U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

LAKE SHAWNEE

GREENE COUNTY

OHIO

EPA REGION V

WORKING PAPER No. 410

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
LAKE SHAWNEE
GREENE COUNTY
OHIO
EPA REGION V
WORKING PAPER No. 410

WITH THE COOPERATION OF THE
OHIO ENVIRONMENTAL PROTECTION AGENCY
AND THE
OHIO NATIONAL GUARD

JUNE, 1975

CONTENTS

FOREWORD

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 Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Yougер, Ohio Environmental Protection Agency, 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.

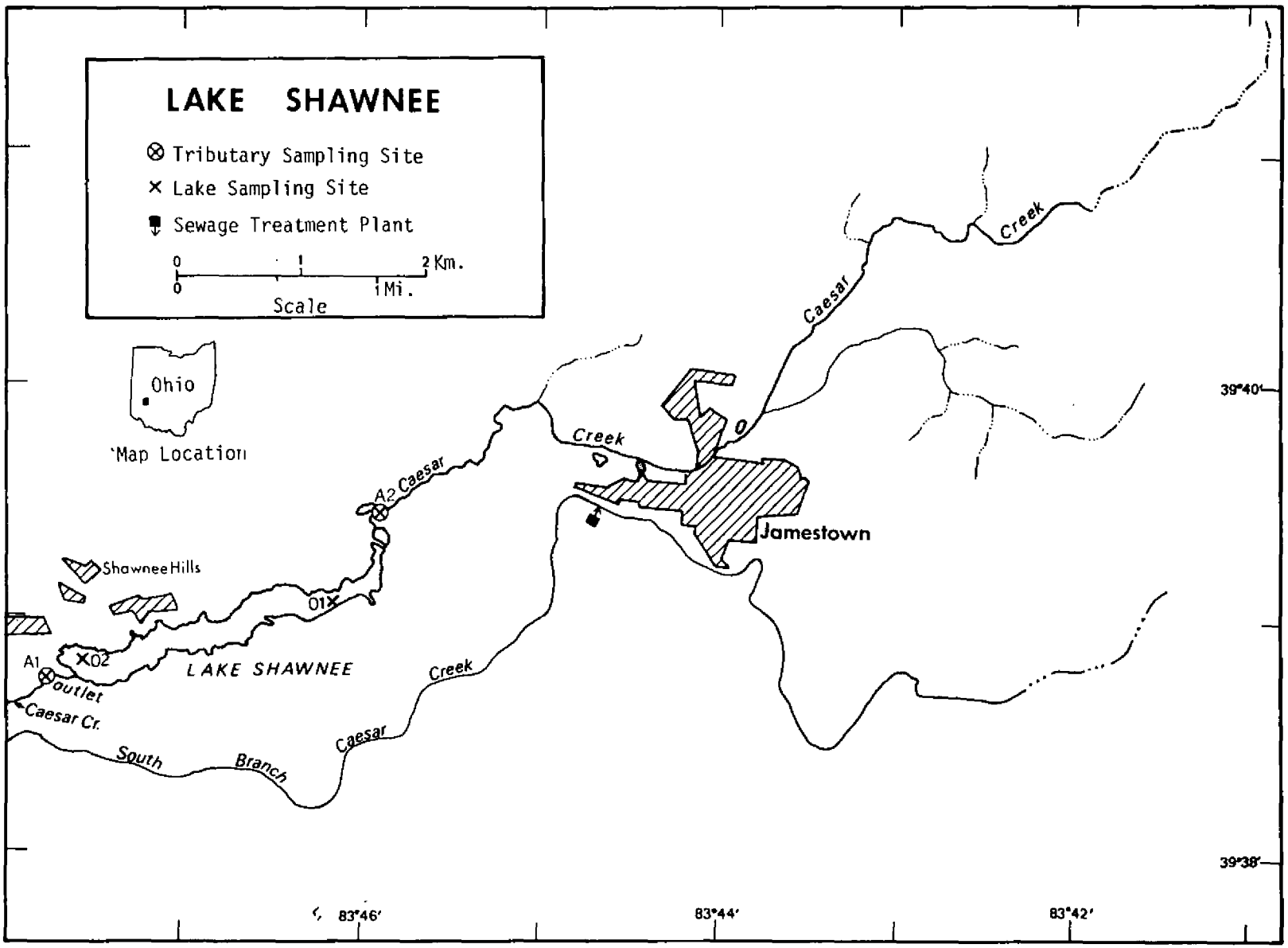
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


LAKE SHAWNEE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
0 1 2 Km.
0 1 Mi.
Scale
Ohio
Map Location
Caesar Creek
A2
Caesar Creek
Jamestown
Shawnee Hills
01
02
A1
Outlet
LAKE SHAWNEE
Caesar Cr.
South Branch
Caesar Creek
39°40'
39°38'
83°46'
83°44'
83°42'

LAKE SHAWNEE

STORET NO. 3933

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Shawnee is eutrophic. It ranked fourteenth in overall trophic quality when the 20 Ohio lakes sampled in 1973 were compared using a combination of six lake parameters*. Seven lakes had less median total phosphorus, five had less median orthophosphorus, 17 had less median inorganic nitrogen, 12 had less mean chlorophyll a, and nine had a greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at station 2 in August, and depletion occurred there in October.

Survey limnologists did not observe algae concentrations or macrophytes, with the exception of an April algal bloom at station 2.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Shawnee was phosphorus limited at the time the sample was collected. This finding is substantiated by the lake data; i.e., the mean N/P ratios were 37/1 or greater on all sampling occasions.

C. Nutrient Controllability:

1. Point sources--During the sampling year, the estimated phosphorus contribution from known point sources was only 1.1% of the total load to Lake Shawnee. This input is attributed to

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* See Appendix A.

the unsewered homes around the lake. The U.S.G.S. map used for determining the number of residences was dated 1968 and showed only fifteen dwellings. However, the Survey limnologists reported the shoreline was almost completely developed with homes. The additional homes probably would add significantly to the phosphorus input to Lake Shawnee.

The present estimated loading of 0.60 $g/m^2/yr$ of total phosphorus is below that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). However, the lake is obviously eutrophic, and all phosphorus inputs to the lake should be minimized to the greatest practicable extent to slow the rate of eutrophication.

2. Non-point sources--About 78% of the total annual phosphorus input to Lake Shawnee was contributed by Caesar Creek, and about 17% is estimated to have been contributed by the immediate drainage and minor tributaries.

The phosphorus export rate of Caesar Creek was a relatively low 15 $kg/km^2/yr$ (see page 10) and compares well with the export rates of two unimpacted tributaries of nearby Deer Creek Reservoir* (21 and 28 $kg/km^2/yr$).

* Working Paper No. 398.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.77 kilometers^2.
2. Mean depth: 2.5 meters.
3. Maximum depth: >7.6 meters.
4. Volume: 1.905 x 10^6 m^3.
5. Mean hydraulic retention time: 73 days.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Caesar Creek	24.3	0.2
Minor tributaries & immediate drainage -	3.1	<0.1
Totals	27.4	0.3

2. Outlet -

Caesar Creek	28.2**	0.3

C. Precipitation***:

1. Year of sampling: 108.4 centimeters.
2. Mean annual: 98.6 centimeters.

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† Table of metric equivalents--Appendix B.
†† Youger, 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

Lake Shawnee 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 two or more depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m or 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 1.8 meters at station 1 and 7.6 meters at station 2.

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 SHAWNEE LAKE
STORET CODE 3933

	1ST SAMPLING (4/28/73)			2ND SAMPLING (8/ 1/73)			3RD SAMPLING (10/ 9/73)		
	2 SITES			2 SITES			2 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	11.8 - 13.1	12.5	12.7	16.8 - 25.3	23.3	24.8	19.7 - 22.5	21.0	21.1
DISS OXY (MG/L)	9.3 - 14.6	10.8	9.7	0.2 - 8.8	4.8	7.1	0.0 - 7.8	3.4	3.0
CNDCTVY (MCROMO)	460. - 520.	478.	473.	404. - 434.	421.	422.	337. - 379.	349.	345.
PH (STAND UNITS)	7.8 - 8.5	8.2	8.2	7.5 - 8.7	8.1	8.3	7.3 - 8.8	8.2	8.2
TOT ALK (MG/L)	166. - 180.	176.	180.	146. - 220.	166.	158.	137. - 163.	145.	142.
TOT P (MG/L)	0.073 - 0.254	0.123	0.085	0.054 - 0.183	0.081	0.062	0.059 - 0.120	0.074	0.067
ORTHO P (MG/L)	0.004 - 0.020	0.010	0.006	0.006 - 0.013	0.009	0.009	0.008 - 0.034	0.015	0.011
NO2+NO3 (MG/L)	3.800 - 4.000	3.867	3.800	0.150 - 2.300	1.838	2.175	0.090 - 0.210	0.147	0.140
AMMONIA (MG/L)	0.040 - 0.080	0.052	0.040	0.100 - 2.680	0.623	0.170	0.130 - 1.210	0.408	0.245
KJEL N (MG/L)	0.800 - 1.200	0.983	0.900	0.700 - 4.200	1.633	1.250	1.300 - 3.500	1.733	1.400
INORG N (MG/L)	3.840 - 4.080	3.918	3.840	2.060 - 2.830	2.462	2.380	0.250 - 1.330	0.555	0.405
TOTAL N (MG/L)	4.600 - 5.200	4.850	4.700	2.900 - 4.350	3.472	3.365	1.390 - 3.620	1.880	1.570
CHLRPYL A (UG/L)	39.1 - 62.2	50.6	50.6	8.6 - 46.3	27.4	27.4	38.8 - 42.4	40.6	40.6
SECCHI (METERS)	0.4 - 0.5	0.5	0.5	0.6 - 0.9	0.7	0.7	0.7 - 0.8	0.8	0.8

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/28/73	1. *Stephanodiscus sp.*	45,654
	2. Flagellates	9,519
	3. *Dactylococcopsis sp.*	1,571
	4. *Cryptomonas sp.*	739
	5. *Gymnodinium sp.*	185
	Other genera	278
	Total	57,946
08/01/73	1. *Oscillatoria sp.*	21,734
	2. *Raphidiopsis sp.*	12,419
	3. *Synedra sp.*	2,734
	4. Flagellates	1,807
	5. *Stephanodiscus sp.*	834
	Other genera	3,430
	Total	42,958
10/09/73	1. *Raphidiopsis sp.*	66,849
	2. *Synedra sp.*	3,564
	3. *Oscillatoria sp.*	2,970
	4. Flagellates	1,650
	5. *Achnanthes sp.*	726
	Other genera	1,846
	Total	77,605

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
04/28/73	01	39.1
	02	62.2
08/01/73	01	8.6
	02	46.3
10/09/73	01	42.4
	02	38.8

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	0.016	0.940	3.0
0.050 P	0.066	0.940	21.0
0.050 P + 1.0 N	0.066	1.940	22.7
1.0 N	0.016	1.940	4.0

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Shawnee was moderately high at the time the sample was collected. The addition of phosphorus alone produced a significant increase in yield over that of the control. Note that addition of nitrogen alone produced an insignificant increase in yield, and phosphorus limitation is indicated.

The lake data substantiate phosphorus limitation. At all sampling times, the mean inorganic nitrogen/orthophosphorus ratios were 37/1 or greater, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio 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 months of February and March when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio 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 shown are those measured minus point-source loads, if any.

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 B-1 and C-1 of nearby Rocky Fork Reservoir and multiplying the means by the ZZ area in km^2.

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* See Working Paper No. 175.

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) -		
Caesar Creek	360	78.2
b. Minor tributaries & immediate drainage (non-point load) -	80	17.4
c. Known municipal STP's - None	-	-
d. Septic tanks* -	5	1.1
e. Known industrial - None	-	-
f. Direct precipitation** -	15	3.3
Total	460	100.0

2. Outputs -

Lake outlet - Caesar Creek 550

3. Net annual P loss - 90 kg.

* Estimate based on 15 seasonal lakeshore dwellings (from 1968 U.S.G.S. quad. map); 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) -		
Caesar Creek	34,480	90.4
b. Minor tributaries & immediate drainage (non-point load) -	2,665	7.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	160	0.4
e. Known industrial - None	-	-
f. Direct precipitation** -	830	2.2
Total	38,135	100.0

2. Outputs -

Lake outlet - Caesar Creek 30,495

3. Net annual N accumulation - 7,640 kg.

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

Tributary	kg P/km^2/yr	kg N/km^2/yr
Caesar Creek	15	1,419

* Estimate based on 15 seasonal lakeshore dwellings (from 1968 U.S.G.S. quad. map); see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loadings:

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	0.60	loss*	49.5	9.9

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Shawnee:

"Dangerous" (eutrophic loading)	0.68
"Permissible" (oligotrophic loading)	0.34

* There was an apparent loss of phosphorus from Lake Shawnee during the sampling year. This may have been due to unknown and unsampled point sources discharging directly to the lake or, more probably, to underestimation of septic tank contributions.

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.

Youger, John, 1975. Personal communication (lake morphometry). OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3928	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

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
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

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
3901	BEACH CITY RESERVOIR	0.122	1.990	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

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 OHIO 1/27/75

LAKE CODE 3933 LAKE SHAWNEE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 28.2

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3933A1	24.2	0.45	0.59	0.74	0.59	0.34	0.16	0.11	0.07	0.05	0.05	0.12	0.27	0.30
3933A2	24.3	0.40	0.51	0.62	0.51	0.28	0.15	0.10	0.07	0.05	0.04	0.11	0.24	0.25
3933ZZ	3.9	0.06	0.08	0.10	0.08	0.05	0.02	0.02	0.01	0.01	0.01	0.02	0.04	0.04

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 28.2
SUM OF SUB-DRAINAGE AREAS = 28.2
TOTAL FLOW IN = 3.56
TOTAL FLOW OUT = 3.58

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3933A1	5	73	0.27	5	0.37				
	6	73	0.59	10	0.21				
	7	73	0.51	15	0.25				
	8	73	0.10	11	0.15				
	9	73	0.08	15	0.01				
	10	73	0.14	21	0.09				
	11	73	0.68	11	0.10				
	12	73	0.82	9	0.57				
	1	74	1.13	12	0.42				
	2	74	0.62	9	0.68	23	0.93		
	3	74	0.54	9	0.59	24	0.31		
	4	74	1.27	20	0.37				
3933A2	5	73	0.23	5	0.31				
	6	73	0.51	10	0.18				
	7	73	0.45	15	0.22				
	8	73	0.09	11	0.13				
	9	73	0.07	15	0.01				
	10	73	0.12	21	0.08				
	11	73	0.57	11	0.09				
	12	73	0.71	9	0.51				
	1	74	0.96	12	0.34				
	2	74	0.54	9	0.59	23	0.82		
	3	74	0.45	9	0.51	24	0.26		
	4	74	1.10	20	0.31				
3933ZZ	5	73	0.04						
	6	73	0.08						
	7	73	0.07						
	8	73	0.01						
	9	73	0.01						
	10	73	0.02						
	11	73	0.08						
	12	73	0.11						
	1	74	0.16						
	2	74	0.09						
	3	74	0.08						
	4	74	0.19						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/27

393301
39 39 05.0 083 46 07.0
SHAWNEE LAKE
39057 OHIO

11EPALES
3

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	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
73/04/28	15 00	0000	11.8		16	470	8.10	170	0.070	1.200	4.000	0.018
	15 00	0006	11.8	14.6		460	7.80	166	0.080	1.200	4.000	0.020
73/08/01	11 25	0000	25.0		24	420	8.50	158	0.140	1.300	2.270	0.006
	11 25	0004	24.9	7.1		425	8.40	158	0.150	0.700	2.200	0.006
73/10/09	17 10	0000	21.3		28	341	8.70	140	0.130	1.400	0.160	0.008
	17 10	0005	21.0	4.0		346	8.00	144	0.310	1.300	0.210	0.017

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/28	15 00	0000	0.167	39.1
	15 00	0006	0.254	
73/08/01	11 25	0000	0.069	8.6
	11 25	0004	0.054	
73/10/09	17 10	0000	0.059	42.4
	17 10	0005	0.068	

STORET RETRIEVAL DATE 75/01/27

393302
39 36 48.0 083 47 33.0
SHAWNEE LAKE
39057 OHIO

11EPALES 2111202
3 0027 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 N02&N03 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/28	15 20	0000	13.1		20	465	8.50	179	0.040	0.900	3.800	0.004
	15 20	0006	13.1	9.9		520	8.20	180	0.040	0.800	3.800	0.004
	15 20	0015	12.9	9.5		480	8.50	180	0.040	0.900	3.800	0.005
	15 20	0023	12.6	9.3		475	8.20	180	0.040	0.900	3.800	0.007
73/08/01	10 25	0000	25.3	8.8	34	404	8.70	146	0.100	1.200	1.960	0.009
	10 25	0005	25.2	7.5		412	8.20	152	0.190	1.000	2.150	0.009
	10 25	0010	24.7			424						
	10 25	0015	23.8	0.3		426	7.60	163	0.480	1.400	2.300	0.013
	10 25	0020	21.1			420						
	10 25	0025	16.8	0.2		434	7.50	220	2.680	4.200	0.150	0.009
73/10/09	16 45	0000	22.5		32	343	8.80	137	0.130	1.500	0.120	0.011
	16 45	0005	21.3	7.8		337	8.40	139	0.180	1.300	0.090	0.009
	16 45	0015	20.5	2.0		348	7.80	146	0.490	1.400	0.180	0.034
	16 45	0022	19.7	0.0		379	7.30	163	1.210	3.500	0.120	0.012

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/28	15 20	0000	0.073	62.2
	15 20	0006	0.073	
	15 20	0015	0.080	
	15 20	0023	0.090	
73/08/01	10 25	0000	0.056	46.3
	10 25	0005	0.055	
	10 25	0015	0.069	
	10 25	0025	0.183	
73/10/09	16 45	0000	0.070	38.8
	16 45	0005	0.060	
	16 45	0015	0.066	
	16 45	0022	0.120	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/03

3933A1
39 38 45.0 083 47 45.0
CEASAR CREEK
39071 7.5 CEDARVILLE
O/LAKE SHAWNEE
JASPER RD BRDG 2.5 MI W OF JAMESTOWN
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
73/05/05	14 00		2.500	1.600	0.037	0.005K	0.030
73/06/10	11 15		2.000	0.660	0.046	0.010	0.030
73/07/15	14 00		2.400	1.470	0.154	0.029	0.050
73/08/11	19 30		1.440	1.470		0.007	0.057
73/09/15	15 16		0.290	0.920	0.076	0.008	0.050
73/10/21	13 30		0.370	1.650	0.210	0.012	0.020
73/11/11	14 55		0.384	1.550	0.168	0.012	0.045
73/12/09	13 40		2.300	1.600	0.156	0.036	0.095
74/01/12	14 25		3.200	0.600	0.012	0.012	0.060
74/02/09			3.080	1.000	0.015	0.010	0.075
74/02/23	14 26		2.560	1.600	0.015	0.010	0.090
74/03/09	15 30		2.500	1.600	0.030	0.005K	0.120
74/04/20	13 00		0.160	3.300	0.050	0.017	0.035

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3933A2
39 39 28.0 083 45 50.0
CEASAR CREEK
39 7.5 CEDARVILLE
1/LAKE SHAWNEE
QUARRY RD BRDG 1 MI W OF JAMESTOWN
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
73/05/05	14	30	5.000	0.290	0.022	0.006	0.020
73/06/10	11	32	3.600	0.720	0.025	0.007	0.015
73/07/15	14	05	6.300	1.470	0.270	0.039	0.110
73/08/11	19	35	1.600	1.150	0.052	0.019	0.095
73/09/15	15	29	0.071	0.800	0.140	0.020	0.080
73/10/21	13	45	0.890	0.350	0.026	0.009	0.018
73/11/11	15	10	1.800	0.550	0.028	0.012	0.020
73/12/09	13	50	4.100	0.500	0.032	0.020	0.035
74/01/12	14	35	4.300	0.300	0.008	0.012	0.020
74/02/09			4.800	0.700	0.015	0.020	0.020
74/02/23	14	37	5.100	0.400	0.005K	0.020	0.055
74/03/09	15	40	4.800	0.600	0.015	0.020	0.100
74/03/24	12	23	3.300	0.500	0.015	0.010	0.015
74/04/20	13	05	3.200	2.900	0.040	0.005	0.015

K VALUE KNOWN TO BE
LESS THAN INDICATED