U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

LAKE NORDEN

HAMLIN COUNTY

SOUTH DAKOTA

EPA REGION VIII

WORKING PAPER No. 614

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

☆G.P.O. 699-440

REPORT

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WITH THE COOPERATION OF THE

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENTAL PROTECTION

AND THE

SOUTH DAKOTA NATIONAL GUARD

JANUARY, 1977

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 freshwater 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 freshwater 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 South Dakota Departments of Environmental Protection and Game, Fish and Parks for professional involvement, to the South Dakota National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples.

Allyn Lockner, Secretary, and Blaine Barker and Duane Murphy, Department of Environmental Quality; Douglas Hansen, Department of Game, Fish and Parks; and James Hayden, Director, State Lakes Preservation Committee 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.

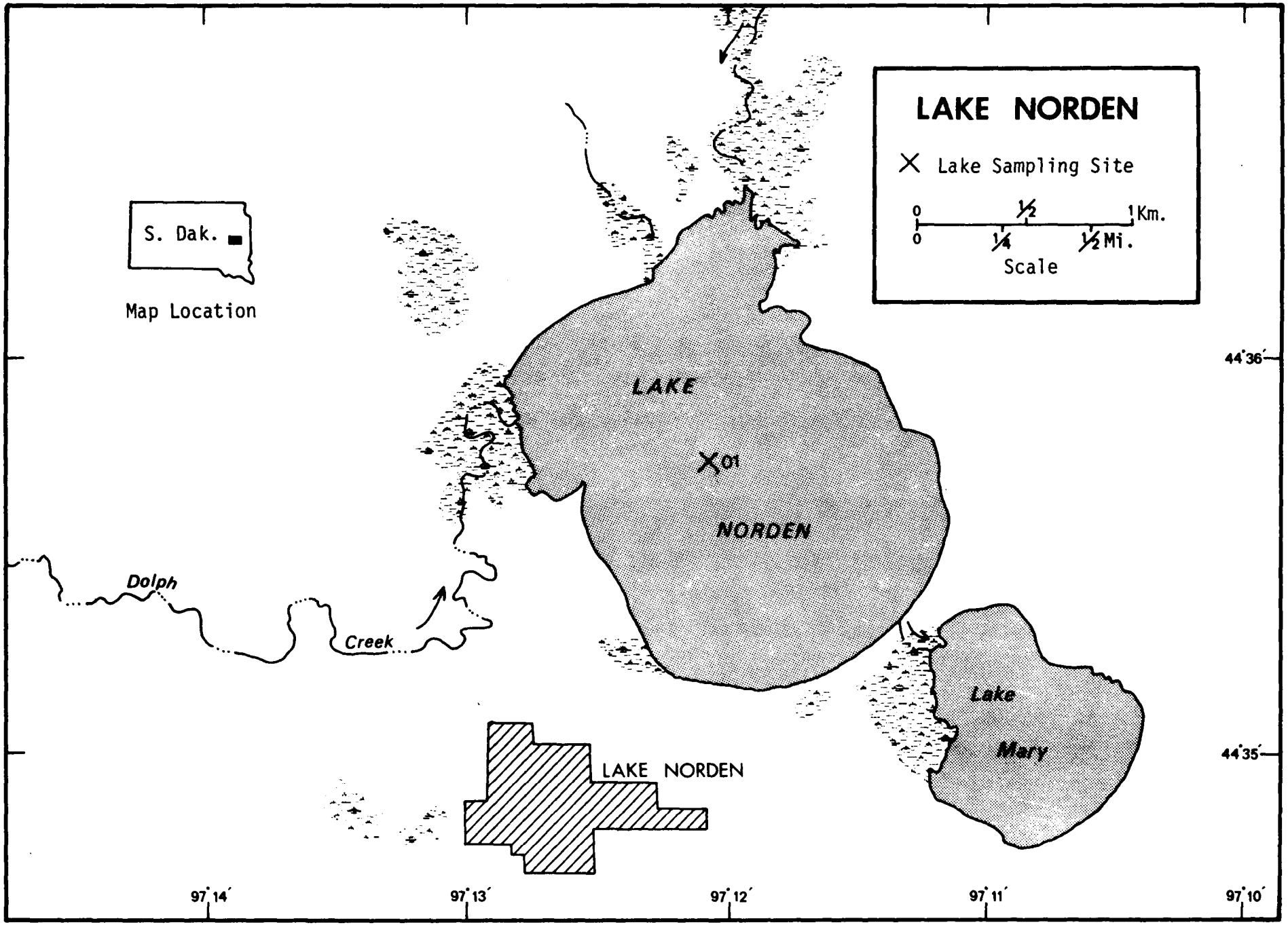
Major General Duane L. Corning, the Adjutant General of South Dakota, and Project Officer Colonel Robert D. Chalberg, who directed the volunteer efforts of the South Dakota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF SOUTH DAKOTA

LAKE NAME	COUNTY
Albert	Kingsbury
Alvin	Lincoln
Angostura	Fall River
Brant	Lake
Byron	Beadle
Clear	Marshall
Clear	Minnehaha
Cochrane	Deuel
Cottonwood	Spink
Deerfield	Pennington
Enemy Swim	Day
Herman	Lake
John	Hamlin
Kampeska	Codington
Madison	Lake
Mitchell	Davidson
Norden	Hamlin
East Oakwood	Brookings
West Oakwood	Brookings
Pactola	Pennington
Pickerel	Day
Poinsett	Brookings, Lake
Red Iron South	Marshall
Richmond	Brown
Roy	Marshall
Sand	Brown
Sheridan	Pennington
Stockdale	Custer
East Vermillion	McCook
Wall	Minnehaha
Waubay	Day


LAKE NORDEN
Lake Sampling Site
0 ½ 1 Km.
0 ¼ ½ Mi.
Scale
S. Dak.
Map Location
LAKE
NORDEN
01
Dolph
Creek
Lake
Mary
LAKE NORDEN
44°36'
44°35'
97°14'
97°13'
97°12'
97°11'
97°10'

LAKE NORDEN

STORET NO. 4617

I. INTRODUCTION

Lake Norden was included in the National Eutrophication Survey as a water body of interest to the South Dakota Departments of Environmental Protection and Game, Fish and Parks. Tributaries and nutrient sources were not sampled, and this report relates only to the lake sampling data.

II. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Norden is eutrophic. It ranked twenty-seventh in overall trophic quality when the 31 South Dakota lakes sampled in 1974 were compared using a combination of six parameters*. Twenty-three of the lakes had less median total phosphorus and median inorganic nitrogen, 18 had less median dissolved orthophosphorus and mean chlorophyll a, and 26 had greater mean Secchi transparency.

Survey limnologists noted that the lake was turbid and reported on algal bloom in progress in July.

B. Rate-Limiting Nutrient:

The algal assay results indicate Lake Norden was nitrogen limited at the time the sample was collected (04/23/74). The lake data indicate nitrogen limitation at the other sampling times as well.

* See Appendix A.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 3.02 kilometers^2.
2. Mean depth: 2.1 meters.
3. Maximum depth: 4.6 meters.
4. Volume 6.342×10^6 m^3.

B. Precipitation*:

1. Year of sampling: 39.1 centimeters.
2. Mean annual: 56.3 centimeters.

† Table of metric equivalents--Appendix B.
†† Murphey, 1974.
* See Working Paper No. 175, "...Survey Methods, 1973-1976".

IV. LAKE WATER QUALITY SUMMARY

Lake Norden was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from one or more depths at a single station on the lake (see map, page v). During each visit, a 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 first visit, an 18.9-liter depth-integrated sample was taken for algal assays. The maximum depth sampled was 0.9 meters.

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

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE NORDEN
STORET CODE 4617

PARAMETER	1ST SAMPLING (4/23/74) 1 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/12/74) 1 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/19/74) 1 SITES RANGE	MEAN	MEDIAN
TEMP (C)	9.2 - 9.2	9.2	9.2	25.0 - 25.1	25.1	25.1	17.0 - 17.0	17.0	17.0
DISS OXY (MG/L)	10.0 - 10.0	10.0	10.0	5.0 - 6.6	5.8	5.8	8.6 - 8.8	8.7	8.7
CNDCTVY (MCROMO)	684. - 684.	684.	684.	1511. - 1512.	1511.	1511.	1426. - 1426.	1426.	1426.
PH (STAND UNITS)	8.3 - 8.3	8.3	8.3	8.6 - 8.7	8.6	8.6	8.1 - 8.1	8.1	8.1
TOT ALK (MG/L)	183. - 183.	183.	183.	234. - 240.	237.	236.	193. - 196.	195.	195.
TOT P (MG/L)	0.258 - 0.258	0.258	0.258	0.255 - 0.281	0.266	0.262	0.161 - 0.182	0.171	0.171
ORTHO P (MG/L)	0.018 - 0.018	0.018	0.018	0.083 - 0.096	0.091	0.094	0.006 - 0.007	0.006	0.006
NO2+NO3 (MG/L)	0.040 - 0.040	0.040	0.040	0.060 - 0.070	0.063	0.060	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.080 - 0.080	0.080	0.080	0.150 - 0.170	0.157	0.150	0.040 - 0.040	0.040	0.040
KJEL N (MG/L)	1.600 - 1.600	1.600	1.600	1.800 - 2.100	1.967	2.000	2.200 - 2.200	2.200	2.200
INORG N (MG/L)	0.120 - 0.120	0.120	0.120	0.210 - 0.230	0.220	0.220	0.060 - 0.060	0.060	0.060
TOTAL N (MG/L)	1.640 - 1.640	1.640	1.640	1.870 - 2.160	2.030	2.060	2.220 - 2.220	2.220	2.220
CHLRPYL A (UG/L)	28.5 - 28.5	28.5	28.5	60.6 - 60.6	60.6	60.6	51.3 - 51.3	51.3	51.3
SECCHI (METERS)	0.3 - 0.3	0.3	0.3	0.3 - 0.3	0.3	0.3	0.3 - 0.3	0.3	0.3

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/23/74	1. Chroomonas sp.	30,800
	2. Synedra sp.	9,774
	3. Ankistrodesmus sp.	1,524
	4. Cryptomonas sp.	1,255
	5. Melosira sp.	1,210
	Other genera	2,243
	Total	46,806
07/12/74	1. Crucigenia sp.	10,706
	2. Aphanizomenon sp.	1,798
	3. Oocystis sp.	1,389
	4. Chroomonas sp.	1,144
	5. Cymbella sp.	1,062
	Other genera	3,229
	Total	19,328
09/19/74	1. Melosira sp.	7,307
	2. Aphanizomenon sp.	2,036
	3. Chlorophytan filaments	1,437
	4. Synedra sp.	898
	5. Stephanodiscus sp.	659
	Other genera	4,074
	Total	16,411

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/23/74	1	28.5
07/12/74	1	60.6
09/19/74	1	51.3

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	0.040	0.108	4.7
0.050 P	0.090	0.108	4.3
0.050 P + 1.0 N	0.090	1.108	29.5
1.0 N	0.040	1.108	20.9

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Norden was high at the time the assay sample was collected (04/23/74). The increase in yield with the addition of nitrogen alone and the lack of such response when only orthophosphorus was added indicate nitrogen limitation.

The lake data indicate nitrogen limitation at all sampling times; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 10/1 or less, and nitrogen limitation would be expected.

V. LITERATURE REVIEWED

Murphey, Duane G., 1974. Personal communication (lake morphometry). SD Dept. of Env. Prot., Pierre.

Petri, Lester R., and L. Rodney Larson, 1966(?). Quality of water in selected lakes of eastern South Dakota. Rept. of Inv. #1, SD Water Res. Comm., Pierre.

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
4601	LAKE ALBERT	0.321	0.170	489.111	106.289	9.200	0.019
4602	ALVIN LAKE	0.067	0.970	442.833	4.700	9.400	0.017
4603	ANGOSTURA RESERVOIR	0.019	0.160	423.333	3.717	13.000	0.005
4604	BRANT LAKE	0.194	0.130	432.833	34.150	11.800	0.113
4605	LAKE BYRON	0.443	0.370	488.333	149.350	9.000	0.146
4606	CLEAR LAKE	0.027	0.075	430.167	11.983	8.800	0.009
4607	CLEAR LAKE	1.400	0.270	495.333	691.000	7.000	0.468
4608	COCHRANE LAKE	0.037	0.150	446.000	15.683	15.000	0.008
4609	COTTONWOOD LAKE	0.685	0.265	490.333	112.017	8.600	0.417
4610	DEERFIELD RESERVOIR	0.033	0.080	303.333	3.650	15.000	0.022
4611	ENEMY SWIM LAKE	0.037	0.085	442.600	14.200	8.200	0.013
4612	LAKE HERMAN	0.340	0.155	485.000	58.733	8.600	0.174
4613	ST JOHN LAKE	0.348	0.080	489.400	120.880	9.800	0.025
4614	LAKE KAMPESKA	0.220	0.105	468.889	20.567	8.200	0.128
4615	MADISON LAKE	0.250	0.090	445.555	22.578	14.000	0.107
4616	LAKE MITCHELL	0.099	0.085	465.833	14.883	13.800	0.015
4617	LAKE NORDEN	0.256	0.165	488.667	46.800	10.000	0.050
4618	OAKWOOD LAKE EAST	0.146	0.175	487.000	113.600	10.000	0.009
4619	OAKWOOD LAKE WEST	0.181	0.135	485.833	159.667	9.600	0.021
4620	PACTOLA RESERVOIR	0.011	0.070	248.444	1.478	11.000	0.006
4621	PICKEREL LAKE	0.049	0.095	439.833	15.833	9.600	0.009
4622	LAKE POINSETT	0.115	0.315	468.444	40.211	10.000	0.023
4623	LAKE RED IRON SOUTH	0.042	0.110	430.333	6.883	7.600	0.010
4624	RICHMOND LAKE	0.187	0.150	410.000	18.467	10.000	0.144
4625	ROY LAKE	0.034	0.070	431.000	13.333	11.000	0.010
4626	SAND LAKE	0.489	0.110	471.800	65.790	12.800	0.288
4627	SHERIDAN LAKE	0.053	0.105	394.000	15.433	15.000	0.016
4628	STOCKADE LAKE	0.233	0.150	432.000	25.400	15.000	0.109

.AKE DATA TO BE USED IN RANKINGS

.AKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
4629	LAKE VERMILLION	0.211	0.100	472.833	100.800	9.200	0.092
4630	WALL LAKE	0.194	0.160	441.667	55.267	7.400	0.076
4631	WAUBAY LAKE NORTH	0.098	0.145	469.555	127.033	11.400	0.023

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
4601	LAKE ALBERT	20 (6)	20 (6)	10 (3)	23 (7)	68 (20)	60 (18)	201
4602	ALVIN LAKE	67 (20)	0 (0)	57 (17)	90 (27)	63 (19)	63 (19)	340
4603	ANGOSTURA RESERVOIR	97 (29)	30 (9)	87 (26)	93 (28)	20 (6)	100 (30)	427
4604	BRANT LAKE	40 (12)	53 (16)	70 (21)	47 (14)	27 (8)	23 (7)	260
4605	LAKE BYRON	10 (3)	3 (1)	17 (5)	7 (2)	73 (22)	13 (4)	123
4606	CLEAR LAKE	93 (28)	93 (28)	83 (25)	83 (25)	77 (23)	90 (27)	519
4607	CLEAR LAKE	0 (0)	10 (3)	0 (0)	0 (0)	100 (30)	0 (0)	110
4608	COCHRANE LAKE	83 (25)	40 (11)	50 (15)	67 (20)	5 (0)	93 (28)	338
4609	COTTONWOOD LAKE	3 (1)	13 (4)	3 (1)	20 (6)	82 (24)	3 (1)	124
4610	DEERFIELD RESERVOIR	90 (27)	88 (26)	97 (29)	97 (29)	5 (0)	53 (16)	430
4611	ENEMY SWIM LAKE	80 (24)	82 (24)	60 (18)	77 (23)	88 (26)	73 (22)	460
4612	LAKE HERMAN	17 (5)	33 (10)	27 (8)	33 (10)	82 (24)	10 (3)	202
4613	ST JOHN LAKE	13 (4)	88 (26)	7 (2)	13 (4)	53 (16)	43 (13)	217
4614	LAKE KAMPESKA	33 (10)	65 (19)	40 (12)	57 (17)	88 (26)	20 (6)	303
4615	MADISON LAKE	27 (8)	77 (23)	53 (16)	53 (16)	13 (4)	30 (9)	253
4616	LAKE MITCHELL	60 (18)	82 (24)	47 (14)	73 (22)	17 (5)	70 (21)	349
4617	LAKE NORDEN	23 (7)	23 (7)	13 (4)	40 (12)	45 (12)	40 (12)	184
4618	OAKWOOD LAKE EAST	53 (16)	17 (5)	20 (6)	17 (5)	45 (12)	85 (25)	237
4619	OAKWOOD LAKE WEST	50 (15)	50 (15)	23 (7)	3 (1)	58 (17)	57 (17)	241
4620	PACTOLA RESERVOIR	100 (30)	98 (29)	100 (30)	100 (30)	35 (10)	97 (29)	530
4621	PICKEREL LAKE	73 (22)	73 (22)	67 (20)	63 (19)	58 (17)	85 (25)	419
4622	LAKE POINSETT	57 (17)	7 (2)	43 (13)	43 (13)	45 (12)	47 (14)	242
4623	LAKE RED IRON SOUTH	77 (23)	58 (17)	80 (24)	87 (26)	93 (28)	78 (23)	473
4624	RICHMOND LAKE	47 (14)	40 (11)	90 (27)	60 (18)	45 (12)	17 (5)	299
4625	ROY LAKE	87 (26)	98 (29)	77 (23)	80 (24)	35 (10)	78 (23)	455
4626	SAND LAKE	7 (2)	58 (17)	33 (10)	30 (9)	23 (7)	7 (2)	158
4627	SHERIDAN LAKE	70 (21)	65 (19)	93 (28)	70 (21)	5 (0)	67 (20)	370
4628	STOCKADE LAKE	30 (9)	40 (11)	73 (22)	50 (15)	5 (0)	27 (8)	225

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
4629	LAKE VERMILLION	37 (11)	70 (21)	30 (9)	27 (8)	68 (20)	33 (10)	265
4630	WALL LAKE	43 (13)	27 (8)	63 (19)	37 (11)	97 (29)	37 (11)	304
4631	WAUBAY LAKE NORTH	63 (19)	47 (14)	37 (11)	10 (3)	30 (9)	50 (15)	237

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4620	PACTOLA RESERVOIR	530
2	4606	CLEAR LAKE	519
3	4623	LAKE RED IRON SOUTH	473
4	4611	ENEMY SWIM LAKE	460
5	4625	ROY LAKE	455
6	4610	DEERFIELD RESERVOIR	430
7	4603	ANGOSTURA RESERVOIR	427
8	4621	PICKEREL LAKE	419
9	4627	SHERIDAN LAKE	370
10	4616	LAKE MITCHELL	349
11	4602	ALVIN LAKE	340
12	4608	COCHRANE LAKE	338
13	4630	WALL LAKE	304
14	4614	LAKE KAMPESKA	303
15	4624	RICHMOND LAKE	299
16	4629	LAKE VERMILLION	265
17	4604	BRANT LAKE	260
18	4615	MADISON LAKE	253
19	4622	LAKE POINSETT	242
20	4619	OAKWOOD LAKE WEST	241
21	4631	WAUBAY LAKE NORTH	237
22	4618	OAKWOOD LAKE EAST	237
23	4628	STOCKADE LAKE	225
24	4613	ST JOHN LAKE	217
25	4612	LAKE HERMAN	202
26	4601	LAKE ALBERT	201
27	4617	LAKE NORDEN	184
28	4626	SAND LAKE	158

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	4609	COTTONWOOD LAKE	124
30	4605	LAKE BYRON	123
31	4607	CLEAR LAKE	110

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

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

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/11/25

461701
44 35 35.0 097 12 00.0
LAKE NORDEN
46057 SOUTH DAKOTA

11EPALES
4

2111202
0006 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
74/04/23	13 45	0000	9.2	10.0	10	684	8.30	183	0.080	1.600	0.040	0.018
74/07/12	12 40	0000	25.1	6.6	12	1511	8.70	236	0.170	2.100	0.060	0.096
	12 40	0001	25.1			1511	8.60	240	0.150	2.000	0.060	0.094
	12 40	0003	25.0	5.0		1512	8.60	234	0.150	1.800	0.070	0.083
74/09/19	15 55	0000	17.0	8.8	12	1426	8.11	196	0.040	2.200	0.020K	0.006
	15 55	0002	17.0	8.6		1426	8.11	193	0.040	2.200	0.020K	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/23	13 45	0000	0.258	28.5	
74/07/12	12 40	0000	0.281	60.6	
	12 40	0001	0.262		1.0
	12 40	0003	0.255		
74/09/19	15 55	0000	0.161	51.3	
	15 55	0002	0.182		1.0

K VALUE KNOWN TO BE
LESS THAN INDICATED