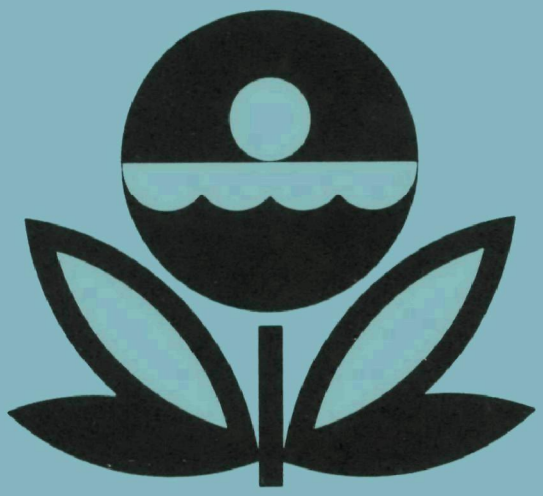
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT
ON
CARRIGAN LAKE
WRIGHT COUNTY
MINNESOTA
EPA REGION V
WORKING PAPER No. 139

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

☆ GPO—697-032

REPORT

ON

CARRIGAN LAKE

WRIGHT COUNTY

MINNESOTA

EPA REGION V

WORKING PAPER No. 139

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

JULY, 1975

CONTENTS

F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the 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.

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* The lake discussed in this report was included in the National Eutrophication Survey as a water body of interest to the Minnesota Pollution Control Agency. Tributaries were not sampled, and this report relates only to the data obtained from lake sampling.

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.

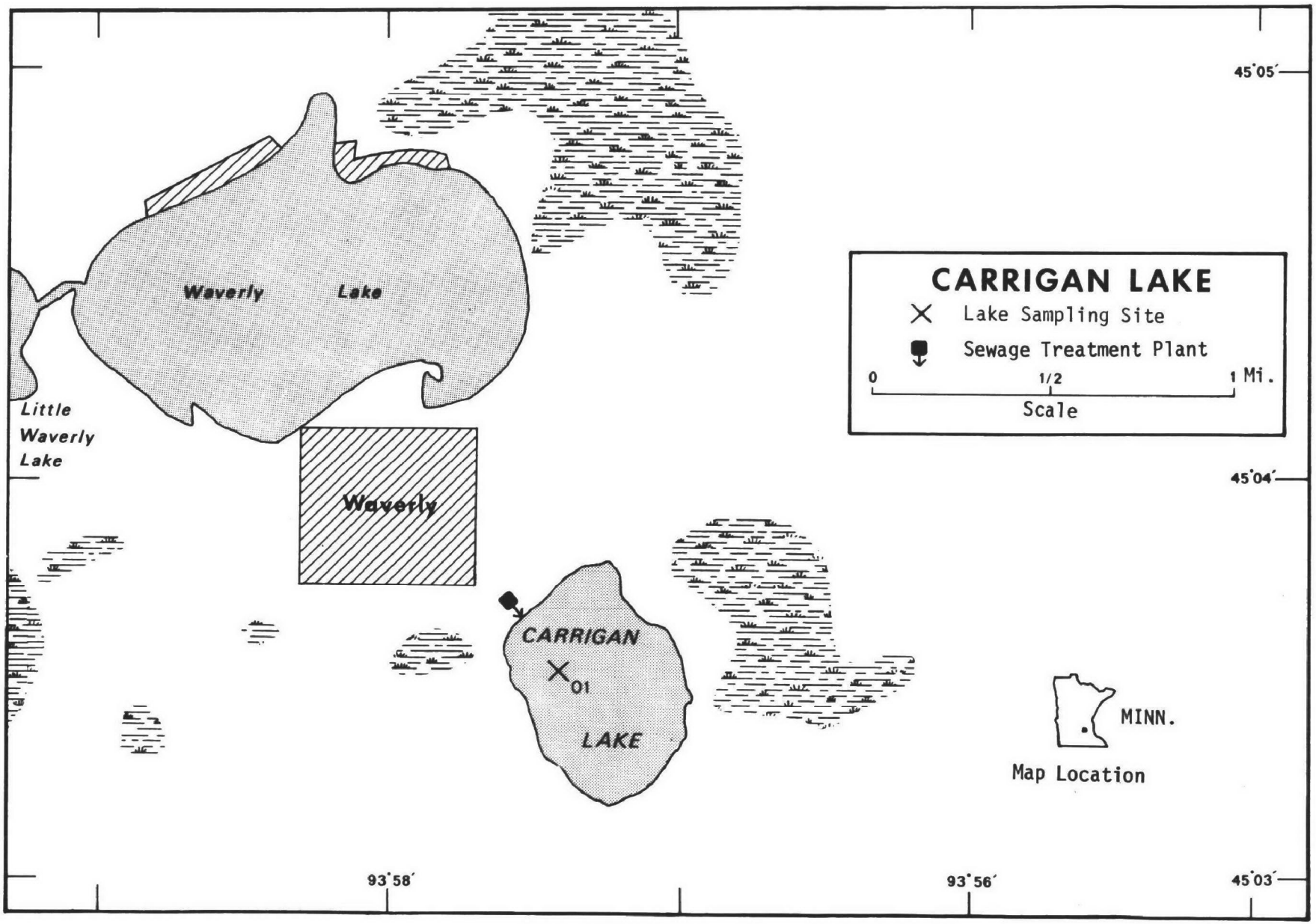
NATIONAL EUTROPHICATION SURVEY

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


CARRIGAN LAKE
Lake Sampling Site
Sewage Treatment Plant
0
1/2
1 Mi.
Scale
Waverly Lake
Little Waverly Lake
Waverly
CARRIGAN
01
LAKE
MINN.
Map Location
45°05'
45°04'
45°03'
93°58'
93°56'
N

CARRIGAN LAKE

STORET NO. 2714

I. INTRODUCTION

Carrigan Lake was included in the National Eutrophication Survey as a water body of interest to the Minnesota Pollution Control Agency. Wastewater treatment plant samples were provided by the Village of Waverly (Appendix B); however, tributaries were not sampled, and other nutrient sources were not evaluated. Therefore, this report primarily relates to the lake sampling data.

II. CONCLUSIONS

A. Trophic Condition:

Survey data show Carrigan Lake is hypereutrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 52 had less mean total phosphorus, 54 had less mean dissolved phosphorus, and 29 had less mean inorganic nitrogen. Of the 80 Minnesota lakes sampled, 66 had less mean chlorophyll a, and 70 had greater and three had the same mean Secchi disc transparency.

Survey limnologists noted this shallow lake was overgrown with rooted aquatic plants and observed algal blooms in progress in August and October, 1972.

B. Rate-Limiting Nutrient:

The algal assay results indicate Carrigan Lake was nitrogen limited at the time the sample was taken (10/26/72). The lake data indicate nitrogen limitation in June and August as well.

C. Point-Source Nutrient Contribution:

Based on analyses of effluent samples from the activated sludge plant serving the Village of Waverly*, this point source contributed 380 pounds of total phosphorus and 810 pounds of total nitrogen directly to Carrigan Lake during the Survey sampling year.

* Anonymous, 1974.

III. LAKE CHARACTERISTICS

A. Morphometry:

1. Surface area: 162 acres*.
2. Mean depth: unknown.
3. Maximum depth: >4 feet (based on Survey sampling).
4. Volume: unknown.

B. Precipitation**:

1. Year of sampling: 26.9 inches.
2. Mean annual: 25.6 inches.

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* Anonymous, 1968.
** See Working Paper No. 1, "Survey Methods, 1972".

IV. LAKE WATER QUALITY SUMMARY

Carrigan Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from one or two depths at a single station on the lake (see map, page vi). During each visit, a single depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration, and a similar sample was collected for chlorophyll a analysis. During the last visit, a single five-gallon depth-integrated sample was taken for algal assays. The maximum depth sampled was 4 feet.

The results obtained are presented in full in Appendix A, and the data for the fall sampling period are summarized in the following table. 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 A.

A. Physical and chemical characteristics:

Parameter	FALL VALUES (10/26/72) Surface Sample Only
Temperature (Cent.)	5.0
Dissolved oxygen (mg/l)	13.2
Conductivity (μmhos)	600
pH (units)	9.1
Alkalinity (mg/l)	188
Total P (mg/l)	0.810
Dissolved P (mg/l)	0.570
NO_2 + NO_3 (mg/l)	0.080
Ammonia (mg/l)	0.120

	ALL VALUES			
	Minimum	Mean	Median	Maximum
Secchi disc (inches)	8	11	12	13

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/30/72	1. Dinobryon	5,036
	2. Mallomonas	344
	3. Schroederia	266
	4. Cocconeis	45
	5. Fragilaria	18
	Total	5,709
08/29/72	1. Anabaena	21,818
	2. Merismopedia	2,727
	3. Mecrocystis	455
	4. Mallomonas	455
	5. Nitzschia	182
	Total	25,637
10/26/72	1. Cyclotella	35,152
	2. Dinobryon	5,758
	3. Flagellates	5,303
	4. Dictyosphaerium	1,364
	5. Cryptomonas	606
	Other genera	3,787
	Total	51,970

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/30/72	01	5.4
08/29/72	01	66.7
10/26/72	01	180.9

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	0.510	0.276	13.2
0.006 P	0.516	0.276	11.3
0.012 P	0.522	0.276	12.3
0.024 P	0.534	0.276	12.1
0.060 P	0.570	0.276	10.8
0.060 P + 10.0 N	0.570	10.276	141.0
10.0 N	0.510	10.276	148.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Carrigan Lake was high at the time the sample was collected (10/26/72). Also, the results show that Carrigan Lake was nitrogen limited at that time. Note that no growth response resulted from spikes of phosphorus alone, but the nitrogen only spike resulted in a yield more than ten-fold that of the control.

The lake data show nitrogen limitation at all sampling times; i.e., the N/P ratios were less than 1/1 at all sampling times, and nitrogen limitation would be expected.

V. LITERATURE REVIEWED

Anonymous, 1968. An inventory of Minnesota lakes. Bull. No. 25, MN Dept. Cons., St. Paul.

Anonymous, 1974. Wastewater disposal facilities inventory. MPCA, Minneapolis.

VI. APPENDICES

APPENDIX A

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

271401
45 03 30.0 093 57 30.0
CARRIGAN LAKE
27 MINNESOTA

11ERALES 2111202
5 0002 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/30	19 30	0000			12							
	19 30	0002		12.6		580	9.40	177	0.040	0.040	0.446	0.340
72/08/29	11 15	0000			9	580	9.45	182	0.190	0.190	1.620	1.000
	11 15	0004	19.0	3.6		620	8.75	188	0.150	0.450	1.780	1.520
72/10/26	09 35	0000	5.0	13.2	13	600	9.10	188	0.080	0.120	0.810	0.570

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/30	19 30	0000	5.4J
72/08/29	11 15	0000	66.7J
72/10/26	09 35	0000	120.0J

J VALUE KNOWN TO BE IN ERROR

APPENDIX B

WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/30

271451 AS271451 P000564
45 48 30.0 093 57 30.0
WAVERLY
27 15 BUFFALO
D/CARRIGAN LAKE
CARRIGAN LAKE
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
73/01/23	11 00								
CP(T)-			0.170	4.300	0.730	1.200	1.370	0.070	0.070
73/01/23	13 00								
73/02/19	11 00								
CP(T)-			0.060	4.000	0.660	1.600	1.800	0.075	0.071
73/02/19	13 00								
73/04/23	11 00								
CP(T)-			0.045	2.700	0.084	0.240	0.470	0.070	0.065
73/04/23	13 00								
73/06/07	11 00								
CP(T)-			0.130	2.200	0.220	1.160	1.350	0.060	0.055
73/06/07	13 00								
73/07/11	10 00		1.470	1.300	0.005K		2.100	0.065	0.065
73/09/25	10 00		0.440	6.800	0.440	1.800	4.200	0.060	
73/10/30	10 00								
CP(T)-			2.000	7.600	0.010K	1.200	5.400		0.060
73/10/30	12 00								
73/11/30	10 00								
CP(T)-			1.890	5.400	0.110	2.800	4.900	0.045	0.044
73/11/30	12 00								
73/12/28	09 00								
CP(T)-			0.880	10.500	0.260	4.100	4.300	0.055	0.050
73/12/28	11 00								
74/01/28	10 00								
CP(T)-			4.900	5.000	0.063	5.450	7.600	0.064	0.058
74/01/28	12 00								
74/02/26	09 00								
CP(T)-			11.200	3.700	0.050K	4.900	7.700	0.054	
74/02/26	11 00								

K VALUE KNOWN TO BE LESS
THAN INDICATED