U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

WOLF LAKE

BELTRAMI AND HUBBARD COUNTIES

MINNESOTA

EPA REGION V

WORKING PAPER No. 136

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

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WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

NOVEMBER, 1974

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 Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

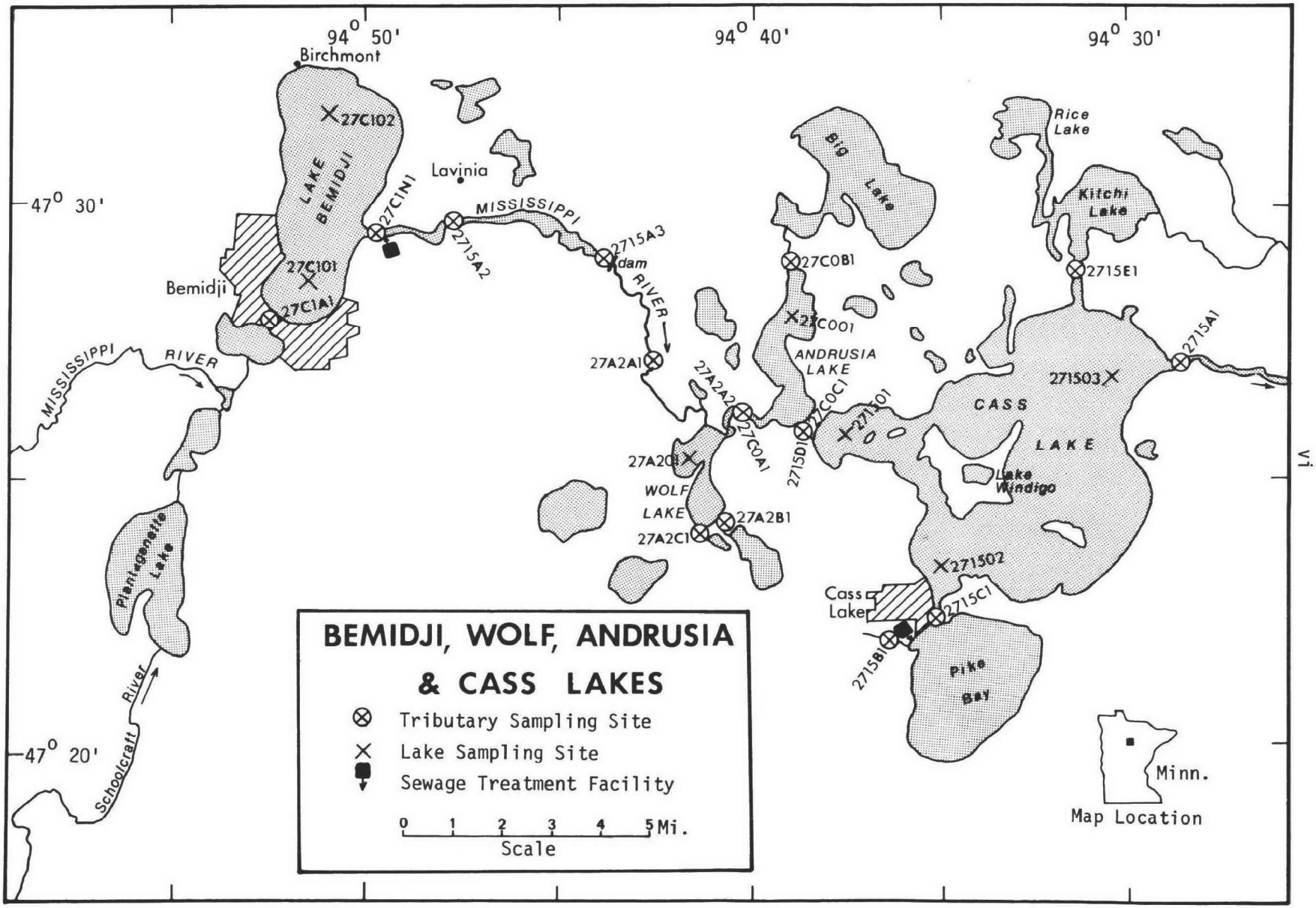
NATIONAL EUTROPHICATION SURVEY

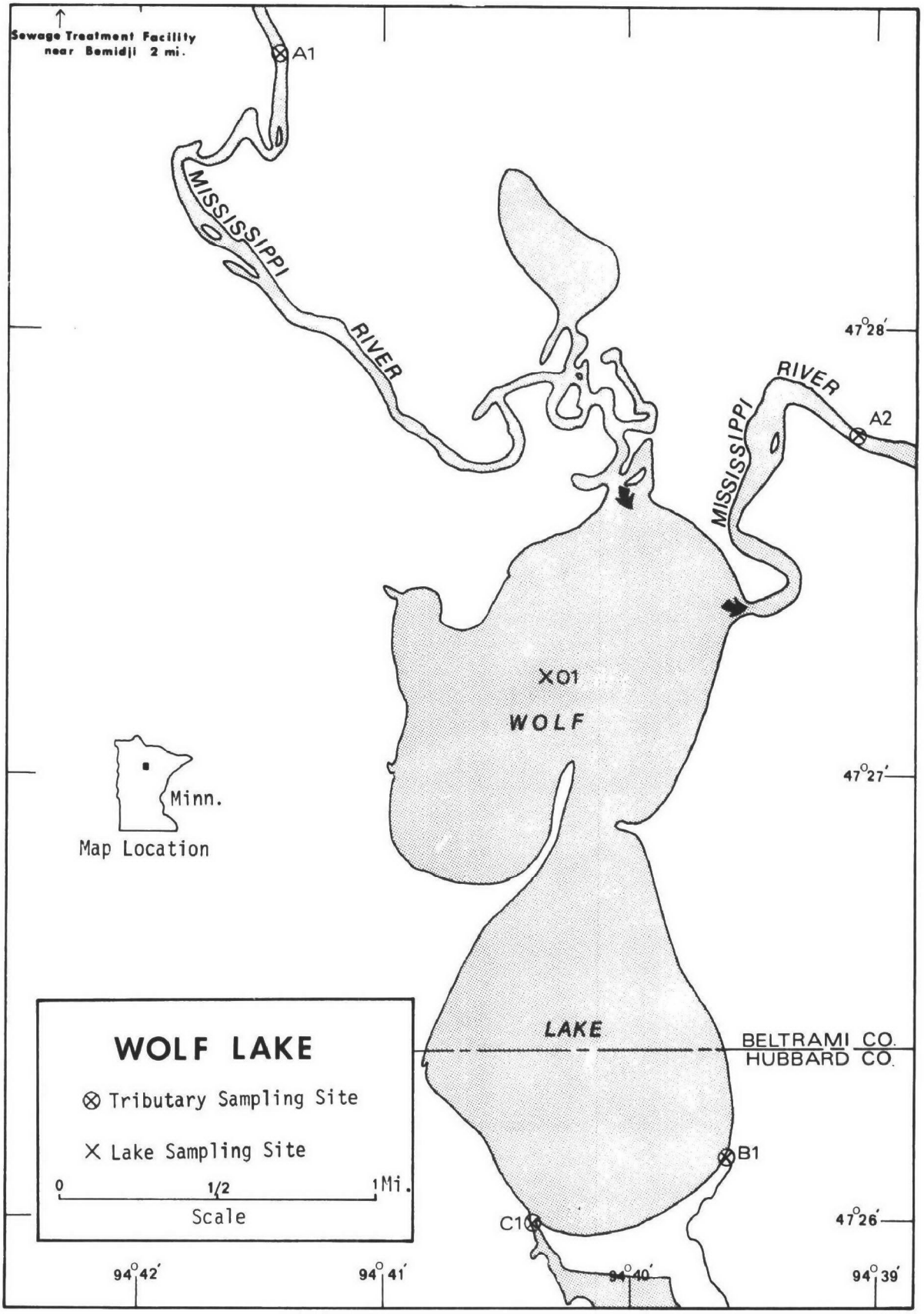
STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


94° 50'
94° 40'
94° 30'
47° 30'
47° 20'
Birchmont
Lavinia
Bemidji
LAKE BEMIDJI
27C102
27C101
27C1A1
27C1N1
MISSISSIPPI
2715A2
2715A3
dam
RIVER
MISSISSIPPI RIVER
27A2A1
27A2A2
27A2C1
WOLF LAKE
27A2B1
27A2C1
27C0A1
27C0B1
27C001
ANDRUSIA LAKE
27C0C1
2715D1
271501
271503
CASS LAKE
Lake Windigo
271502
2715A1
2715E1
Rice Lake
Big Lake
Kitchi Lake
Cass Lake
2715C1
2715B1
Pike Bay
Plantagenette Lake
Schoolcraft River
BEMIDJI, WOLF, ANDRUSIA & CASS LAKES
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 4 5 Mi.
Scale
Minn.
Map Location


Sewage Treatment Facility
near Bemidji 2 mi.
A1
MISSISSIPPI RIVER
47°28′
MISSISSIPPI RIVER
A2
X01
WOLF
LAKE
47°27′
Minn.
Map Location
WOLF LAKE
⊗ Tributary Sampling Site
× Lake Sampling Site
0 1/2 1 Mi.
Scale
BELTRAMI CO.
HUBBARD CO.
B1
C1
47°26′
94°42′
94°41′
94°40′
94°39′

WOLF LAKE

STORET NO. 27A2

I. CONCLUSIONS

A. Trophic Condition:

Survey data and the records of others (Lang, et al., 1969) show that Wolf Lake is eutrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 35 had less mean total phosphorus, 29 had less mean dissolved phosphorus, but only six had less mean inorganic nitrogen. Of the 80 lakes studied, 55% had less mean chlorophyll a, and 49% had greater Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred during the July sampling.

Wolf Lake has been chemically treated a number of times for control of rooted aquatic vegetation and filamentous algae (Bonnema and Johnson, 1972).

B. Rate-Limiting Nutrient:

Algal assay results show nitrogen limitation at the time the sample was collected in October, 1972. The lake data indicate nitrogen limitation at the other sampling times as well.

C. Nutrient Controllability:

1. Point sources--The phosphorus removal facilities planned for the Bemidji wastewater treatment plant will meet

a mean effluent limit of 1 mg/l (Schilling, 1974). When operational, these facilities will reduce the total phosphorus load to Wolf Lake by about 44%. This will reduce the loading rate from the present 57 lbs/acre/yr (6.4 $g/m^2/yr$) to 32 lbs/acre/yr or 3.6 $g/m^2/yr$.

The 3.6 $g/m^2/yr$ rate is still about twice the rate proposed by Vollenweider (in press) as a dangerous or eutrophic rate (see page 14). However, because of the proximity of the Wolf Lake outlet to the inlet (see map, page vii), it is believed a substantial degree of short-circuiting of nutrients occurs; i.e., under most flow conditions, it is probable that much of the incoming water (with nutrients) flows more or less directly to the outlet. Note that only 12% of the phosphorus load and none of the nitrogen load was retained in the lake during the year.

It is concluded that the degree of phosphorus removal to be instituted at the Bemidji waste treatment plant will result in improvement of the trophic condition of Wolf Lake.

2. Non-point sources--It is noted that the total phosphorus load measured at the Wolf Lake inlet station (27A2A1) was about 26% greater than can be accounted for by upstream loads. During the year, the Bemidji STP discharged 29,720 lbs of phosphorus, and 16,290 lbs were measured in the Lake Bemidji outlet for a

total of 46,020 lbs. Add to this the 1,520 lbs expected from areal sources between the Lake Bemidji outlet and the Wolf Lake inlet (38 mi^2 at 40 $lbs/mi^2/yr$ [the rate measured at the Lake Bemidji inlet]), and the expected load at the Wolf Lake inlet would be 47,540 lbs for the year. However, the load measured at the Wolf Lake inlet was 59,710 lbs of phosphorus or about 12,000 lbs more than expected.

Personnel of the Minnesota Pollution Control Agency know of no intervening point sources or nutrient sources such as feedlots, but they report an 8- to 12-foot fluctuation in water level at the Otter Tail Power Company hydroelectric dam at station 2715A3 (Schilling, op. cit.). This fluctuation may have resulted in resolubilization of previously sedimented phosphorus and thus the excess load at the Wolf Lake inlet station.

The phosphorus exports in the Wolf Lake drainage were very similar to those of the drainages of the other lakes in this upper Mississippi River chain of lakes. The relatively low exports probably result from the near-headwaters location of the lakes as well as land-use practices in this largely-forested area of Minnesota.

In all, it is estimated that non-point sources contributed about 51% of the total phosphorus load reaching Wolf Lake during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 1,051 acres.
2. Mean depth: 28 feet.
3. Maximum depth: 58 feet.
4. Volume: 29,428 acre/feet.
5. Mean hydraulic retention time: 37 days.

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

1. Tributaries -

Name	Drainage area*	Mean flow*
Mississippi River	668.0 mi^2	396.2 cfs
Little Wolf Lake outlet	10.7 mi^2	5.8 cfs
Mud Lake outlet	0.6 mi^2	0.3 cfs
Minor tributaries & immediate drainage -	4.8 mi^2	2.2 cfs
Totals	684.0 mi^2**	404.5 cfs

2. Outlet -

Mississippi River	684.0 mi^2	404.5 cfs

C. Precipitation***:

1. Year of sampling: 26.7 inches.
2. Mean annual: 23.8 inches.

† DNR lake survey map (1941); mean depth by random-dot method.
* Drainage areas are accurate within ±5%; mean daily flow are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Wolf Lake, one of a chain of upper Mississippi River lakes (see map, page vi), 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 a number of depths at the one station on the lake (see map, page vii). During each visit two depth-integrated (15 feet to surface) samples were collected for phytoplankton identification and enumeration and for chlorophyll *a* analysis; and during the last visit, a single five-gallon depth-integrated sample was collected for algal assays. The maximum depth sampled was 28 feet.

The results obtained are presented in full in Appendix B, 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 B.

A. Physical and chemical characteristics:

FALL VALUES

(10/21/72)

Parameter	Minimum	Mean	Median	Maximum
Temperature (Cent.)	6.1	6.2	6.3	6.3
Dissolved oxygen (mg/l)	10.0	10.7	10.2	12.0
Conductivity (μmhos)	248	251	248	260
pH (units)	8.3	8.3	8.3	8.3
Alkalinity (mg/l)	143	146	146	147
Total P (mg/l)	0.050	0.063	0.061	0.080
Dissolved P (mg/l)	0.021	0.026	0.025	0.034
NO_2 + NO_3 (mg/l)	0.020	0.032	0.030	0.050
Ammonia (mg/l)	0.040	0.052	0.055	0.060

ALL VALUES

Secchi disc (inches)	33	47	60

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/11/72	1. Aphanotheca	8,986
	2. Dinobryon	399
	3. Anabaena	181
	4. Fragilaria	109
	5. Tabellaria	36
	Other genera	72
	Total	9,783
09/08/72	1. Anabaena	987
	2. Microcystis	475
	3. Flagellates	264
	4. Oscillatoria	158
	5. Melosira	128
	Other genera	656
	Total	2,668
10/21/72	1. Melosira	8,163
	2. Fragilaria	1,566
	3. Anabaena	1,144
	4. Stephanodiscus	361
	5. Flagellates	361
	Other genera	935
	Total	12,530

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)
07/11/72	01	13.0
09/08/72	01	12.7
10/21/72	01	25.8

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	0.022	0.056	1.6
0.005 P	0.027	0.056	2.0
0.010 P	0.032	0.056	2.1
0.020 P	0.042	0.056	1.9
0.050 P	0.072	0.056	2.3
0.050 P + 10.0 N	0.072	10.056	26.4
"10.0 N"	0.022	0.056	1.7

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity was moderate at the time the sample was collected; however, there was a loss of 51 µg/l of inorganic nitrogen and 21 µg/l of dissolved phosphorus between the time the sample was collected and the assay was begun. Had this loss not occurred, the expected control yield would have been about 3 mg/l.

The lack of significant yield response to increasing levels of orthophosphorus until nitrogen was also added shows that the lake was nitrogen limited when sampled. Through an oversight, no nitrogen was added to the "10.0 N" flasks; and, therefore, the yield was the same as the control.

The lake data indicate nitrogen limitation at all sampling times (the July N/P = 9/1; the September N/P = 12/1; and the October N/P = 3/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, from October, 1972 through September, 1973, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vii), except for the high runoff month of April, when two samples were collected, and the colder months when samples were omitted at most stations because of low flows.

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

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient loads, in $lbs/mi^2/year$, in tributaries of nearby Leech Lake at stations 2746C-1, D-1, F-1, G-1, H-1, and J-1 and multiplying the means by the ZZ area in mi^2.

The operator of the Bemidji wastewater treatment plant provided monthly effluent samples and corresponding flow data. In this report it is assumed that all of the nutrients discharged at the Bemidji plant reached Wolf Lake.

In the loading tables that follow, the loads attributed to the Mississippi River inlet are those measured at station A-1 minus the Bemidji loads (but see discussion on pages 2 and 3).

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* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served*	Treatment	Mean Flow (mgd)	Receiving Water
Bemidji	11,400	trickling filter	0.942	Mississippi River

2. Known industrial - None

* 1970 Census.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Mississippi River	29,980	49.7
Little Wolf Lake outlet	220	0.4
Mud Lake outlet	10	<0.1
b. Minor tributaries & immediate drainage (non-point load) -	130	0.2
c. Known municipal -		
Bemidji	29,730	49.3
d. Septic tanks* -	80	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	160	0.3
Total	60,310	100.0

2. Outputs -

Lake outlet - Mississippi River 52,790

3. Net annual P accumulation - 7,520 pounds

* Estimated 74 dwellings, 4 resorts, and 1 camp 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) -		
Mississippi River	433,020	76.5
Little Wolf Lake outlet	8,320	1.5
Mud Lake outlet	600	0.1
b. Minor tributaries & immediate drainage (non-point load) -	6,000	1.1
c. Known municipal -		
Bemidji	105,010	18.6
d. Septic tanks* -	2,800	0.5
e. Known industrial - None	-	-
f. Direct precipitation** -	10,130	1.7
Total	565,880	100.0

2. Outputs -

Lake outlet - Mississippi River 733,380

3. Net annual N loss - 167,500 pounds

* Estimated 74 dwellings, 4 resorts, and 1 camp on shoreline; see Working Paper No. 1.
** See Working Paper No. 1.

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

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Mississippi River inlet	45	648
Little Wolf Lake outlet	21	778
Mud Lake outlet	17	1,000

E. Yearly Loading Rates:

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

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	57.4	7.2	538.4	loss*
grams/m^2/yr	6.43	0.80	60.3	-

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

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

* The apparent loss of nitrogen during the sampling year may have resulted from nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, or insufficient sampling. However, a similar nitrogen loss has been observed at Shagawa Lake which has been studied intensively by EPA's Eutrophication Research and Lake Restoration Branch.

V. LITERATURE REVIEWED

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VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27A2 WOLF LAKE

TOTAL DRAINAGE AREA OF LAKE 684.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27A2A1	668.00	248.05	190.66	230.54	910.48	936.74	699.40	372.56	214.00	280.15	262.64	209.14	196.49	396.18
27A2A2	684.00	248.07	192.62	233.48	933.90	958.22	715.02	380.37	218.88	286.01	268.49	214.02	199.43	404.32
27A2B1	10.70	1.79	1.16	2.41	13.20	15.60	12.80	6.10	2.71	5.10	3.99	2.56	2.25	5.82
27A2C1	0.60	0.06	0.02	0.14	0.84	0.79	0.74	0.31	0.06	0.11	0.16	0.09	0.08	0.28
27A2ZZ	4.77	0.86	0.45	1.21	5.46	5.66	5.75	2.21	0.72	1.72	1.09	0.64	0.82	2.22

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 684.00
SUM OF SUB-DRAINAGE AREAS = 684.07
TOTAL FLOW IN = 4850.44
TOTAL FLOW OUT = 4848.50

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27A2A1	10	72	248.00	14	327.00				
	11	72	203.00	5	203.00				
	12	72	304.00	10	295.00				
	1	73	280.00	20	244.00				
	2	73	210.00	18	210.00				
	3	73	647.00	17	1941.00				
	4	73	220.00	1	233.00	14	202.00		
	5	73	218.00	19	201.00				
	6	73	202.00						
	7	73	189.00	8	168.00				
	8	73	213.00	11	213.00				
	9	73	315.00	16	365.00				
27A2A2	10	72	253.00	14	334.00				
	11	72	208.00	5	208.00				
	12	72	308.00	10	299.00				
	1	73	280.00	20	244.00				
	2	73	212.00	18	212.00				
	3	73	655.00	17	1965.00				
	4	73	239.00	1	253.00	14	220.00		
	5	73	225.00	19	205.00				
	6	73	211.00						
	7	73	183.00	8	163.00				
	8	73	202.00	11	202.00				
	9	73	300.00	16	348.00				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2742 [illegible] LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2742R1	10	72	3.[illegible]	14	4.80				
	11	72	2.[illegible]	[illegible]	2.40				
	12	72	[illegible]	10	3.30				
	1	73	[illegible]	20	1.70				
	2	73	1.24	12	1.20				
	3	73	6.38	17	20.00				
	4	73	4.33	1	4.60	14	4.00		
	5	73	4.22	19	3.80				
	6	73	3.50						
	7	73	2.[illegible]	6	2.40				
	8	73	3.73	11	3.80				
	9	73	4.11	16	4.80				
2742C1	10	72	[illegible]	14	0.30				
	11	72	0.14	5	0.10				
	12	72	0.08	10	0.08				
	1	73	[illegible]	20	0.10				
	2	73	[illegible]	13	0.02				
	3	73	0.35	17	1.10				
	4	73	0.26	1	0.30	14	0.20		
	5	73	.25	19	0.20				
	6	73	0.21						
	7	73	[illegible]	6	0.14				
	8	73	0.[illegible]	11	0.23				
	9	73	0.25	16	0.29				
2742Z7	10	72	1.[illegible]	14	1.30				
	11	72	[illegible]	5	0.60				
	12	72	1.24	10	1.20				
	1	73	0.45	20	0.80				
	2	73	[illegible]	12	0.50				
	3	73	3.30	17	4.30				
	4	73	1.44	1	2.10	14	1.40		
	5	73	1.[illegible]	14	1.71				
	6	73	1.57						
	7	73	1.19	6	1.10				
	8	73	1.[illegible]	11	1.70				
	9	73	1.[illegible]	16	2.10				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

27A201
47 25 30.0 094 40 30.0
WOLF LAKE
27 MINNESOTA

11EPALES
4

2111202
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	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
72/07/11	17 30	0000			33							
	17 30	0004	24.3	13.0		270	8.70	137	0.070	0.080	0.038	0.023
	17 30	0015	19.4	6.0		300	8.00	143	0.070	0.080	0.027	0.012
	17 30	0020	17.0	7.0		340	7.40	164	0.050	0.100	0.042	0.017
	17 30	0027	11.4	0.4		355	7.20	169	0.110	0.630	0.249	0.078
72/09/08	18 00	0000			60	280	8.10	139	0.060	0.150	0.047	0.018
	18 00	0004	18.4	6.7		280	8.10	139	0.060	0.140	0.050	0.018
	18 00	0015	17.4	6.4		283	7.90	139	0.050	0.190	0.037	0.015
	18 00	0020	17.4	3.3		290	7.50	146	0.050	0.490	0.071	0.043
	18 00	0027	16.6	5.7		293	7.50	148	0.050	0.490	0.075	0.045
72/10/21	11 40	0000			48	260	8.30	143	0.040	0.060	0.050	0.021
	11 40	0004	6.3	12.0		248	8.30	145	0.050	0.060	0.066	0.025
	11 40	0015	6.3	10.0		248	8.30	147	0.020	0.040	0.056	0.026
	11 40	0028	6.1	10.2		248	8.30	147	0.020	0.050	0.080	0.034

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/11	17 30	0000	13.0J
72/09/08	18 00	0000	12.7J
72/10/21	11 40	0000	25.8J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/30

27A2A1 LS27A2A1
47 27 00.0 094 42 30.0
MISSISSIPPI
27 CO #4. SHEET #1
I/WOLF LAKE
CO HWY 8 BRDG 2 MI UPSTREAMWOLF LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	12 10		0.020	0.550	0.034	0.042	0.059
72/11/05	11 30		0.015	0.560	0.070	0.053	0.082
73/03/17	10 47		0.120	0.700	0.092	0.072	0.105
73/04/01	14 40		0.031	0.480	0.010	0.012	0.050
73/04/14	09 58		0.010K	0.900	0.005	0.010	0.055
73/05/19	10 41		0.010K	0.600	0.009	0.020	0.055
73/06/03	10 40		0.010K	0.560	0.091	0.033	0.170
73/07/08	10 50		0.010K	0.750	0.032	0.066	0.075
73/09/11	09 10		0.015	0.900	0.020	0.048	0.085
73/09/15	10 25		0.074	0.860	0.040	0.055	0.085

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 72/12/20

27A2A2 27CCA1
47 26 30.0 094 40 30.0
MISSISSIPPI RIVER
27 CO #4, SHEET #1
O/WOLF LAKE
CO HWY 8 BRDG .75 MI UPSTRMLK ANDRUSIA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3&NO2 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
72/10/14	12 00		0.034	0.325	0.087	0.013	0.056
72/11/05	11 25		0.013	1.616	0.120	0.014	0.039
73/01/20	10 50		0.044	0.780	0.140	0.064	0.045
73/03/17	09 42		0.176	1.600	0.140	0.069	0.095
73/04/01	14 20		0.049	0.600	0.026	0.008	0.060
73/04/14	09 54		0.010K	0.245	0.005K	0.009	0.065
73/06/03	10 30		0.012K	0.930	0.056	0.013	0.035
73/07/04			0.012K	0.905	0.013	0.018	0.045
73/08/11	09 15		0.015	1.325	0.110	0.023	0.075
73/09/15	13 20		0.014	1.200	0.115	0.060	0.145

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A2B1 LS27A2B1
47 24 30.0 094 40 30.0
LITTLE WOLF LK/WOLF LK CONNECT
27 CO #29
T/WOLF LAKE
AT 2ND XING NEAR WOLF LAKE SHORE
11FPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT K JEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14			0.038	0.483	0.038	0.006	0.022
72/11/05	11 50		0.012	0.400	0.073	0.010	0.018
73/03/17	10 04		0.086	0.750	0.040	0.005K	0.010
73/04/01	14 40		0.042	1.320	0.033	0.005K	0.005K
73/04/14	10 15		0.017	0.440	0.009	0.005K	0.010
73/05/19	13 00		0.015	0.420	0.007	0.005K	0.030
73/06/03	11 00		0.010K	0.660	0.017	0.005K	0.035
73/07/03	11 05		0.014	1.800	0.034	0.008	0.025
73/08/11	09 23		0.010K	0.700	0.030	0.007	0.030
73/09/16	10 35		0.046	0.340	0.035	0.011	0.020

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A2C1 LS27A2C1
47 24 00.0 094 41 00.0
MUD LK / WOLF LAKE CONNECTION
27 CO #11
T/WOLF LAKE
AT SECONDARY ROAD CROSSING
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
72/10/14			0.048	0.625	0.022	0.005K	0.021
72/11/05	11 45		0.039	0.470	0.084	0.008	0.014
72/12/10	11 40		0.010K	0.710	0.140	0.007	0.018
73/01/20	11 05		0.010K	0.720	0.220	0.005K	
73/02/18	13 10		0.027	1.890	0.300	0.007	0.025
73/03/17	10 00		0.054	1.260	0.420	0.010	0.025
73/04/01	14 50		0.024	0.900	0.132	0.009	0.025
73/04/14	10 10		0.024	0.480	0.035	0.005K	0.015
73/05/19	10 58		0.012	1.200	0.021	0.005K	0.025
73/06/03	10 50		0.010K	0.590	0.033	0.005K	0.015
73/07/09	11 00		0.034	2.600	0.930	0.005K	0.035
73/08/11	09 20		0.032	0.540	0.037	0.008	0.030
73/09/16	10 30		0.052	2.500	0.092	0.009	0.025

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A251 TF27A251 P011490
47 29 30.0 094 50 00.0
BEMIDJI
27 CO #4 SHEET #1
T/WOLF LAKE
MISSISSIPPI 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	11 00								
CP(T)-			1.250	39.900	22.000	5.400	8.400	0.785	0.984
73/01/29	13 00								
73/02/28	10 30								
CP(T)-			1.260	41.000	24.000	8.200	9.000	1.000	0.900
73/02/28	12 30								
73/03/30	10 30								
CP(T)-			2.300	26.000	11.600	9.200	9.600	0.900	0.866
73/03/30	13 00								
73/04/30	11 00								
CP(T)-			2.100	30.000	13.200	6.200	10.300	1.000	0.846
73/04/30	13 00								
73/05/31	11 00								
CP(T)-			2.820	42.000	25.100	8.890	11.500	1.350	1.000
73/05/31	13 00								
73/06/29	11 00								
CP(T)-			2.200	31.000	16.400	6.600	9.900	1.200	1.200
73/06/29	13 00								
73/07/31	11 00								
CP(T)-			2.800	26.000	7.000	3.300	9.680	1.000	1.000
73/07/31	13 00								
73/09/04	10 30								
CP(T)-			2.080	28.600	8.100			1.200	1.000
73/09/04	12 30								
73/10/01	11 00								
CP(T)-			1.050	31.500	20.000	7.000	10.500	0.925	0.900
73/10/01	13 00								
73/10/31	12 00								
CP(T)-			0.540	40.000	18.000	6.000	12.000	0.950	0.900
73/10/31	14 00								
73/11/30	11 00								
CP(T)-			0.060	49.000	28.000	4.900	11.000	0.870	0.790
73/11/30	13 00								
74/01/02	11 00								
CP(T)-			2.000	31.500	21.000	10.600	11.500	0.900	0.977
74/01/02	13 00								

STORET RETRIEVAL DATE 74/10/30

274251 TF274251 P011490
47 29 30.0 094 50 00.0
BE 11DJI
27 CO #4 SHEET #1
T/WOLF LAKE
MISSISSIPPI 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
74/02/04	10 00								
CP(T)-			2.320	17.600	17.600	9.600	12.500	0.950	0.932
74/02/04	12 00								