

**U.S. ENVIRONMENTAL PROTECTION AGENCY  
NATIONAL EUTROPHICATION SURVEY**

**WORKING PAPER SERIES**



REPORT  
ON  
MCQUADE LAKE  
ST. LOUIS COUNTY  
MINNESOTA  
EPA REGION V  
WORKING PAPER No. 112

**PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY**

**An Associate Laboratory of the**

**NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON**

**and**

**NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA**

REPORT  
ON  
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MINNESOTA  
EPA REGION V  
WORKING PAPER No. 112

WITH THE COOPERATION OF THE  
MINNESOTA POLLUTION CONTROL AGENCY  
AND THE  
MINNESOTA NATIONAL GUARD  
OCTOBER, 1974

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## 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.

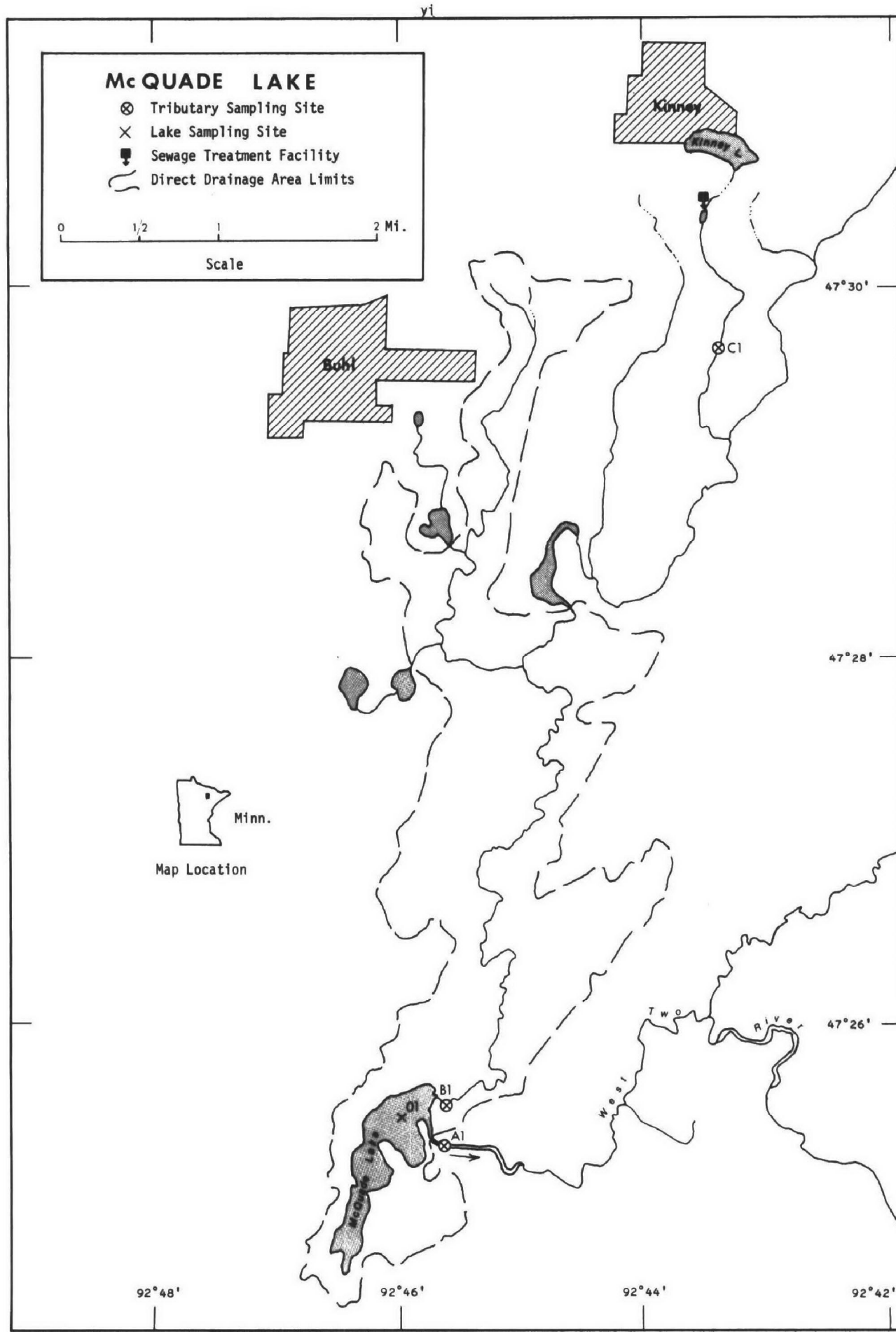
## NATIONAL EUTROPHICATION SURVEY

## STUDY LAKES

STATE OF MINNESOTA

| <u>LAKE NAME</u> | <u>COUNTY</u>                        |
|------------------|--------------------------------------|
| Albert Lea       | Freeborn                             |
| Andrusia         | Beltrami                             |
| Badger           | Polk                                 |
| Bartlett         | Koochiching                          |
| Bear             | Freeborn                             |
| Bemidji          | Beltrami                             |
| Big              | Stearns                              |
| Big Stone        | Big Stone, MN; Roberts,<br>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                            |

| <u>LAKE NAME</u> | <u>COUNTY</u>                              |
|------------------|--|
| 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;<br>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,<br>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                          |





## MCQUADE LAKE

STORET NO. 2757

### I. CONCLUSIONS

#### A. Trophic Condition:

Limited Survey data indicate McQuade Lake is eutrophic. Survey limnologists noted an algal bloom in progress in July, 1972, and reported much rooted aquatic vegetation in the shallows.

Of the 60 Minnesota lakes on which sampling was completed, 21 had less mean total phosphorus, 15 had less mean dissolved phosphorus, and 15 had less mean inorganic nitrogen. For all lakes sampled, 46% had greater mean Secchi disc transparency, and 32% had less mean chlorophyll a.

#### B. Rate-Limiting Nutrient:

McQuade Lake was not sampled the third time, so no algal assay sample was collected. However, the limited lake data indicate nitrogen limitation in July and September of 1972 (N/P ratios were less than 10/1, and nitrogen limitation would be expected).

#### C. Nutrient Controllability:

1. Point sources--During the sampling year, McQuade Lake received a total phosphorus load at a rate about  $1\frac{1}{2}$  times the rate proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 11). Of this load, the Village of Kinney is estimated to have contributed about 46%.

It is concluded that 80% phosphorus removal at the Kinney waste treatment plant would reduce the loading rate to 6.7 lbs/acre/yr or  $0.75 \text{ g/m}^2/\text{yr}$  and thus less than the eutrophic rate but greater than the oligotrophic rate.

2. Non-point sources--The estimated nutrient exports of the unnamed stream during the sampling year (see page 11) compare favorably with the exports of unimpacted Minnesota streams studied elsewhere. This indicates a lack of intensive agriculture in the area as well as a reasonable estimate of point-source loads.

## II. LAKE AND DRAINAGE BASIN CHARACTERISTICS:

### A. Lake Morphometry\*:

1. Surface area: 164 acres.
2. Mean depth: 9 feet.
3. Maximum depth: 21 feet.
4. Volume: 1,476 acre/feet.
5. Mean hydraulic retention time: 57 days.

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

#### 1. Tributaries -

| <u>Name</u>                                 | <u>Drainage area</u> <sup>†</sup> | <u>Mean flow</u> <sup>†</sup> |
|---|-----------------------------------|-------------------------------|
| Unnamed Creek (B-1)                         | 22.7 mi <sup>2</sup>              | 12.1 cfs                      |
| Minor tributaries &<br>immediate drainage - | <u>1.8 mi<sup>2</sup></u>         | <u>1.0 cfs</u>                |
| Totals                                      | 24.5 mi <sup>2</sup>              | 13.1 cfs                      |

#### 2. Outlet -

|                |                        |                        |
|----------------|------------------------|------------------------|
| West Two River | 24.8 mi <sup>2++</sup> | 13.1 cfs <sup>++</sup> |
|----------------|------------------------|------------------------|

### C. Precipitation<sup>+++</sup>:

1. Year of sampling: 28.0 inches.
2. Mean annual: 26.9 inches.

---

\* Anonymous, 1972.

† Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi<sup>2</sup>.

++ Includes area of lake; outflow adjusted to equal sum of inflows.

+++ See Working Paper No. 1, "Survey Methods".

### III. LAKE WATER QUALITY SUMMARY

McQuade Lake was sampled two 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 at two depths from one 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 depth-integrated sample was collected for chlorophyll a analysis. The maximum depth sampled was 6 feet.

The results obtained are presented in full in Appendix B and are summarized below. The mean values presented in these summary tables are not volume-weighted; nonetheless, the means are useful as a general guide to differences in water quality at the different sampling times.

#### A. Physical and chemical characteristics:

| <u>Parameter</u>                         | <u>Mean Values</u>                     |  |
|--|--|--|
|  | <u>1st Sample</u><br><u>(07/08/72)</u> | <u>2nd Sample</u><br><u>(09/09/72)</u> |
| Temperature (Cent.)                      | 21.6                                   | 16.3                                   |
| Dissolved oxygen (mg/l)                  | -                                      | 9.1                                    |
| Conductivity ( $\mu$ mhos)               | 130                                    | 145                                    |
| pH (units)                               | 8.4                                    | 7.9                                    |
| Alkalinity (mg/l)                        | 56                                     | 61                                     |
| Total P (mg/l)                           | 0.032                                  | 0.043                                  |
| Dissolved P (mg/l)                       | 0.012                                  | 0.021                                  |
| NO <sub>2</sub> + NO <sub>3</sub> (mg/l) | 0.050                                  | 0.050                                  |
| Ammonia (mg/l)                           | 0.060                                  | 0.080                                  |
| Chlorophyll a ( $\mu$ g/l)               | 19.2                                   | 2.2                                    |
| Secchi disc (inches)                     | 60                                     | 48                                     |

| <u>Parameter</u>                  | <u>Min. for<br/>all samples</u> | <u>Max. for<br/>all samples</u> | <u>Mean for<br/>all samples</u> |
|-----------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Temperature                       | 16.3                            | 21.6                            | 19.8                            |
| Dissolved oxygen                  | 9.1                             | 9.1                             | 9.1                             |
| Conductivity                      | 130                             | 145                             | 140                             |
| pH                                | 7.9                             | 8.4                             | 8.1                             |
| Alkalinity                        | 56                              | 61                              | 59                              |
| Total P                           | 0.032                           | 0.046                           | 0.039                           |
| Dissolved P                       | 0.012                           | 0.023                           | 0.018                           |
| NO <sub>2</sub> + NO <sub>3</sub> | 0.050                           | 0.050                           | 0.050                           |
| Ammonia                           | 0.060                           | 0.080                           | 0.073                           |
| Chlorophyll <u>a</u>              | 2.2                             | 19.2                            | 10.7                            |
| Secchi disc                       | 48                              | 60                              | 54                              |

## B. Biological characteristics:

### 1. Phytoplankton -

| <u>Sampling<br/>Date</u> | <u>Dominant<br/>Genera</u> | <u>Number<br/>per ml</u> |
|--------------------------|----------------------------|--------------------------|
| 07/08/72                 | 1. Dinobryon               | 2,754                    |
|                          | 2. Anabaena                | 1,920                    |
|                          | 3. Microcystis             | 1,087                    |
|                          | 4. Cryptomonas             | 435                      |
|                          | 5. Tabellaria              | 326                      |
|                          | Other genera               | <u>869</u>               |
|                          | Total                      | 7,391                    |
| 09/09/72                 | 1. Anabaena                | 442                      |
|                          | 2. Melosira                | 382                      |
|                          | 3. Tabellaria              | 291                      |
|                          | 4. Cryptomonas             | 281                      |
|                          | 5. Microcystis             | 221                      |
|                          | Other genera               | <u>803</u>               |
|                          | Total                      | 2,420                    |

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

| <u>Sampling<br/>Date</u> | <u>Station<br/>Number</u> | <u>Chlorophyll <u>a</u><br/>(<math>\mu</math>g/l)</u> |
|--------------------------|---------------------------|---|
| 07/08/72                 | 01                        | 19.2  |
| 09/09/72                 | 01                        | 2.2   |

C. Limiting Nutrient Study:

No algal assay sample was collected, since the lake was only sampled two times.

The lake data indicate nitrogen limitation in July (N/P ratio = 9/1) and September (N/P = 6/1).

#### IV. NUTRIENT LOADINGS (See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected, and the colder months when ice cover and access prevented sampling. Sampling was begun in October, 1972, and was completed in September, 1973.

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 loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were determined by using the pounds per square mile per year calculated for station B-1 (minus point-source loads) and multiplying that by the ZZ area in square miles.

The Village of Kinney declined participation in the Survey, and nutrient loads were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

In the tables that follow, loads attributed to tributaries are those measured minus point-source loads, if any.

## A. Waste Sources:

## 1. Known municipal -

| <u>Name</u> | <u>Pop.<br/>Served</u> | <u>Treatment</u> | <u>Mean<br/>Flow (mgd)</u> | <u>Receiving<br/>Water</u> |
|-------------|------------------------|------------------|----------------------------|----------------------------|
| Kinney      | 325*                   | Imhoff tank      | 0.032**                    | Unnamed Creek              |

## 2. Known industrial - None

---

\* Anonymous, 1973.

\*\* Estimated at 100 gal/capita/day.



## B. Annual Total Phosphorus Loading - Average Year:

## 1. Inputs -

| <u>Source</u>   | <u>lbs P/<br/>yr</u> | <u>% of<br/>total</u> |
|---|----------------------|-----------------------|
| a. Tributaries (non-point load) -                               |                      |                       |
| Unnamed Creek (B-1)   | 840                  | 48.0                  |
| b. Minor tributaries & immediate<br>drainage (non-point load) - | 70                   | 4.0                   |
| c. Known municipal -  |                      |                       |
| Kinney  | 810                  | 46.3                  |
| d. Septic tanks - None  | -                    | -                     |
| e. Known industrial - None                                      | -                    | -                     |
| f. Direct precipitation* -                                      | <u>30</u>            | <u>1.7</u>            |
| Total   | 1,750                | 100.0                 |

## 2. Outputs -

Lake outlet - West Two River      1,240

## 3. Net annual P accumulation - 510 pounds

---

\* See Working Paper No. 1.

## C. Annual Total Nitrogen Loading - Average Year:

## 1. Inputs -

| <u>Source</u>   | <u>lbs N/<br/>yr</u> | <u>% of<br/>total</u> |
|---|----------------------|-----------------------|
| a. Tributaries (non-point load) -                               |                      |                       |
| Unnamed Creek (B-1)   | 45,720               | 85.7                  |
| b. Minor tributaries & immediate<br>drainage (non-point load) - | 3,630                | 6.8                   |
| c. Known municipal -  |                      |                       |
| Kinney  | 2,440                | 4.6                   |
| d. Septic tanks - None  | -                    | -                     |
| e. Known industrial - None                                      | -                    | -                     |
| f. Direct precipitation* -                                      | <u>1,560</u>         | <u>2.9</u>            |
| Total   | 53,350               | 100.0                 |

## 2. Outputs -

Lake outlet - West Two River      46,760

## 3. Net annual N accumulation - 6,590 pounds

---

\* See Working Paper No. 1.

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

| <u>Tributary</u> | <u>lbs P/mi<sup>2</sup>/yr</u> | <u>lbs N/mi<sup>2</sup>/yr</u> |
|------------------|--------------------------------|--------------------------------|
| Unnamed Creek    | 37                             | 2,014                          |

## 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".

| <u>Units</u>             | <u>Total Phosphorus</u> |                    | <u>Total Nitrogen</u> |                    |
|--------------------------|-------------------------|--------------------|-----------------------|--------------------|
|                          | <u>Total</u>            | <u>Accumulated</u> | <u>Total</u>          | <u>Accumulated</u> |
| lbs/acre/yr              | 10.7                    | 3.1                | 325.3                 | 40.2               |
| grams/m <sup>2</sup> /yr | 1.20                    | 0.35               | 36.5                  | 4.5                |

Vollenweider loading rates for phosphorus  
(g/m<sup>2</sup>/yr) based on mean depth and mean  
hydraulic retention time of McQuade Lake:

|                                   |      |
|-----------------------------------|------|
| "Dangerous" (eutrophic rate)      | 0.82 |
| "Permissible" (oligotrophic rate) | 0.41 |

## V. LITERATURE REVIEWED

Anonymous, 1972. Survey questionnaire. MPCA, Minneapolis.

Anonymous, 1973. Wastewater disposal facilities inventory--State of Minnesota. MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz. A. Hydrol.

## VII. APPENDICES

### APPENDIX A

#### TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA

10/30/74

LAKE CODE 2757 MCQUADE LAKE

TOTAL DRAINAGE AREA OF LAKE 24.80

| TRIBUTARY | SUB-DRAINAGE AREA | NORMALIZED FLOWS |      |      |       |       |       |       |      |      |      |      |      |       |
|-----------|-------------------|------------------|------|------|-------|-------|-------|-------|------|------|------|------|------|-------|
|           |                   | JAN              | FEB  | MAR  | APR   | MAY   | JUN   | JUL   | AUG  | SEP  | OCT  | NOV  | DEC  | MEAN  |
| 2757A1    | 24.40             | 0.44             | 1.05 | 2.95 | 65.50 | 33.00 | 16.40 | 13.10 | 4.13 | 4.56 | 9.24 | 6.18 | 1.53 | 13.25 |
| 2757A1    | 22.70             | 0.44             | 1.32 | 2.47 | 59.60 | 30.20 | 15.50 | 12.00 | 3.75 | 4.20 | 8.39 | 5.60 | 1.45 | 12.12 |
| 275777    | 2.75              | 0.35             | 0.24 | 0.15 | 4.68  | 2.58  | 1.44  | 1.05  | 0.29 | 0.42 | 0.64 | 0.40 | 0.10 | 0.99  |

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 24.80  
 SUM OF SUB-DRAINAGE AREAS = 24.75  
 TOTAL FLOW IN = 157.43  
 TOTAL FLOW OUT = 159.13

MEAN MONTHLY FLOWS AND DAILY FLOWS

| TRIBUTARY | MONTH | YEAR | MEAN FLOW | DAY | FLOW  | DAY | FLOW  | DAY | FLOW |
|-----------|-------|------|-----------|-----|-------|-----|-------|-----|------|
| 2757A1    | 10    | 72   | 5.76      | 15  | 5.70  |     |       |     |      |
|           | 11    | 72   | 3.09      | 16  | 3.90  |     |       |     |      |
|           | 12    | 72   | 1.00      | 18  | 1.00  |     |       |     |      |
|           | 1     | 73   | 0.72      | 14  | 0.80  |     |       |     |      |
|           | 2     | 73   | 1.07      | 4   | 1.20  |     |       |     |      |
|           | 3     | 73   | 6.31      | 10  | 1.30  |     |       |     |      |
|           | 4     | 73   | 14.40     | 5   | 7.90  | 24  | 28.00 |     |      |
|           | 5     | 73   | 25.10     | 6   | 22.00 | 21  | 9.00  |     |      |
|           | 6     | 73   | 12.00     | 18  | 14.00 |     |       |     |      |
|           | 7     | 73   | 5.76      | 17  | 3.50  |     |       |     |      |
|           | 8     | 73   | 7.93      | 21  | 12.10 |     |       |     |      |
|           | 9     | 73   | 2.63      | 14  | 2.20  |     |       |     |      |
| 2757B1    | 10    | 72   | 5.23      | 15  | 5.20  |     |       |     |      |
|           | 11    | 72   | 2.49      | 16  | 3.60  |     |       |     |      |
|           | 12    | 72   | 0.95      | 14  | 0.90  |     |       |     |      |
|           | 1     | 73   | 0.79      | 14  | 0.70  |     |       |     |      |
|           | 2     | 73   | 1.63      | 4   | 1.20  |     |       |     |      |
|           | 3     | 73   | 6.14      | 10  | 1.40  |     |       |     |      |
|           | 4     | 73   | 13.10     | 6   | 7.20  | 24  | 25.00 |     |      |
|           | 5     | 73   | 23.00     | 6   | 23.00 | 21  | 8.30  |     |      |
|           | 6     | 73   | 11.00     | 18  | 13.00 |     |       |     |      |
|           | 7     | 73   | 5.28      | 17  | 3.20  |     |       |     |      |
|           | 8     | 73   | 7.21      | 27  | 4.60  |     |       |     |      |
|           | 9     | 73   | 2.63      | 14  | 2.00  |     |       |     |      |
| 275777    | 10    | 72   | 0.43      | 15  | 0.40  |     |       |     |      |
|           | 11    | 72   | 0.20      | 16  | 0.20  |     |       |     |      |
|           | 12    | 72   | 0.06      | 14  | 0.06  |     |       |     |      |
|           | 1     | 73   | 0.14      | 14  | 0.04  |     |       |     |      |
|           | 2     | 73   | 0.64      | 4   | 0.05  |     |       |     |      |
|           | 3     | 73   | 0.72      | 10  | 0.07  |     |       |     |      |
|           | 4     | 73   | 1.33      | 6   | 0.60  | 24  | 2.00  |     |      |
|           | 5     | 73   | 1.66      | 6   | 1.70  | 21  | 0.70  |     |      |
|           | 6     | 73   | 1.12      | 18  | 1.20  |     |       |     |      |
|           | 7     | 73   | 5.48      | 17  | 0.24  |     |       |     |      |
|           | 8     | 73   | 6.56      | 21  | 0.46  | 27  | 0.36  |     |      |
|           | 9     | 73   | 2.25      | 14  | 0.20  |     |       |     |      |

## APPENDIX B

### PHYSICAL and CHEMICAL DATA

STOPET RETRIEVAL DATE 74/10/30

275701  
47 25 32.0 092 45 59.0  
MCQUADE LAKE  
27 MINNESOTA

11FPALES  
3

2111202  
0006 FEET DEPTH

| DATE<br>FROM<br>TO | TIME<br>OF<br>DAY | DEPTH<br>FEET | 00010<br>WATER<br>TEMP<br>CENT | 00300<br>DO<br>MG/L | 00077<br>TRANSP<br>SECCHI<br>INCHES | 00094<br>CONDUCTVY<br>FIELD<br>MICROMHO | 00400<br>PH<br>SU | 00410<br>T ALK<br>CAC03<br>MG/L | 00630<br>NO2&NO3<br>N-TOTAL<br>MG/L | 00610<br>NH3-N<br>TOTAL<br>MG/L | 00665<br>PHOS-TOT<br>MG/L P | 00666<br>PHOS-DIS<br>MG/L P |
|--------------------|-------------------|---------------|--------------------------------|---------------------|-------------------------------------|---|-------------------|---------------------------------|-------------------------------------|---------------------------------|-----------------------------|-----------------------------|
| 72/07/02           | 13 30             | 0000          | 21.5                           |                     | 60                                  |   |                   |                                 |                                     |                                 |                             |                             |
|                    | 13 30             | 0006          | 21.5                           |                     |                                     | 130                                     | 8.40              | 56                              | 0.050                               | 0.060                           | 0.032                       | 0.012                       |
| 72/09/09           | 13 00             | 0000          |                                |                     | 48                                  | 145                                     | 7.90              | 61                              | 0.050                               | 0.080                           | 0.040                       | 0.023                       |
|                    | 13 00             | 0004          | 16.3                           | 9.1                 |                                     | 145                                     | 7.90              | 60                              | 0.050                               | 0.080                           | 0.046                       | 0.020                       |

| DATE<br>FROM<br>TO | TIME<br>OF<br>DAY | DEPTH<br>FEET | 32217<br>CHLOROPHYL<br>A<br>UG/L |
|--------------------|-------------------|---------------|----------------------------------|
| 72/07/02           | 13 30             | 0000          | 19.2J                            |
| 72/09/09           | 13 00             | 0000          | 2.2J                             |

J VALUE KNOWN TO BE IN ERROR



APPENDIX C  
TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/30

2757A1 LS2757A1  
 47 25 30.0 092 45 30.0  
 UNWAMPED TRIP FROM LK TO W TWO RV  
 27 7.5 BUHL  
 O/MOQUADE LAKE  
 CO HWY 453 BRDG E OF LAKE OUTLET  
 11EPALES 2111204  
 4 0000 FEET DEPTH

| DATE     | TIME | DEPTH | 00630<br>JOPAN03<br>N-TOTAL<br>MG/L | 00625<br>TOT KJEL<br>N<br>MG/L | 00610<br>NH3-N<br>TOTAL<br>MG/L | 00671<br>PHOS-DIS<br>ORTHO<br>MG/L P | 00665<br>PHOS-TOT<br>MG/L P |
|----------|------|-------|-------------------------------------|--------------------------------|---------------------------------|--------------------------------------|-----------------------------|
| FROM     | OF   | FEET  |                                     |                                |                                 |                                      |                             |
| TO       | DAY  |       |                                     |                                |                                 |                                      |                             |
| 72/10/15 | 09   | 30    | 0.018                               | 0.810                          | 0.070                           | 0.005K                               | 0.042                       |
| 72/11/15 | 13   | 10    | 0.072                               | 0.720                          | 0.100                           | 0.008                                | 0.036                       |
| 73/04/05 | 09   | 45    | 0.052                               | 3.780                          | 0.069                           | 0.020                                | 0.055                       |
| 73/04/24 | 08   | 45    | 0.010K                              | 2.100                          | 0.050                           | 0.007                                | 0.068                       |
| 73/05/06 | 19   | 05    | 0.012                               | 1.760                          | 0.050                           | 0.016                                | 0.045                       |
| 73/05/21 | 18   | 45    | 0.010K                              | 1.050                          | 0.031                           | 0.012                                | 0.060                       |
| 73/06/18 | 09   | 35    | 0.010K                              | 1.020                          | 0.039                           | 0.010                                | 0.035                       |
| 73/07/17 | 19   | 40    | 0.027                               | 2.000                          | 0.098                           | 0.008                                | 0.052                       |
| 73/08/21 | 19   | 40    | 0.066                               | 3.570                          | 0.220                           | 0.008                                | 0.067                       |
| 73/09/14 | 19   | 40    | 0.055                               | 1.900                          | 0.380                           | 0.019                                | 0.070                       |

K VALUE KNOWN TO BE LESS  
 THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

275781 L5275781  
 47 25 30.0 092 45 30.0  
 UNNAMED TRIB TO NE CR MCQUADE LK  
 27 7.5 BUHL  
 I/MCQUADE LAKE  
 CO HWY 453 BRDG JUST E OF NE CORNER LAKE  
 ILEPALES 2111204  
 4 0000 FEET DEPTH

| DATE<br>FROM<br>TO | TIME<br>OF<br>DAY | DEPTH<br>FEET | 00630<br>NH3-N<br>TOTAL<br>MG/L | 00625<br>TOT KJEL<br>N<br>MG/L | 00610<br>NH3-N<br>TOTAL<br>MG/L | 00671<br>PHOS-DIS<br>ORTHO<br>MG/L P | 00665<br>PHOS-TOT<br>MG/L P |
|--------------------|-------------------|---------------|---------------------------------|--------------------------------|---------------------------------|--------------------------------------|-----------------------------|
| 72/10/15           | 09 15             |               | 0.024                           | 0.630                          | 0.080                           | 0.009                                | 0.050                       |
| 73/04/06           | 09 40             |               | 0.120                           | 2.900                          | 0.063                           | 0.020                                | 0.065                       |
| 73/04/24           | 08 35             |               | 0.110                           | 2.600                          | 0.058                           | 0.012                                | 0.070                       |
| 73/05/06           | 19 00             |               | 0.025                           | 0.780                          | 0.028                           | 0.022                                | 0.040                       |
| 73/05/21           | 18 40             |               | 0.010                           | 0.760                          | 0.048                           | 0.021                                | 0.060                       |
| 73/06/18           | 09 30             |               | 0.054                           | 1.260                          | 0.046                           | 0.058                                | 0.135                       |
| 73/07/17           | 19 35             |               | 0.017                           | 1.760                          | 0.054                           | 0.032                                | 0.070                       |
| 73/08/27           | 19 25             |               | 0.034                           | 2.900                          | 0.105                           | 0.052                                | 0.090                       |
| 73/09/14           | 19 35             |               | 0.150                           | 5.000                          | 0.210                           | 0.052                                | 0.105                       |

K VALUE KNOWN TO BE LESS  
 THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

2757C1 LS2757C1  
 47 29 30.0 092 43 30.0  
 UNNAMED OUTLET KINNEY LAKE  
 27 7.5 KIRK  
 T/MCQUADE LAKE  
 US 169 XING 2.25 MI BELOW KINNEY STP  
 11EPALES 2111204  
 4 0000 FEET DEPTH

| DATE<br>FROM<br>TO | TIME<br>OF<br>DAY | DEPTH<br>FEET | 00630<br>NO2+NO3<br>N-TOTAL<br>MG/L | 00625<br>TOT KjEL<br>N<br>MG/L | 00610<br>NH3-N<br>TOTAL<br>MG/L | 00671<br>PHOS-DIS<br>UPH0<br>MG/L P | 00665<br>PHOS-TOT<br>MG/L P |
|--------------------|-------------------|---------------|-------------------------------------|--------------------------------|---------------------------------|-------------------------------------|-----------------------------|
| 72/10/15           | 09 55             |               | 0.510                               | 0.400                          | 0.063                           | 0.154                               | 0.190                       |
| 72/11/16           | 13 30             |               | 0.640                               | 1.200                          | 0.580                           | 0.294                               | 0.336                       |
| 73/04/06           | 10 00             |               | 0.270                               | 6.900                          | 0.292                           | 0.102                               | 0.185                       |
| 73/04/24           | 09 05             |               | 0.180                               | 2.730                          | 0.100                           | 0.025                               | 0.060                       |
| 73/05/06           | 19 25             |               | 0.210                               | 0.720                          | 0.110                           | 0.083                               | 0.135                       |
| 73/05/21           | 19 00             |               | 0.086                               | 0.650                          | 0.050                           | 0.082                               | 0.140                       |
| 73/06/18           | 09 50             |               | 0.189                               | 1.700                          | 0.100                           | 0.150                               | 0.250                       |
| 73/07/17           | 20 00             |               | 0.350                               | 1.470                          | 0.054                           | 0.220                               | 0.260                       |
| 73/08/27           | 20 00             |               | 0.240                               | 2.940                          | 0.100                           | 0.160                               | 0.240                       |
| 73/09/14           | 20 00             |               | 0.660                               | 5.700                          | 0.360                           | 0.270                               | 0.330                       |