IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

# PHASE I
# LAKE MANAGEMENT PLAN
# LONG LAKE
# SHAWANO COUNTY, WISCONSIN

REPORT TO:
LONG LAKE PROPERTY OWNERS ASSOCIATION

April, 1993

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|---|---|
| <u>**N/P Ratio**</u> | Total nitrogen divided by the total phosphorus found in a water sample. A value greater than 15 indicates that phosphorus is limiting for primary production. |
| <u>**Physicochemical**</u> | Pertaining to physical and/or chemical characteristics. |
| <u>**Residence Time**</u> | Commonly called the hydraulic residence time. The amount of time required to completely replace the lake's current volume of water with an equal volume of "new" water. |
| <u>**Secchi Depth**</u> | A measure of optical water clarity as determined by lowering a weighted Secchi disk (20 cm in diameter) into the water body to a point where it is no longer visible. |
| <u>**Stratification**</u> | Layering of water caused by differences in water density. Thermal stratification is typical of most deep lakes during the Summer. Chemical stratification can also occur. |

## SUMMARY

Long Lake, Shawano County, Wisconsin is a small (86 acre) lake with a relatively large and predominantly open/agricultural watershed. Nutrient levels were near those expected (relatively high) for the ecoregion in which Long Lake is located and transparency was low. Water quality parameters, according to Trophic State Index, indicated late **mesotrophic**[1] to **eutrophic** conditions. Nutrient levels in surface runoff were much higher than in-lake readings.

Aquatic plant populations appeared to benefit the resource; plants on muck substrates near the inlet were more abundant and of a different species assemblage than on sandy substrate areas.

Recreational use, as indicated by survey responses, was moderate and largely restricted to landowners along the highly developed shoreline. Fifteen respondents were permanent residents; average use among seasonal residents was about 12 weeks and 22 weekends. Viewing/watching nature, swimming and sunbathing, and fishing were the most popular activities. Ninety-four watercraft were reported; these were predominantly rowboats but included a significant number of motorboats over 50 horsepower. Most respondents did not perceive crowding or safety problems.

Water quality was generally perceived to be fair to poor and unchanged or deteriorated over the past five years. Thirty-seven respondents indicated having 30 conventional septic tanks, 4 holding tanks and 3 outhouses.

Management recommendations emphasize continued monitoring, reduction of nonpoint source nutrient and sediment inputs and consideration of access development.

- Water quality and self-help monitoring should be continued to supplement the small amount of historic information and track trends. Event monitoring should be continued and supplemented with local rainfall data; control measures should be implemented where appropriate and practical.

- Good yard management, runoff control practices and proper sanitary system maintenance should be emphasized. An on-site survey of sanitary systems should be scheduled during summer months. **Best Management Practices (BMP's)** should be adopted on erosion prone areas throughout the watershed.

- Consideration should be given to access development. Lake management activities are often facilitated through state assistance and highest priorities are often given to waterbodies with adequate public access.

[1] Text terms in bold print defined in glossary (pp. vi-vii)

## INTRODUCTION

Long Lake is located in the Town of Belle Plaine in south central Shawano County, Wisconsin. It is a small, natural lake with a mostly upland and highly developed shoreline.

The Long Lake Property Owners Association (LLPOA) was formed on August 31, 1980 to organize and direct the preservation of this resource. The Association is governed by an elected, 10 person, Board of Directors. Directors are elected biannually by the approximately 47 member Association.

The LLPOA, in 1991, decided to pursue development of a long range management plan under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program.
The LLPOA Directors selected IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin as its consultant to assist with development of the plan. A grant application to initiate development of the plan, incorporating required or recommended program components and the following objectives, was prepared, submitted, and approved in October, 1991:

- determination of current lake water quality and establishment of a monitoring strategy to track long-term trends,

- identification of sources of water quality problems, and
- development of the awareness of lake property owners of lake status and problems and establishment of a base of support for lake management efforts.

## DESCRIPTION OF AREA

Long Lake (T26N, R15E, Sections 26, 27) is a **drainage lake** in south-central Shawano County, Wisconsin. The lake is located in a primarily open/agricultural area about 6 miles south of the City of Shawano and 3 miles northeast of the Village of Embarrass (Figure 1).

The general topography of Shawano County is related to glacial activity. Long Lake is located in the bed of what was Glacial Lake Oshkosh or Nicolet during the Wisconsin stage of glaciation which ended about 10,000 - 15,000 years ago (4). Topography in the **immediately adjacent watershed** is nearly level to sloping. Major soil types adjacent to Long Lake are excessively drained Shawano loamy fine sands on 1 - 12% slopes, very poorly drained Markey and Cathro mucks on nearly level slopes and moderately well drained Rousseau loamy fine sands on 2 - 6% slopes. Soil permeability is generally rapid on all soils (5).

Long Lake has a surface area of 86 acres, an average depth of about 19 feet, a maximum depth of about 35 feet and a lake volume of 665 acre-feet (6). The **fetch** is 0.8 miles and lies in a northeast-southwest orientation and maximum width is about 0.2 miles in a northwest-southeast orientation; shoreline length is 2.4 miles. **Residence time** information for Long Lake was not


Figure 1. Location Map, Long Lake, Shawano County, WI.

available, but when back-calculated using linear regression equations based on watershed size (7,8), it was estimated to be 45.4 - 74.0 days. These calculations, considering the proximity of the inlet to the outlet on the northeast corner of Long Lake, probably drastically underestimate the actual residence time.

The Long Lake watershed is about 6,460 acres; predominant land use is open/agricultural (69%), wetland (19%), and forested (12%) (Figure 2). The watershed to lake ratio is about 75.1 to 1 and indicates that 75.1 times more land than lake surface area drains to the lake.

Individual septic systems are in use at all residences (about 80) in the immediate area of the lake. **Littoral** substrates are primarily sand (75%), with muck areas (25%) generally confined to the northeast end of the lake. Moderate **macrophyte** growth occurs in the littoral areas; relatively denser macrophyte beds occur on the muck substrates.

Long Lake supports fish species including northern pike (Esox lucius, black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), largemouth bass (Micropterus salmoides), pumpkinseed (Lepomis gibbosus), white sucker (Catostomus commersoni), bowfin (Amia calva), black bullhead (Ictalurus melas) and carp (Cyprinus carpio) (4). Due to very restricted

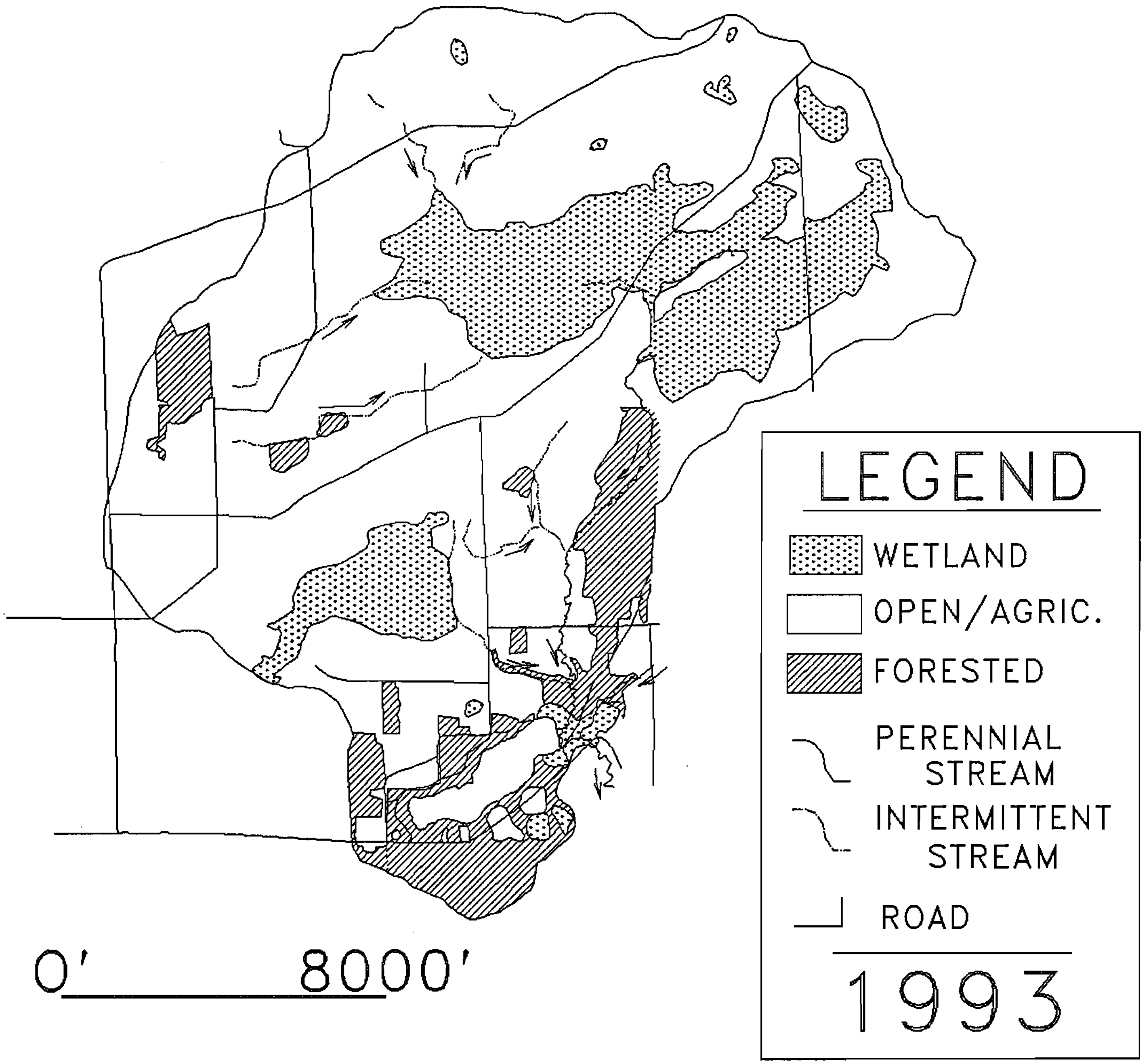


Figure 2. Land Use in the Long Lake Watershed, Shawano County, WI.

access (essentially limited to canoes off Cloverleaf Lake Road via Schoenick Creek into Long Lake), no recent fish surveys have been performed on Long Lake. A bacterial disease has caused bluegill fish kills as late as Fall, 1992; incidences of the disease generally occur during wet Fall periods (pers. comm. WDNR).

Long Lake provides nesting habitat for migrating waterfowl including mallards, black ducks, blue-wing teal, and wood ducks. A wide variety of the ducks and geese common to the central/Mississippi flyways also rest in the area.

# METHODS

## FIELD PROGRAM

Long Lake water sampling was conducted January 28, May 14, July 8 and September 21, 1992 at Stations 1801 (deepest point), 1802 (west end) and 1803 (unnamed inlet) (Table 3, Figure 3). Stations 1801 and 1802 were sampled three feet below the surface (designated "S") and three feet above the bottom (designated "B"). Station 1803 was sampled at mid-depth (designated "M").

**Physicochemical** parameters measured in the field included **Secchi depth**, temperature, dissolved oxygen (DO), pH and conductivity. Measurements were taken using a standard Secchi disk and a Hydrolab Surveyor II multiparameter meter; the Hydrolab unit was calibrated prior to and subsequent to daily use.

Samples taken for laboratory chemical analyses were collected using a Kemmerer water bottle. Samples were labelled, preserved when necessary, and packed on ice in the field; delivery to the laboratory was made via overnight carrier. All laboratory analyses were conducted at the State Laboratory of Hygiene (Madison, WI) using WDNR or APHA (9) methods. Winter water samples were analyzed for total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and

Table 1. Sampling Station Descriptions, Long Lake, 1992.

**WATER QUALITY**

| Regular Site | Latitude/Longitude | Depth |
|---|---|---|
| 1801 | 44° 40' 58'' 88° 38' 14'' | 35.0 ft. |
| 1802 | 44° 40' 42'' 88° 38' 43'' | 28.0 ft. |
| 1803 | 44° 40' 57'' 88° 38' 04'' | 2.0 ft. |

| Event Site | Location |
|---|---|
| 18E1 | Mouth of unnamed inlet to Long Lake |
| 18E2 | Area of possible spring input to lake; Northwest of inlet |
| 18E3 | Unnamed creek; junction with Grass Lake Road |
| 18E4 | Unnamed creek; junction with St. John's Church Road |
| 18E5 | Unnamed creek; junction with Schoenick Lake Road |

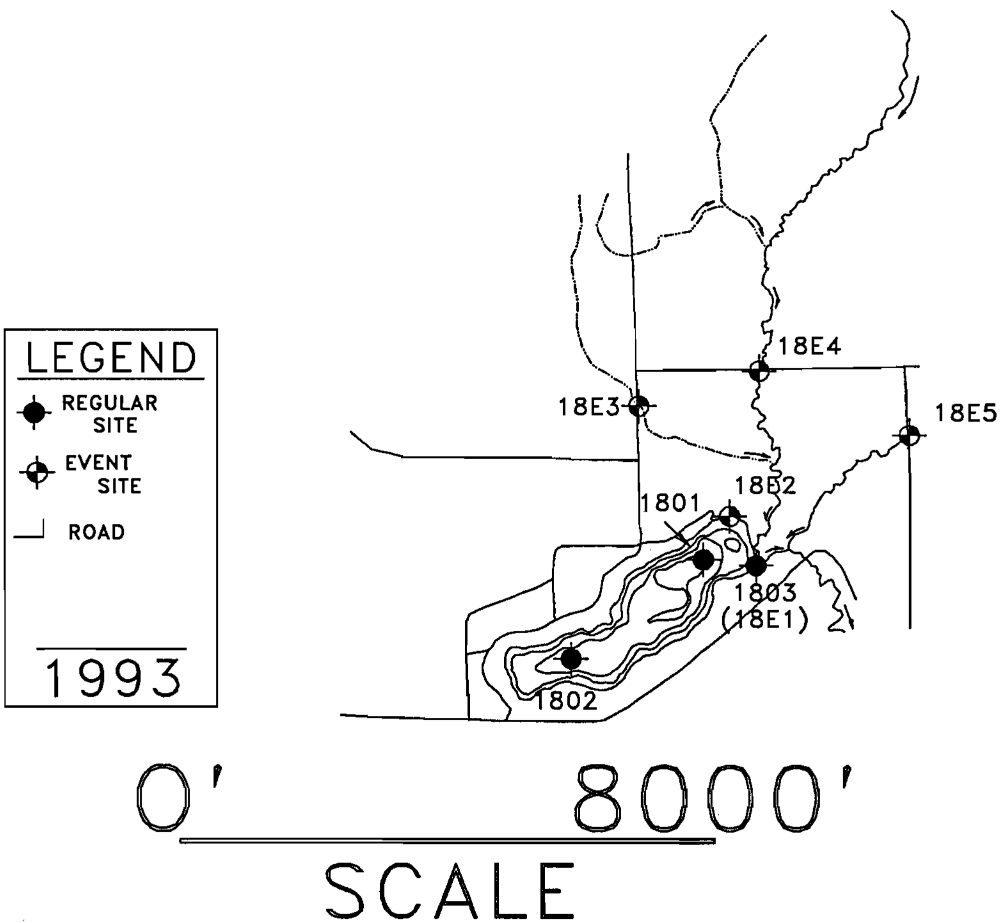


Figure 3. Sampling Station Locations, Long Lake, Shawano County, WI, 1992.

dissolved phosphorus. Spring parameters included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, and dissolved phosphorus, **chlorophyll a**, alkalinity and laboratory pH. Summer and late Summer laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus and chlorophyll a.

Event monitoring stations (Table 3) were located at major inlets and an adjacent stream to characterize water quality during major runoff events. Event sample laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus.

An abbreviated macrophyte survey was performed on July 8, 1992. A SCUBA cruise was made of the northeast shore of the lake to estimate the most abundant plants in the lake.

## OTHER CHARACTERISTICS

### Water Quality Information

Additional lake information was retrieved from the WDNR Surface Water Inventory (4), Self-Help Monitoring Data (10) and the WDNR WI LAKES Electronic Bulletin Board System.

Land Use Information

Details of zoning and specific land use were obtained from the Shawano County UW-Extension, Shawano County zoning maps, United States Soil Conservation Service soil maps (5), aerial photographs, and United States Geological Survey quadrangle maps. Information, when considered questionable or outdated was confirmed by field reconnaissance. Ordinance information was taken from Shawano County Zoning Ordinance and the Shawano County Soil Erosion Control and Animal Waste Water Pollution Control Plans. The Shawano County Farmland Preservation Plan also provided ordinance and watershed information.

Public Involvement Program

Various public involvement activities were coordinated with the planning process; these activities are summarized in Appendix I.

Recreational Use Survey

A recreational use survey (sample survey, Appendix II) was distributed to the LLPOA to solicit opinions and options for future management of the resource. Results are discussed in the Field Data Discussion section of this report.

## FIELD DATA DISCUSSION

Physicochemical characteristics of natural lakes tend toward a state of dynamic equilibrium (i.e., seasonally variable but relatively consistent within that framework over the long-term) as defined by basin morphometry and watershed features. Water supply for Long Lake is predominantly overland runoff from the relatively large open/agricultural watershed and potential effects of nonpoint inflows of sediment and nutrients are greater under these conditions than would be expected in a more forested watershed; wetland areas, however, do help to filter sediment and nutrients from the overland flow.

Phosphorus is often the limiting major nutrient to algal and plant production in lakes. Surface total phosphorus during 1992 monitoring was generally similar for the in-lake monitoring sites [average 0.075 and 0.051 mg/l (parts per million) for sites 1801 and 1802, respectively]. Overall, in-lake surface total phosphorus values ranged from 0.028 to 0.159 mg/l (Tables 2 - 4). Surface total phosphorus levels were higher than an average for natural lakes in the central region of Wisconsin (0.020 mg/l) (8) but were near levels typical of the ecoregion in which Long Lake is located (0.030 - 0.050 mg/l) (11). Substantially higher values for total phosphorous and other nutrient parameters were observed near bottom at Stations 1801 and 1802 and suggested

Table 2. Water Quality Parameters, Station 1801 (Deepest Point), Long Lake, 1992.

| PARAMETER | SAMPLE[1] | 01/28/92 | 05/14/92 | 07/08/92 | 09/21/92 |
|---|---|---|---|---|---|
| Secchi (feet) | | NR[2] | 5.2 | 3.25 | 4.5 |
| Cloud Cover (%) | | 100 | 100 | 50 | 100 |
| Temperature (°C) | S | 3.66 | 18.56 | 22.31 | 17.17 |
| | B | 3.55 | 7.13 | 6.69 | 8.80 |
| pH (S.U.) | S | 8.11 | 8.40 | NR | 8.48 |
| | B | 7.65 | 6.80 | NR | 6.83 |
| D.O. (mg/l) | S | 6.04 | 12.09 | 10.20 | 8.96 |
| | B | 5.50 | 0.74 | 0.19 | 0.50 |
| Conductivity ($\mu$mhos/cm) | S | 301 | 270 | 267 | 266 |
| | B | 304 | 290 | 320 | 327 |
| Laboratory pH (S.U.) | S | 8.20 | NR | NR | NR |
| | B | 8.00 | NR | NR | NR |
| Total Alkalinity (mg/l) | S | 162 | NR | NR | NR |
| | B | 160 | NR | NR | NR |
| Total Kjeldahl N (mg/l) | S | 2.1 | NR | 0.8 | 1.0 |
| | B | 1.4 | NR | 2.6 | 3.6 |
| Ammonia Nitrogen (mg/l) | S | 0.536 | NR | 0.019 | 0.121 |
| | B | 0.696 | NR | 1.73 | 2.48 |
| $NO_2$ + $NO_3$ Nitrogen (mg/l) | S | 0.221 | NR | ND[3] | ND |
| | B | 0.228 | NR | ND | ND |
| Total Nitrogen (mg/l) | S | 2.321 | NR | 0.80 | 1.00 |
| | B | 1.628 | NR | 2.60 | 3.60 |
| Total Phosphorus (mg/l) | S | 0.159 | NR | 0.033 | 0.034 |
| | B | 0.064 | NR | 0.29 | 0.34 |
| Diss. Phosphorus (mg/l) | S | 0.032 | NR | ND | 0.004 |
| | B | 0.041 | NR | 0.20 | 0.26 |
| N/P Ratio | S | 14.6 | NR | 24.2 | 29.4 |
| | B | 25.4 | NR | 78.8 | 10.6 |
| Chlorophyll _a_ ($\mu$g/l) | S | NR | NR | 16 | 19.5 |

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable

Table 3. Water Quality Parameters, Station 1802 (West End), Long Lake, 1992.

| PARAMETER | SAMPLE[1] | 01/28/92 | 05/14/92 | 07/08/92 | 09/21/92 |
|---|---|---|---|---|---|
| Secchi (feet) | | NR[2] | 5.2 | 3.75 | 4.75 |
| Cloud Cover (%) | | 100 | 100 | 50 | 100 |
| Temperature (°C) | S | 2.87 | 18.02 | 22.21 | 17.17 |
| | B | 3.14 | 7.27 | 7.81 | 8.41 |
| pH (S.U.) | S | 7.67 | 9.10 | 9.18 | 8.47 |
| | B | 7.57 | 6.90 | 6.71 | 6.78 |
| D.O. (mg/l) | S | 6.64 | 13.04 | 10.08 | 9.04 |
| | B | 5.65 | 1.50 | 0.13 | 0.73 |
| Conductivity (μmhos/cm) | S | 301 | 255 | 264 | 265 |
| | B | 303 | 270 | 296 | 329 |
| Laboratory pH (S.U.) | S | 8.20 | 9.10 | NR | NR |
| | B | 8.10 | 8.05 | NR | NR |
| Total Alkalinity (mg/l) | S | 161 | 142 | NR | NR |
| | B | 161 | 144 | NR | NR |
| Total Kjeldahl N (mg/l) | S | 1.4 | 1.0 | 0.8 | 0.8 |
| | B | 1.3 | 1.3 | 1.5 | 2.5 |
| Ammonia Nitrogen (mg/l) | S | 0.391 | 0.016 | 0.023 | 0.013 |
| | B | 0.622 | 0.383 | 0.701 | 1.61 |
| $NO_2$ + $NO_3$ Nitrogen (mg/l) | S | 0.368 | ND[3] | ND | ND |
| | B | 0.287 | 0.178 | ND | ND |
| Total Nitrogen (mg/l) | S | 1.768 | 1.00 | 0.80 | 0.80 |
| | B | 1.587 | 1.478 | 1.50 | 2.50 |
| Total Phosphorus (mg/l) | S | 0.089 | 0.052 | 0.033 | 0.028 |
| | B | 0.051 | 0.075 | 0.056 | 0.25 |
| Diss. Phosphorus (mg/l) | S | 0.014 | ND | 0.002 | 0.002 |
| | B | 0.033 | 0.015 | 0.003 | 0.171 |
| N/P Ratio | S | 19.9 | 19.2 | 40.0 | 28.6 |
| | B | 31.1 | 19.7 | 45.5 | 10.0 |
| Chlorophyll *a* (μg/l) | S | NR | 14 | 15 | 17.0 |

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable

Table 4. Water Quality Parameters, Station 1803/18E1 (Unnamed Inlet), Long Lake, 1992.

| PARAMETER | SAMPLE[1] | 07/08/92 | 09/21/92 |
|---|---|---|---|
| Secchi (feet) | | >2.0 | >2.0 |
| Cloud Cover (%) | | 50 | 100 |
| Temperature (°C) | M | 21.69 | 13.09 |
| pH (S.U.) | M | 7.78 | 7.51 |
| D.O. (mg/l) | M | 6.20 | 7.73 |
| Conductivity ($\mu$mhos/cm) | M | 400 | 436 |
| Laboratory pH (S.U.) | M | NR[2] | NR |
| Total Alkalinity (mg/l) | M | NR | NR |
| Total Kjeldahl N (mg/l) | M | 0.7 | 1.7 |
| Ammonia Nitrogen (mg/l) | M | 0.073 | 0.126 |
| $NO_2$ + $NO_3$ Nitrogen(mg/l) | M | 0.146 | 0.223 |
| Total Nitrogen (mg/l) | M | 0.846 | 1.923 |
| Total Phosphorus (mg/l) | M | 0.138 | 0.155 |
| Diss. Phosphorus (mg/l) | M | 0.056 | 0.120 |
| N/P Ratio | M | 6.1 | 12.4 |
| Chlorophyll a ($\mu$g/l) | M | 8 | 0.81[3] |

[1] M = Mid-Depth; [2] NR = No Reading; [3] = Results Approximate

nutrient release from sediments under **anoxic** or near-anoxic conditions in the **hypolimnion** during summer **stratification** at these relatively deep points (Figure 4).

Total nitrogen is highly variable among lakes and should only be compared within the same lake and on a relative or trend basis. Surface total nitrogen levels averaged about 1.12 mg/l for both in-lake sample points. Nitrogen to phosphorus ratios (**N/P ratio**) generally greater than 15 at Stations 1801 and 1802 indicated phosphorus limited conditions most of the time.

Event samples indicated substantially higher (than in-lake) levels of nutrients in the inflows (Table 5). Total nitrogen ranged from 1.477 to 2.686 mg/l and averaged 1.972 mg/l (relatively higher values at Stations 18E1, 18E4 and 18E5). Total phosphorus ranged from 0.058 to 0.282 mg/l and averaged 0.148 mg/l (relatively higher values at Stations 18E1, 18E2, 18E4 and 18E5).

Numerous indices have been developed to assess lake **eutrophication** status based on water quality parameters. The Trophic State Index (TSI) developed by Carlson (<u>12</u>) utilizes Secchi transparency, chlorophyll <u>a</u>, and total phosphorus. As with most indices, application is generally most appropriate on a relative and trend monitoring basis. This index does not account

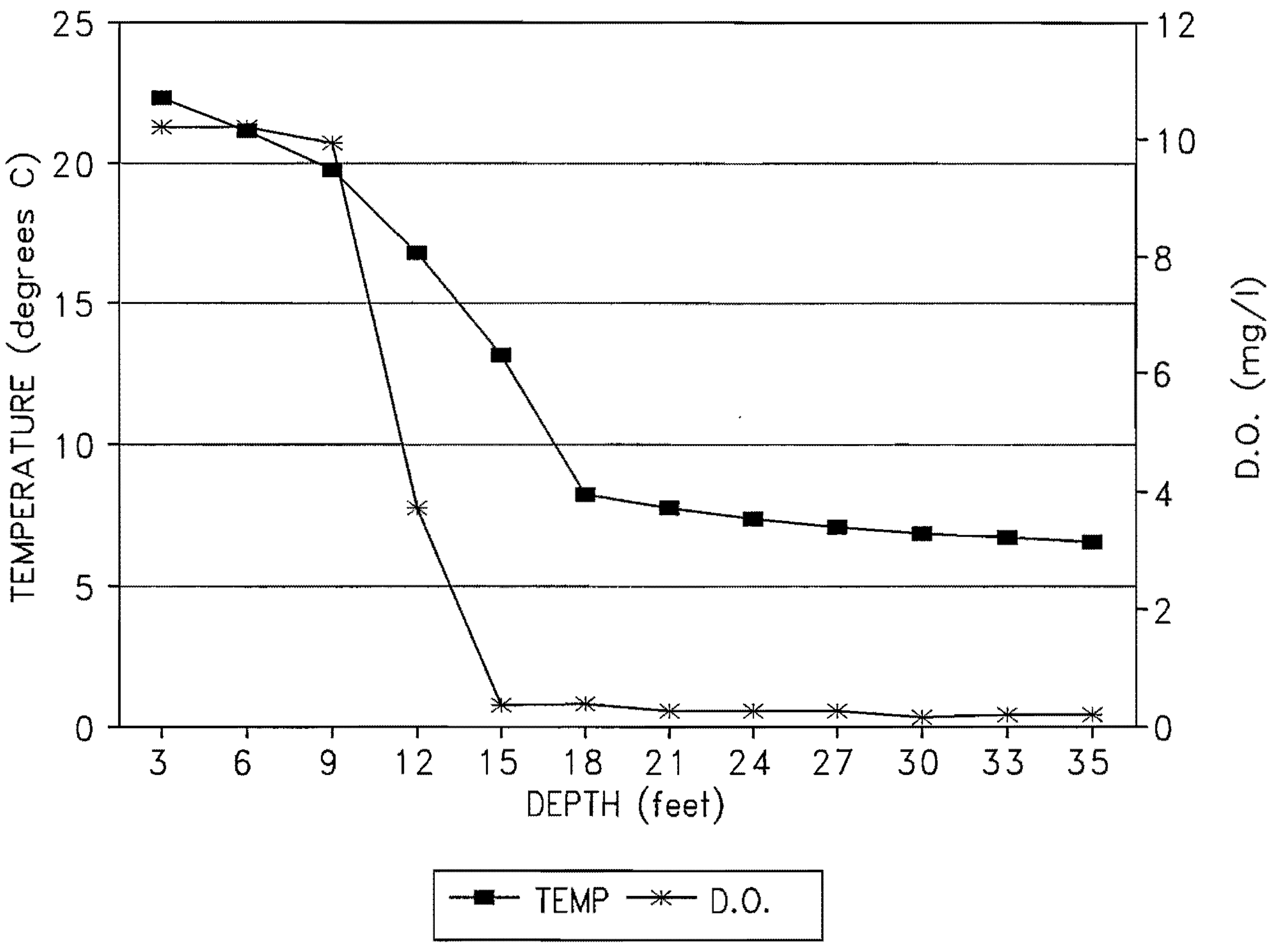


Figure 4. Temperature/DO Profile, Long Lake, July 8, 1992.

Table 5. Event Water Quality Parameters, Long Lake, 1992.

| | | STATION | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PARAMETER | UNITS | 18E1 | 18E1 | 18E2 | 18E2 | 18E3 | 18E4 | 18E5 |
| Date | | 04/23/92 | 05/17/92 | 04/23/92 | 05/17/92 | 09/21/92 | 09/21/92 | 09/21/92 |
| Temperature | °C | NR[1] | NR | NR | NR | 13.63 | 13.79 | 13.02 |
| pH | S.U. | NR | NR | NR | NR | 7.47 | 7.59 | 7.68 |
| D.O. | mg/l | NR | NR | NR | NR | 7.54 | 7.29 | 7.04 |
| Conductivity | µmhos/cm | NR | NR | NR | NR | 446 | 431 | 549 |
| Total Kjeldahl N | mg/l | 2.0 | 1.7 | 1.0 | 1.6 | 1.2 | 1.9 | 1.3 |
| Ammonia Nitrogen | mg/l | 0.397 | 0.059 | 0.129 | 0.031 | 0.039 | 0.174 | 0.086 |
| $NO_2+NO_3$ Nitrogen | mg/l | 0.686 | 0.367 | 0.477 | ND[2] | 0.443 | 0.171 | 0.963 |
| Total Nitrogen | mg/l | 2.686 | 2.067 | 1.477 | 1.60 | 1.643 | 2.071 | 2.263 |
| Total Phosphorus | mg/l | 0.282 | 0.194 | 0.096 | 0.131 | 0.058 | 0.162 | 0.116 |
| Diss. Phosphorus | mg/l | 0.153 | 0.096 | 0.010 | 0.009 | 0.036 | 0.103 | 0.089 |
| N/P Ratio | | 9.5 | 10.7 | 15.4 | 12.2 | 28.3 | 12.8 | 19.5 |

[1] NR = No Reading; [2] ND = Not Detectable

for natural, regional variability in phosphorus levels nor for Secchi transparency reduction unrelated to algal growth.

TSI values for historic (Appendix III) and current deepest point data suggested a late mesotrophic to eutrophic condition (Figure 5). Event data rated on the index would indicate a highly eutrophic situation. No trends were evident from the limited amount of data available for Long Lake.

Moderate macrophyte growth was observed in the relatively narrow littoral zone around the lake perimeter and populations were generally sparse. An area of relatively more abundant growth was observed on muck substrates near the inlet to Long Lake. Dominant plant species on muck substrates (Table 6) appeared to change from that observed on sandier substrates.

Sandy substrates appeared dominated by water celery (*Vallisneria americana*). Water celery is typically found submerged on relatively harder substrates in turbid water (13) and is known to be an excellent waterfowl food source and can provide fish forage, cover and spawning habitat (14). Muck areas were dominated by water lilies (*Nuphar* and *Nymphaea* spp.), curly-leaf pondweed (*Potamogeton crispus*) and water milfoil (*Myriophyllum* spp.).

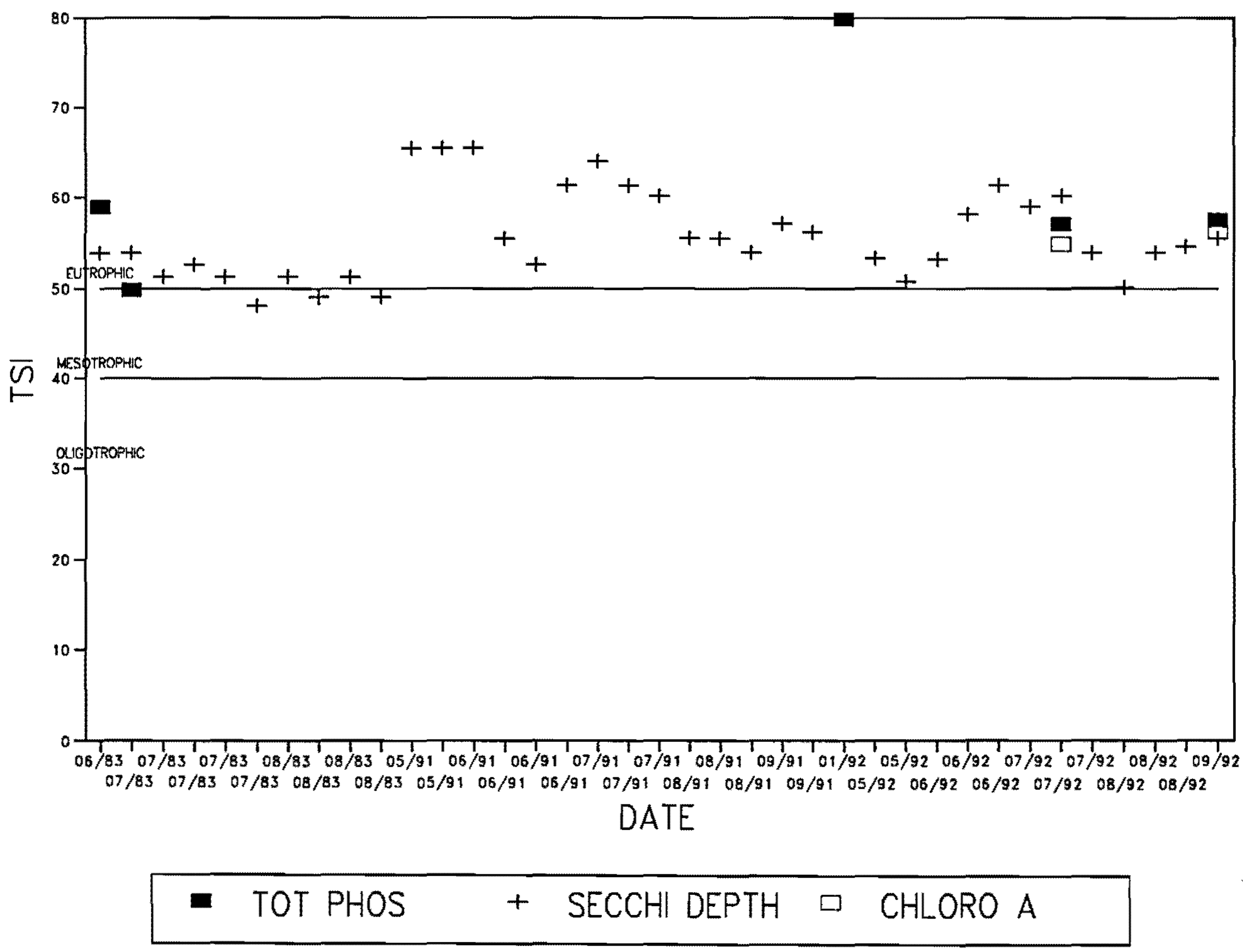


Figure 5. Trophic State Index for Secchi Depth, Chlorophyll a and Total Phosphorus, Long Lake, Shawano County, WI.

Table 6. Macrophyte Species Observed, Long Lake, July 8, 1992.

Sandy Areas

| Taxa | Code |
| --- | --- |
| Coontail (Ceratophyllum demersum) | CERDE |
| Muskgrass (Chara spp.) | CHASP |
| Water milfoil (Myriophyllum spp.) | MYRSPE |
| Bushy pondweed (Najas spp.) | NAJSP |
| Yellow pond lily (Nuphar spp.) | NUPSP |
| White pond lily (Nymphaea tuberosa) | NYMSP |
| Narrow-leaf pondweeds (Potamogeton spp.) | POTAM |
| Clasping-leaf pondweed (Potamogeton richardsonii) | POTRI |
| Water celery (Vallisneria americana) | VALAM |

Muck Areas

| Taxa | Code |
| --- | --- |
| Yellow pond lily (Nuphar spp.) | NUPSP |
| White pond lily (Nymphaea tuberosa) | NYMSP |
| Water milfoil (Myriophyllum spp.) | MYRSPE |
| Curly-leaf pondweed (Potamogeton crispus) | POTCR |

Water milfoil species determination was not verifiable because of a lack of floral bracts during the sample periods. While the plants did not exhibit more obvious distinguishing characteristics of Eurasian Milfoil, e.g. red-tinged stems and greater than 12 pair of leaflets, it may be present. Eurasian Milfoil is an exotic plant known to spread rapidly, displace native plants and change plant and animal assemblages.

Recreational use survey responses were received from 38 (i.e., 81%) of the 47 LLPOA members (Appendix IV); 15 (39%) of the responses were from permanent residents. Seasonal residents indicated an average dwelling occupancy of 12.2 weeks and 22.1 weekends per year.

A total of 94 watercraft were reported including 29 rowboats, 18 motorboats (<25 horsepower, HP), 16 canoes or kayaks and 13 motorboats with greater than 50 HP (6 owned by permanent residents). All respondents indicated using a private launch.

Most popular activities included viewing nature followed by bird/wildlife watching, swimming and sunbathing, and fishing. Participation in winter activities, as a whole, was much less than for summer activities. Ice fishing, ice skating and cross-country skiing were the more common winter activities. Popular activities were similar between permanent and seasonal residents.

User attitudes were also generally similar among permanent and seasonal residents. Seventy-six percent disagreed or strongly disagreed that there were too many watercraft on Long Lake. Most also disagreed (or strongly disagreed) that the number of watercraft on the lake caused safety problems. Almost 70% disagreed that more regulations are needed for the lake. Forty-two percent of the respondents agreed (or strongly agreed) that there is public boater access to Long Lake.

Perceived water quality (% of respondents in parentheses) was very good (0%), good (14%), fair (51%) and poor (35%). Respondents indicated the five year trend of water quality was improved (11%), the same (43%) and deteriorated (46%).

Surveys indicated 30 conventional septic systems, 4 holding tanks and 3 outhouses in use by the respondents. Systems were installed between 1946 and 1992.

## BASELINE CONCLUSIONS

Long Lake, Shawano County is a small (86 acre) lake with a relatively large (10 square miles), predominantly agricultural watershed. The potential for nutrient and sediment input is high but may be reduced somewhat by wetland areas which help to filter surface water runoff.

In-lake nutrient levels were near expected levels for the ecoregion in which the lake is located. Event inflows, however, were much higher in nutrient content and indicated nutrient (and probably sediment) inputs from the extensive watershed. Nutrient, transparency and chlorophyll a readings indicated late mesotrophic to eutrophic conditions when rated on the Trophic State Index.

Aquatic plants probably positively affect the resources through shoreline stabilization, nutrient uptake and fish food and habitat production. Higher abundances of plants were observed near the inlet (on mucky substrates) to the lake and were of a different species composition than sandy areas of the lake.

Shoreline areas of Long Lake are highly developed. Recreational use of the resource appears moderate and, with very limited public access, largely restricted to landowners and occupants of a camp on the west end of the lake. Predominant uses (camp and non-LLPOA member uses were not assessed in this study) were generally passive and included viewing and watching wildlife/nature, swimming and fishing. The potential for use conflicts appears relatively low, e.g., only 8% feel strongly that too many watercraft are present and that they may cause a safety concern.

## MANAGEMENT RECOMMENDATIONS

Long Lake is a relatively small drainage lake that drains an extensive watershed compared to lake size. Management recommendations target continued monitoring, reduction of riparian and nonpoint source nutrient inflows and development of public access to the lake.

Water quality monitoring should be continued on a similar schedule to provide data necessary to track trends. Event monitoring should be continued to assess nutrient levels entering the lake. Further investigation of lands drained to event sites may be warranted. Self-help Secchi monitoring should also be continued.

Riparian land management can have a significant impact on Long Lake water quality given the highly developed shoreline. Practices such as fertilizer management, buffer stripping and runoff control are affordable, common sense approaches that can help to control overland inflow of sediment and nutrients.

Yard practices can minimize both nutrient and sediment inputs. Lawn fertilizers should be used sparingly, if at all. If used, the land owner should use phosphate-free fertilizers and apply small amounts more often instead of large amounts at one or two times. Composting lawn clippings and leaves away from the lake can reduce nutrient inputs to the lake. If leaves are burned, it should be done in an area where the ash cannot wash directly into the lake, or indirectly to the lake via roadside ditches.

Creation of a buffer strip with diverse plants at least 20 feet wide immediately adjacent to the lake can control wave erosion, trap soil eroded from the land above, increase infiltration (to filter nutrients and soil particles), and shade areas of the lake to reduce macrophyte growth (especially on south shores) and provide fish cover. Placement of a low berm in this area can enhance effectiveness of the buffer strip by further retarding runoff during rainfalls. A buffer zone protects lake water quality, creates habitat for wildlife, and provides privacy.

Major nutrient and sediment inflows can occur from the watershed. Best Management Practices (BMP's, Appendix V) implemented on a watershed wide basis, can have positive effects on normal and event inflow water quality.

Investigation into the feasibility of redirecting the inlet may also be assessed. The inlet and outlet streams are in close proximity and local information indicates that the inlet had originally flowed past the lake. Redirection of the inlet to the outlet stream (and making allowances for water level control) would significantly reduce the size of the watershed and the potential for nutrient and sediment inputs.

A sanitary system survey (on-site inspection) should be performed on all Long Lake sanitary systems. The county sanitarian can perform these tests at little or no cost to landowners and should be scheduled for a time of peak use (summer months).

Public access should be developed for Long Lake. Establishment of access to the lake would make fish surveys, water quality monitoring and state funding in lake related matters more attainable. Fisheries information may help to determine the cause of the bacterial disease affecting bluegills, monitoring will establish data necessary for management decisions, and state assistance funds are often necessary to attain management goals for a lake. Steps required for access land acquisition are outlined in Appendix VI.

**IMPLEMENTATION**

The success of any lake management plan relates directly to the ability of the association/district to obtain funds and regulatory approval necessary to implement the plan. The LLPOA is a voluntary association that does not have a lake district's specific legal or financial powers (to adopt ordinances or levy taxes or special assessments) to meet plan objectives.

The Long Lake watershed is located within the political jurisdictions of the Towns of Aukechon and Belle Plaine, County of Shawano and the State of Wisconsin. These units have the power to regulate land uses and land use practices. Sources of information and assistance within these jurisdictions are summarized in Appendix VII. Shawano County ordinances and plans possibly pertinent to the Long Lake plan are summarized in Appendix VIII.

Potential sources of funding are listed in Appendix IX.

## LIST OF REFERENCES


1. North American Lake Management Society. 1988. The Lake and Reservoir Restoration Guidance Manual (First Ed.). EPA 440/5-88/1002. and N.A.C.M.S. 1988. EPA 445/5-88/002.

2. Shaw, Byron, and Chris Mechenich. 1987. A Guide to Interpreting Water Quality Data. Unpublished.

3. Wisconsin Department of Natural Resources, Bureau of Water Resource Management. 1983. Inland Lake Feasibility Studies. Unpublished.

4. Wisconsin Department of Natural Resources. 1968. Surface Water Resources of Shawano County. 147 pp.

5. United States Department of Agriculture, Soil Conservation Service. 1984. Soil Survey of Shawano County Wisconsin.

6. Wisconsin Department of Natural Resources. 1991. Wisconsin Lakes. PUBL-FM-800 91.

7. Bartsch, A. F. and J. Gakstatter. 1978. Management Decisions for Lake Systems Based on a Survey of Trophic Status, Limiting Nutrients, and Nutrient Loadings. U.S. Environ. Prot. Agency, Am.-Sov. Symp. on Use of Math. Models to Optimize Water Qual. Manage., U.S. Environ. Prot. Agency Rep. 600/9-78-024. pp. 372-96.

8. Lillie, R.A., and J.W. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. WDNR Technical Bulletin No. 138. 117 pp.

9. APHA. 1989. Standard Methods for the Examination of Water and Wastewater (17th ED.). American Public Health Association. American Public Health Association Washington, DC 20005.

10. Wisconsin Department of Natural Resources. 1986. Wisconsin Self-Help Monitoring Program Summary Report for 1986 - 1988. PUBL-WR-213 89. 59 pp.

11. Omernik, James M. et. al. 1988. "Summer Total Phosphorus in Lakes: A Map of Minnesota, Wisconsin, and Michigan, USA." Environmental Management 12(6): 815-825.

12. Carlson, R. E. 1977. "A Trophic State Index for Lakes." Limnol. Oceanogr. 22(2): 361-9.

**LIST OF REFERENCES**
(Continued)

13. Whitley, James R., B. Basset, J. G. Dillard, R. A. Haefner. 1990. Water Plants for Missouri Ponds. 151 p.

14. Nichols, Stanley A., and James G. Vennie. 1991. Attributes of Wisconsin Lake Plants. University of Wisconsin-Extension.

15. Wisconsin Department of Natural Resources. 1987. Becoming a Lake-Front Property Owner. PUBL-WR-171 87.