	0.093	114.2
	13 55	0002	0.096	

STORET RETRIEVAL DATE 75/10/23

176602
38 42 04.0 090 05 17.0
HORSESHOE LAKE
17119 ILLINOIS

11EPALES 2111202
3 0003 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	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
73/05/07	13 00	0000	16.0	9.5	15	470	8.70	196	0.120	0.500	6.600	0.101
73/08/10	16 45	0000	28.6		12	615	9.20	58	0.170	4.200	0.270	0.029
	16 45	0003	28.6	9.0		616	9.20	59	0.190	4.900	0.270	0.030
73/10/17	14 10	0000	17.6		26	559	8.80	73	2.000	4.100	0.440	0.009
	14 10	0002	17.6	10.8		557	8.80	94	1.380	3.200	0.810	0.014

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/07	13 00	0000	0.145	244.2
73/08/10	16 45	0000	0.253	290.5
	16 45	0003	0.453	
73/10/17	14 10	0000	0.086	84.8
	14 10	0002	0.117	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/10/23

1766A1
38 40 25.0 090 04 45.0
UNNAMED CANAL
17055 7.5 MONKS MOUND
O/HORSESHOE LAKE
ST RT 111 BRDG 2 MI NE OF FAIRMONT CITY
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
73/06/03	09 00		0.670	3.800	0.115	0.058	0.430
73/07/07	10 15			3.700	0.043	0.105	0.380
73/08/05	10 30		0.170	3.800	0.026	0.068	0.330
73/09/01	09 30		0.160	1.890	0.096	0.066	0.300
73/10/13	09 40		0.640	4.000	1.300	0.040	0.200
73/11/04	09 35		0.910	3.300	1.440	0.014	0.130
73/12/01	09 30		1.180	4.000	1.440	0.015	0.120
74/01/05	08 45		1.850	3.900	2.400	0.008	0.040
74/02/16	10 00		1.800	4.600	1.500	0.015	0.140
74/03/02	10 30		2.000	3.700	1.650	0.010	0.165
74/03/16	10 30		2.200	4.800	2.100	0.010	0.300
74/04/06	10 30		2.400	4.200	0.750	0.020	0.160
74/05/04	10 30		1.300	2.500	0.240	0.025	0.210

STORET RETRIEVAL DATE 75/10/23

176601
38 42 30.0 090 04 15.0
UNNAMED STREAM
17 7.5 MONKS MOUND
T/HORSESHOE LAKE
HWY BRDG NE EDGE OF MOLLENBROCKS
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
73/08/05	10 40		0.010K	2.310	0.005K	0.160	0.410
73/09/01	09 40		0.010K	0.780	0.039	0.190	0.450
73/10/13	09 55		0.084	2.520	0.189	0.095	0.347
73/11/04	10 00		0.280	0.800	0.036	0.066	0.175
73/12/01	10 00		0.140	1.200	0.048	0.240	0.470
74/01/05	09 30		0.352	0.600	0.120	0.140	0.170
74/02/16	09 00		0.120	0.600	0.020	0.050	0.120
74/03/02	10 00		0.144	1.100	0.020	0.075	0.260
74/03/16	10 00		0.140	1.000	0.095	0.070	0.190
74/04/06	09 45		0.028	1.000	0.045	0.105	0.225
74/05/04	09 30		0.010	1.600	0.020	0.117	0.420

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/23

1766E1
38 42 09.0 090 06 45.0
UNNAMED DITCH
17 7.5 MONKS MOUND
T/HORSHOE LAKE
RT 162 BRDG S END OF GRANITE CITY
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
73/08/05	10 50		0.028	2.200	0.230	0.088	0.185
73/09/01			0.240	2.500	0.091	0.100	0.230
73/10/13	10 30		0.380	1.260	0.161	0.240	0.410
73/11/04	10 37		0.168	0.400	0.084	0.066	0.155
73/12/01	10 30		0.140	0.900	0.148	0.092	0.450
74/01/05	09 00		0.252	0.900	0.528	0.032	0.170
74/02/16	09 30		0.152	1.500	0.430	0.050	0.340
74/03/02	09 00		0.240	0.900	0.210	0.055	0.310
74/03/16	09 30		0.350	1.400	0.375	0.130	0.510
74/04/06	09 00		0.192	1.625	0.140	0.085	0.551
74/05/04	09 00		0.640	0.700	0.090	0.045	0.300