Limnological Study of

Horsehead Lake, Oneida County

April 1992 - November 1992

Prepared by:

Northern Lake Service, Inc.

400 North Lake Avenue

Crandon, Wisconsin 54520

July 19, 1993

Table of Contents

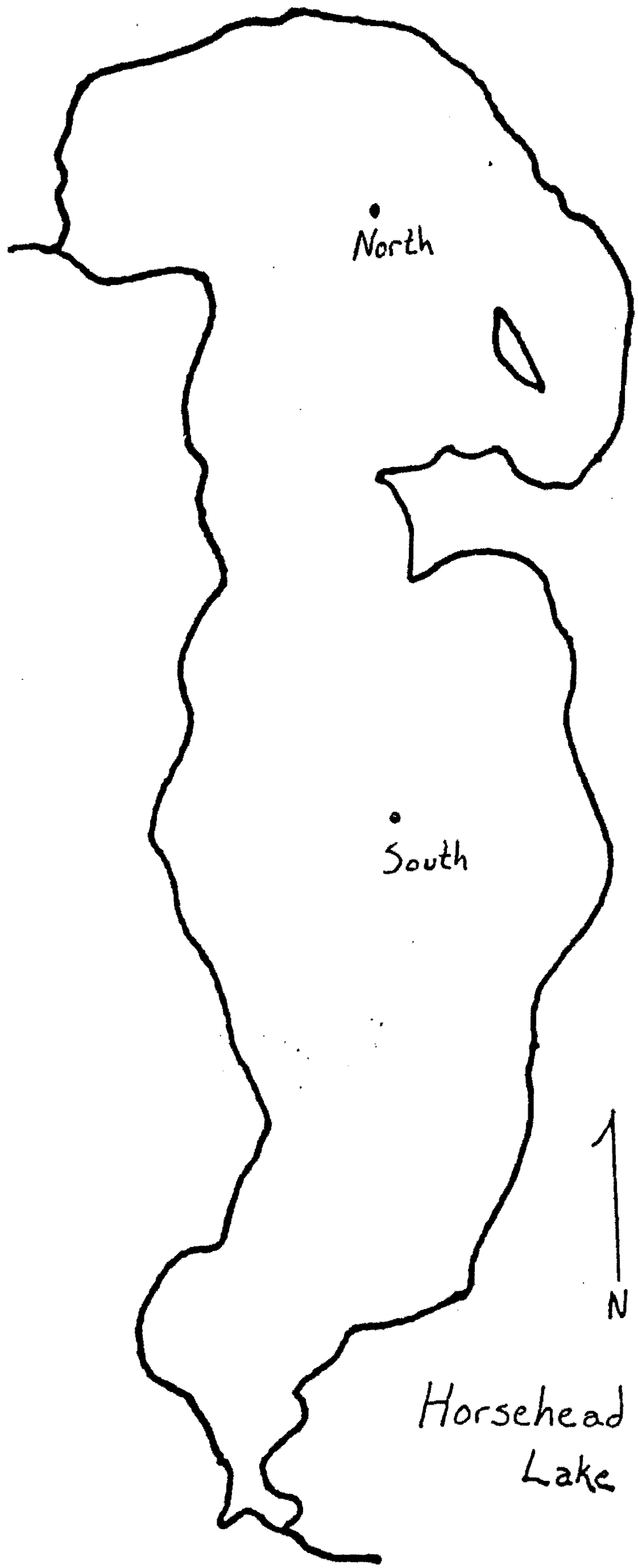
Introduction

The following is a description of and results from the planning-grant study of Horsehead Lake performed by Northern Lake Service between February 1992 and November 1992. The purpose of this study was to determine current water quality for comparison to past and future data and provide a basis for recommending improvement/preservation strategies.

Horsehead Lake is a 356 acre, spring fed lake located in northern Oneida County (T38N, R7E, Section 14). It has a maximum depth of 17 feet, 5.3 miles of shoreline and watershed of 2.0 miles. The shoreline is approximately 85% uplands and 15% wetland. (From Surface Water Resources of Oneida County WDNR- 1966.) The shoreline is moderately developed.

Study

This study consisted of five visits to the lake - 4 during open water and 1 during the winter. On the open-water trips, a water sample was collected at a central location in each of the two lobes of the lake. See the site map (page two) for sampling locations. The samples were taken using a two-meter PVC sampler. They were then dispensed into sample bottles with appropriate preservative and iced for transport to the laboratory. A portion of each sample was used for pH and conductivity determination which was done on site. Dissolved oxygen/temperature profiles were also generated


North
South
N
Horsehead
Lake

and secchi disc visibility measured at each sample site. These activities were done May 6, June 10, August 5, and November 6,1992. During the August 5 sampling, a general macrophyte survey was performed. For a description of this survey see appendix A.

Samples were analyzed by Northern Lake Service for alkalinity, chloride, chlorophyll α, nitrogen (Kjeldahl, ammonia, and nitrate + nitrite) and phosphorus. These parameters are described on the following pages and all data can be found in appendix B.

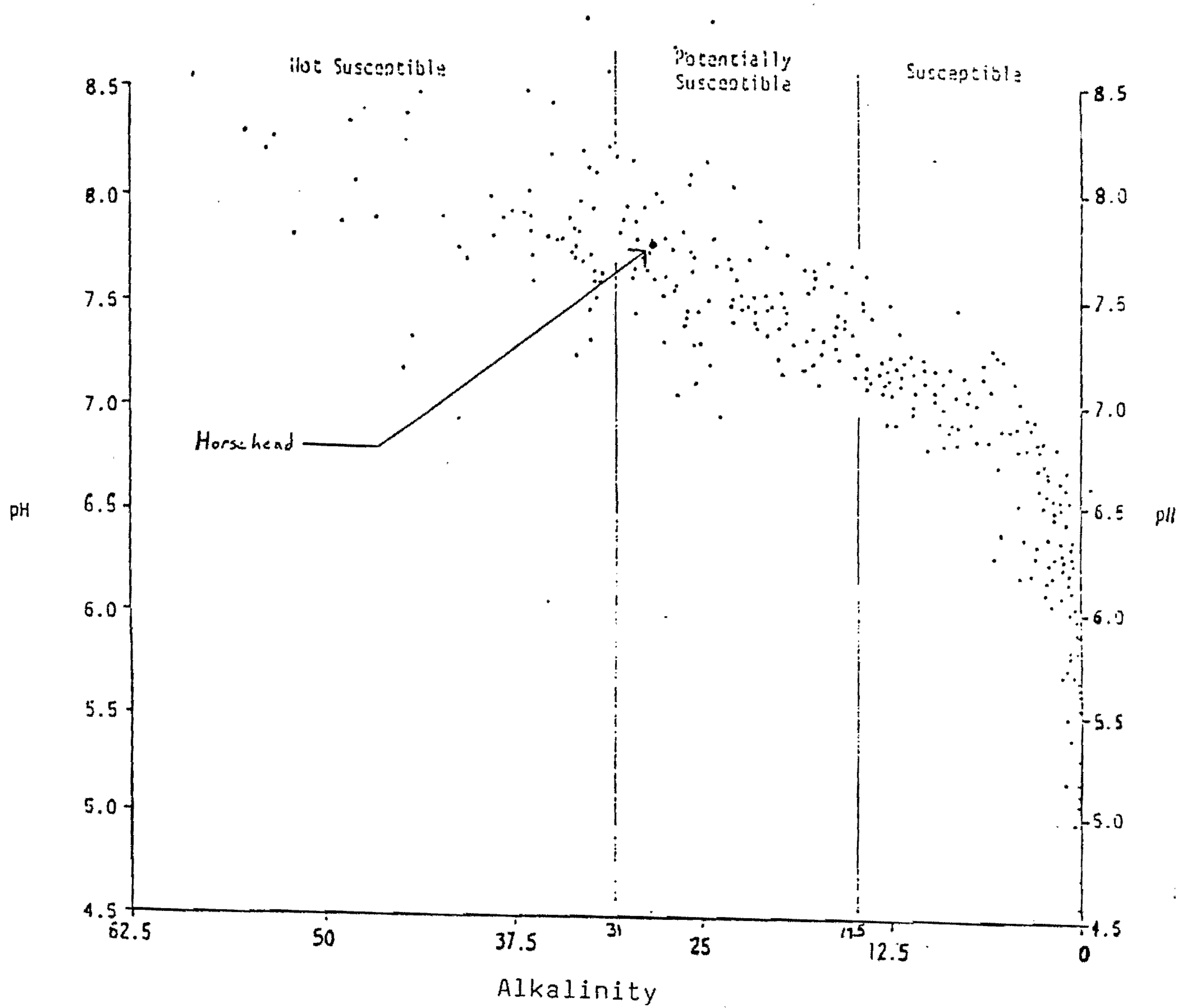
During the winter visit dissolved oxygen/temperature profiles were generated but no samples were collected.

Survey Findings

pH and Buffering Capacity: pH and total alkalinity or acid neutralizing capacity (ANC) are indications of a lake's susceptibility to the effects of acid rain. pH is the measure of acidity on a logarithmic scale from 1 to 14. A pH factor of 1 is most acidic, 14 most basic and 7 neutral. Alkalinity measures the ability of water to neutralize substances on the upper and lower ends of the pH scale. This process, called buffering, is performed by salts, mainly calcium carbonate salts. The more of these salts present, the higher the alkalinity and the more resistant to pH changes the water is. The pH on Horsehead Lake ranged from 7.4 to 9.2, indicating slightly basic conditions. The pH increased during the growing season then fell back to spring levels as the water cooled again. Alkalinity also followed this pattern. Levels were 28 mg/l in early June and rose to 60 by November. This range indicates good buffering potential. According to Surface Water Resources of Oneida County (WDNR-1966), the alkalinity of Horsehead Lake was 38 in the early 1960's, so it seems there has been no depletion of buffering capacity in the last thirty years. Figure 1 shows Horsehead Lake's position among area lakes in acid susceptibility based on these measurements.

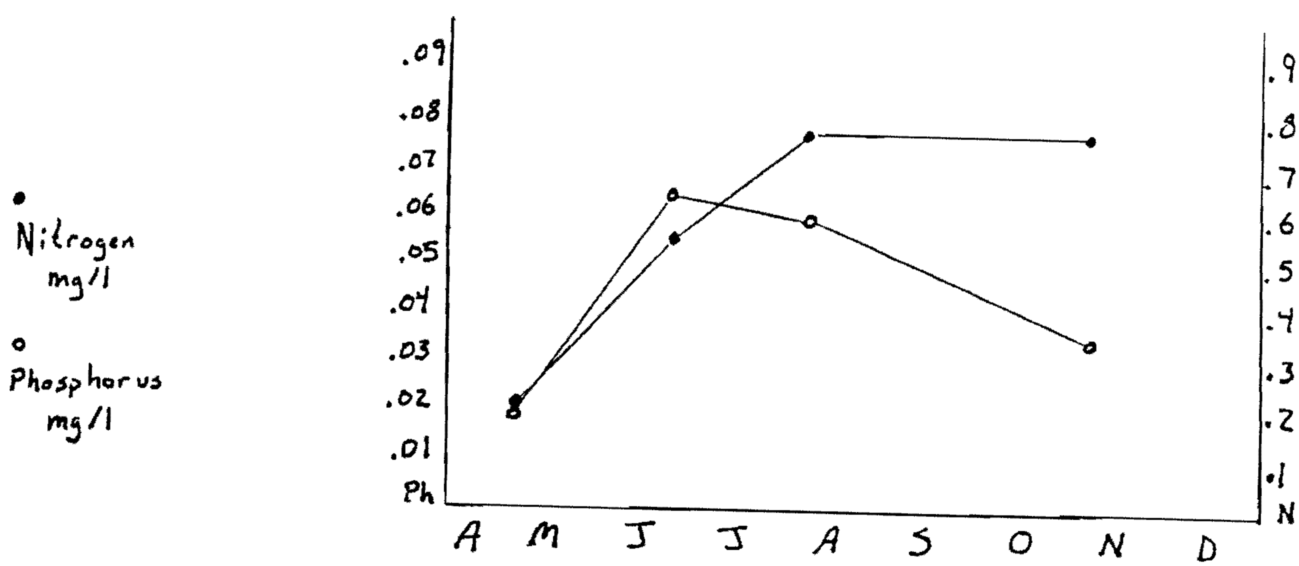
FIGURE 1

ACID RAIN EFFECT SUSCEPTIBILITY
(from Greater Bass Lake Langlade County Feasibility Results;
Management Alternatives. by WDNR Bureau of Water Resources Management - Inland Lake Renewal Section; 1983, p17.)

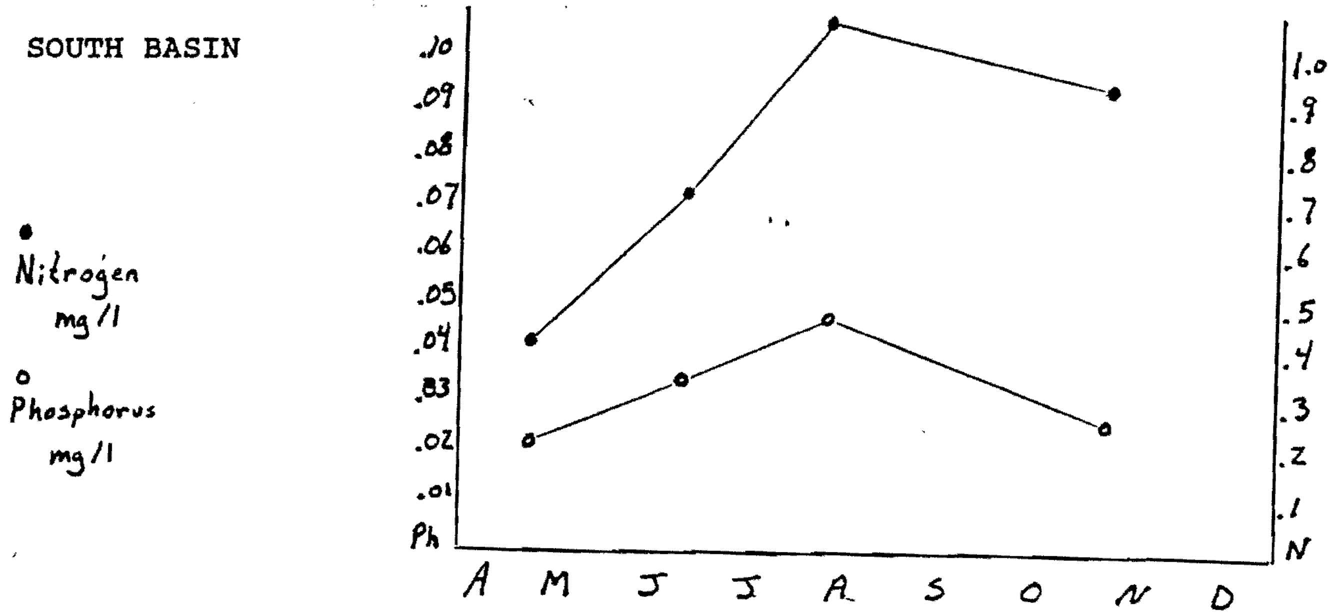


Nutrients: A nutrient is any element, ion or compound necessary for the growth and other life processes of an organism. Most nutrients are required in only trace amounts, but some, the macronutrients, are required in large enough amounts to dictate the productivity of a system. The macronutrients are carbon, nitrogen and phosphorus. Since carbon is so prevalent in a lake its levels do not get low enough to make it a limiting factor. (The limiting factor is the nutrient or energy source that exists in a quantity such that it dictates the extent of growth.) Therefore, nitrogen and phosphorus are considered the most important in terms of potential productivity of a lake. Generally, one or the other of these nutrients will be the obvious limiting nutrient, but on Horsehead the levels are quite different in the two basins making the distinction difficult. Phosphorus levels averaged about 50% higher in the north basin and nitrogen levels were about 50% higher in the south. The following two graphs show total phosphorus and total nitrogen levels over the course of the study.

NORTH BASIN



SOUTH BASIN

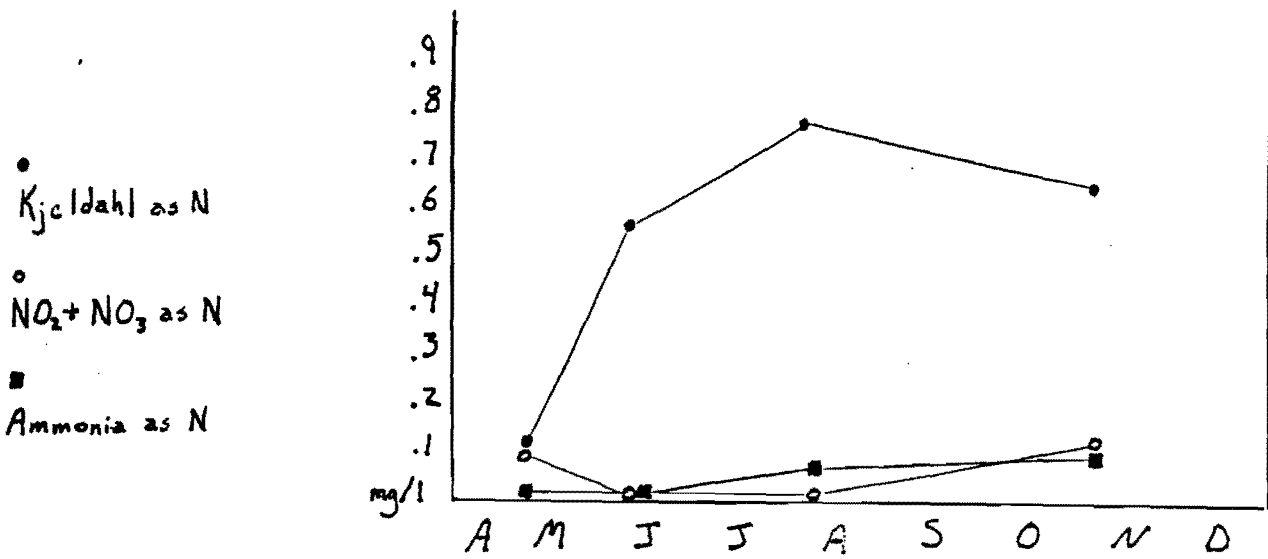


High productivity characterized by nuisance weed or algae growth can be expected when total phosphorus levels exceed 15 ug/l. Phosphorus levels in Horsehead Lake ranged from 20 to 66 ug/l during the study.

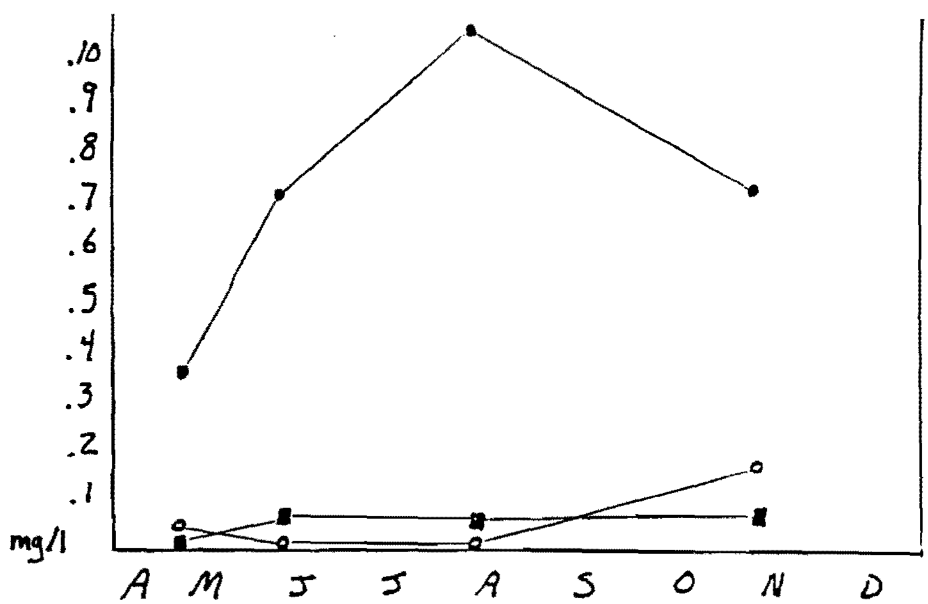
Nitrogen levels ranged from 0.54 mg/l to 0.62 mg/l. These values were consistent with many other lakes in this area. Seventy-five to 100% of the total nitrogen consisted of organic nitrogen. One component of organic nitrogen is ammonia which can be an indicator of septic contamination. Ammonia levels were near or below detection limits throughout the study, raising only slightly in late fall from natural production.

The inorganic portion of total nitrogen is made up of nitrate and nitrite. High levels of these compounds can indicate nutrient contamination from fertilizer or other man-made products. Nitrate + Nitrite levels were also quite low, ranging from below detection limits to .19 mg/l. Again the highest levels were at the end of the growing season. Graphs 3 and 4 show the nitrogen component levels during the study.

NORTH BASIN



SOUTH BASIN

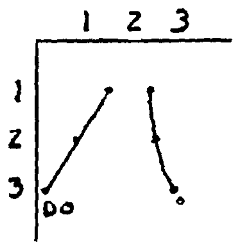


Dissolved Oxygen - Dissolved oxygen is critical to the survival of fish. In the spring, when the ice melts and the lake turns over, dissolved oxygen levels will be at or near saturation throughout the water column. Over the course of the summer, levels near the surface will fluctuate slightly with variations in temperature and mixing. In shallow, productive lakes such as Horsehead, oxygen levels will remain fairly constant throughout the water column during open water periods because of mixing by the wind. In the winter, however, oxygen can be depleted very rapidly when production (by plants and algae) ceases but consumption (by animals and bacteria) continues. If oxygen levels are depleted enough, fish may to suffocate, causing a phenomenon called "winter kill". Total oxygen depletion also provides a more favorable environment for nutrient recycling from the sediments, meaning more nutrients available for macrophyte or algae growth in the spring. While this was once a serious problem on Horsehead, it seems that the installation of aerators has remedied it. Dissolved oxygen levels were still quite low throughout much of the lake but apparently the area kept ice-free by the aerators are providing enough mixing to maintain a healthy fishery.

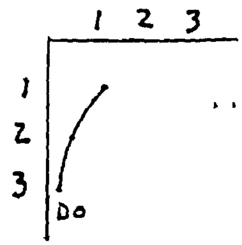
The following page includes all dissolved oxygen/temperature profiles generated during the study. Numbers on the vertical axis are depths in meters. Those on the horizontal axis represent both temperature in °C and dissolved oxygen in mg/l or parts per million. Page 10 shows the locations of winter sampling points. Dissolved oxygen and temperature data is included in appendix B.

2/26/92

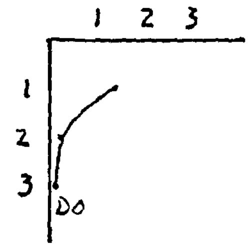
sta 2



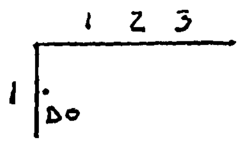
sta 4



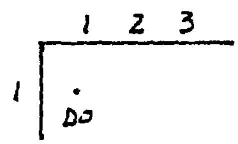
sta 5



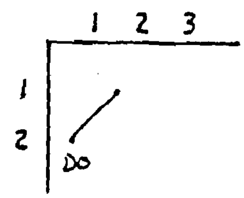
sta 6



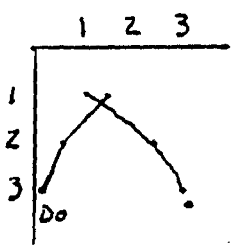
sta 7



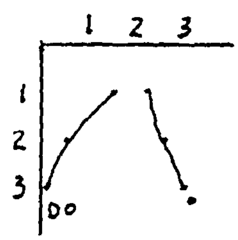
sta A



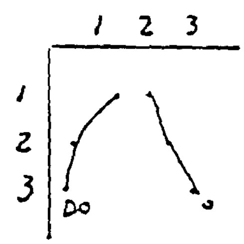
sta B



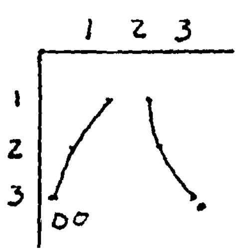
sta C



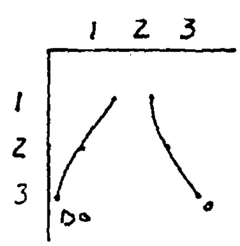
sta D



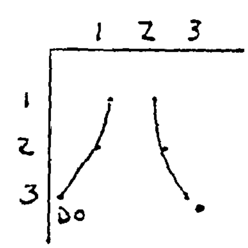
sta E



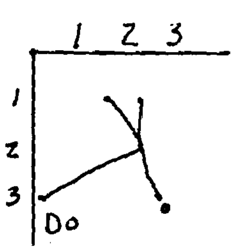
sta F



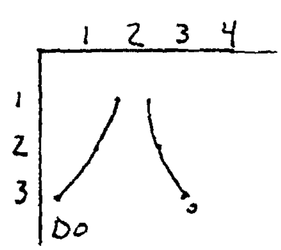
sta G

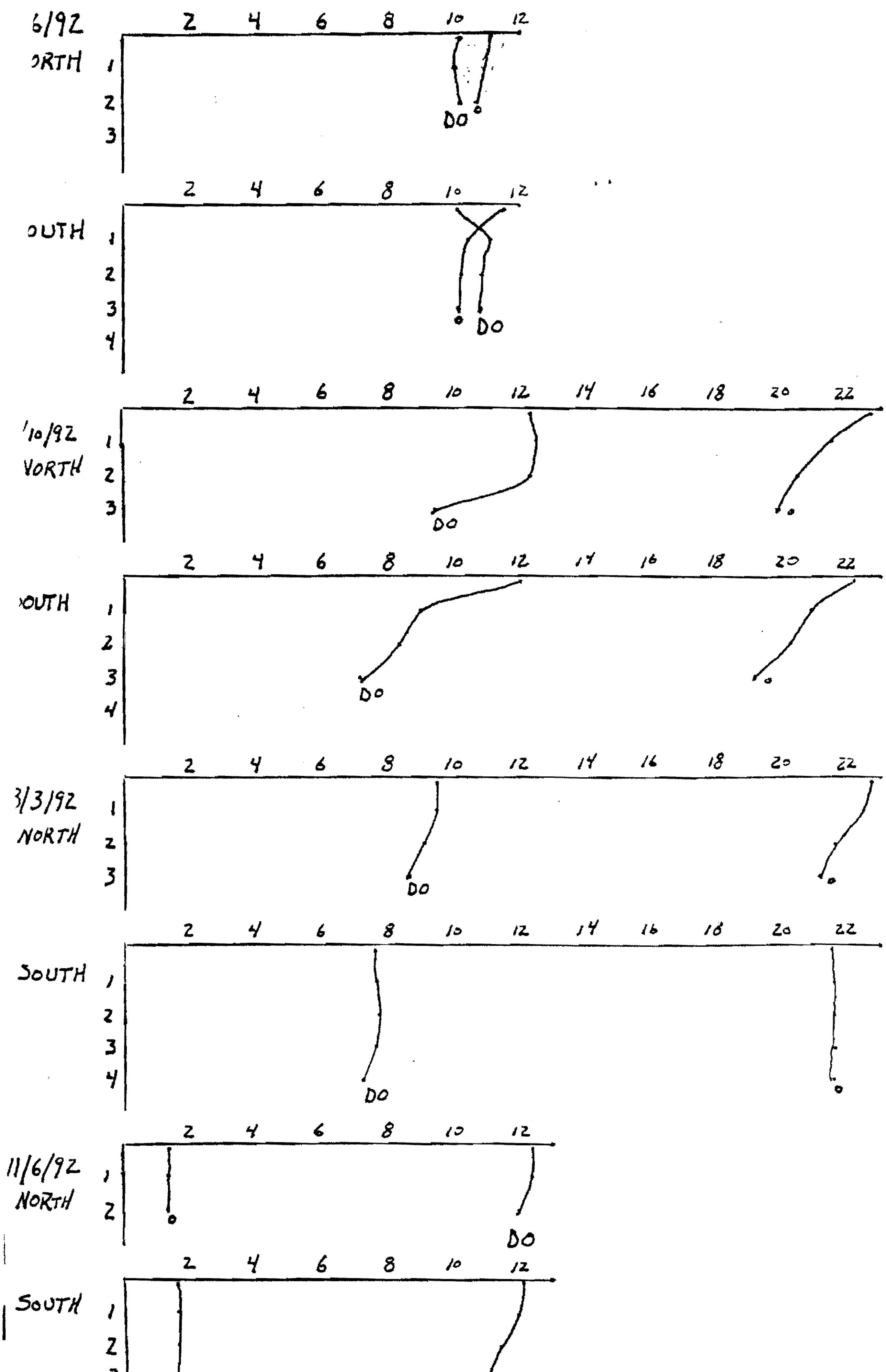


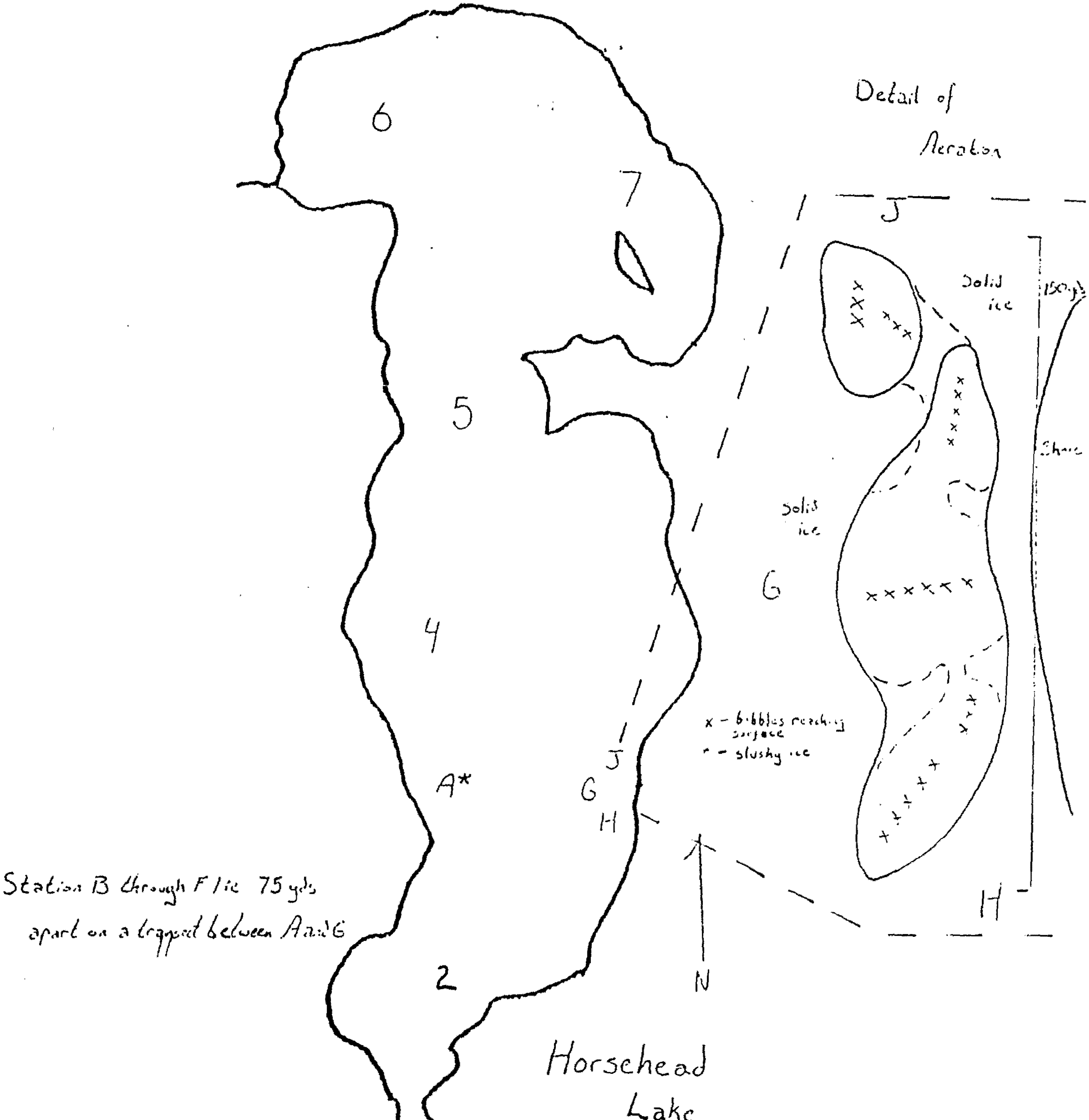
sta H



sta J



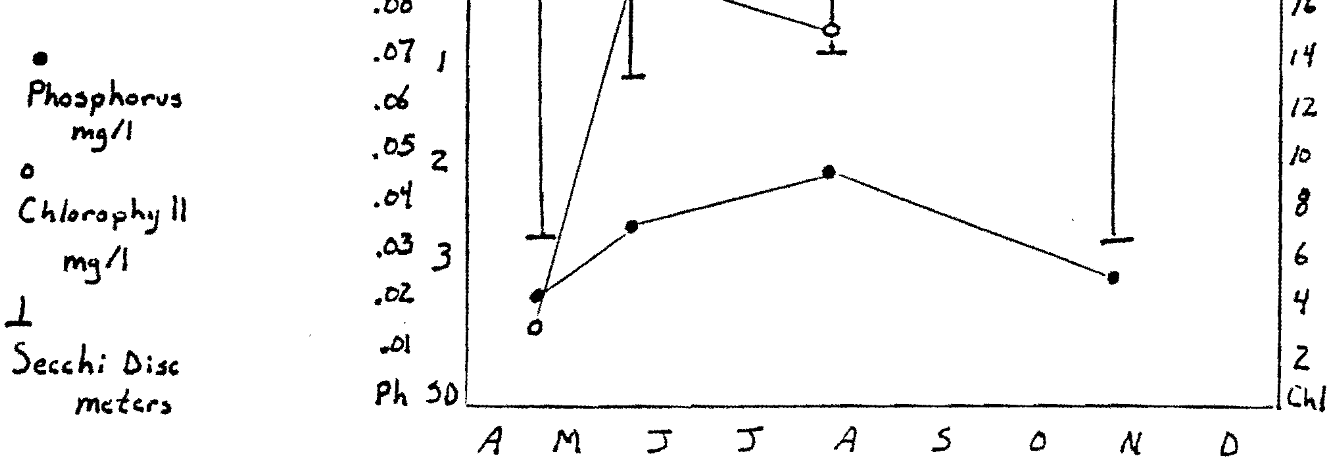

6/92
ORTH
OUTH
10/92
NORTH
OUTH
3/3/92
NORTH
SOUTH
11/6/92
NORTH
SOUTH
2 4 6 8 10 12 14 16 18 20 22
1 2 3 4
DO


Detail of Aeration
J
Solid ice
150 yds
Shore
Solid ice
G
x – bubbles reaching surface
+ – slushy ice
H
6
7
5
4
A*
J
G
H
2
N
Station B through F lie 75 yds
apart on a transect between A and G
Horsehead Lake

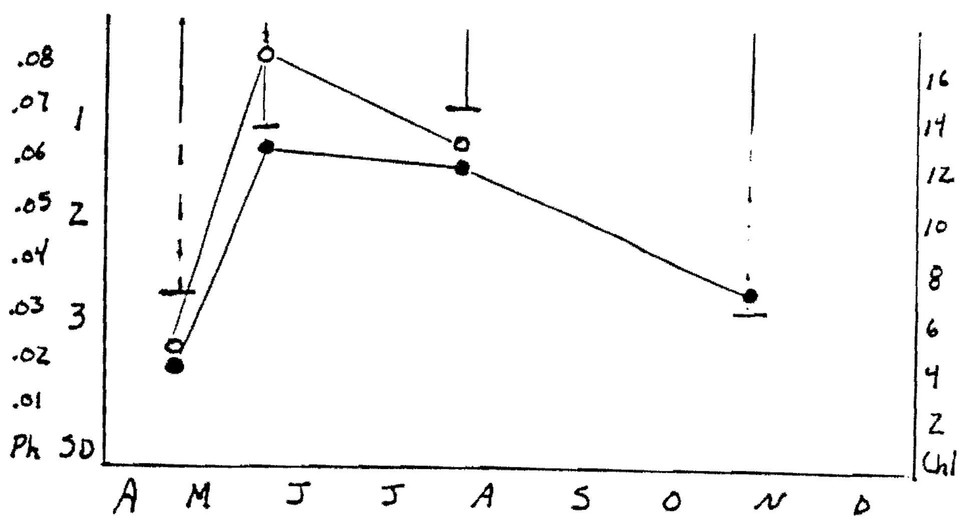
Chlorophyll

Chlorophyll α, a pigment found in algae, is used as an indicator of algal growth. Chlorophyll levels were very high during the open water period indicating heavy algae blooms throughout the summer. It is often closely associated with water clarity and phosphorus levels. Phosphorus is necessary for algal growth and the more algae, the lower the visibility, thus the relationship. The following graphs show that relationship on Horsehead Lake.

NORTH BASIN



SOUTH BASIN



For complete chlorophyll results see appendix 2.

Macrophytes

Macrophyte growth was quite sparse on Horsehead, occurring in five distinct beds. Two of these beds consisted of floating leaf vegetation and were located on each side of the northern lobe. A bed of emergent vegetation occurred at the narrows between the two basins. The remainder of macrophyte growth was found in two beds in the southern basin. One lay along the eastern shore and consisted almost exclusively of *Potamogeton crispus*, an exotic that often thrives in low-light, salty or polluted conditions. The final area of weed growth was found on the very southern end of the lake and consisted of eight different species.

The limited macrophyte growth is probably due to a combination of low light and loose sediment. Heavy algae production kept Secchi depths to 4 feet or less throughout much of the growing season, meaning that most of the lake bottom received little or no light. At many of the stations where light did reach the bottom, the sediment is too flocculent to support growth. Plants that did grow in these areas have extremely thick tuberous roots. A detailed report of the macrophyte survey is included here as appendix A.

Summary & Recommendations

As a lake ages and nutrients accumulate, it becomes more productive or eutrophic. The rate of this process can be dramatically effected by the activities of man. The situation on Horsehead Lake is one of naturally high productivity probably moderately increased by man.

Natural factors include the lake's size, shape and surrounding geography. Since Horsehead Lake is long and relatively shallow, the action of the wind is able to keep recycling nutrients for use by plants or algae. The nutrient load is also increased by the relatively heavy shoreline development.

The following two models use phosphorus, chlorophyll α and Secchi depth to estimate water quality and trophic state (lake age). As the models show Horsehead Lake is quite eutrophic (productive), with water quality in the "fair" range.

Trophic Level	Total Phosphorus	Secchi Disc	Chlorophyll
	•		•
Eutrophic		•	
	20	2.0	8.5
Mesotrophic			
	10	4.0	2.3
Oligotrophic			

(Carlson, R.E., 1977, A trophic state index for lakes:
Limnology and Oceanography, March, v. 22(2), p. 361-369)

Water quality index	Total Phosphorus (mg/l)	Chlorophyll α (ug/l)	Secchi (ft)
Excellent	<0.001	<1	<19.7
very good	.001-.010	1-5	9.8-19.7
good	.010-.030	5-10	6.6-9.8
fair	**.030-.050**	**10-15**	4.9-6.6
poor	.050-.150	15-30	**3.3-4.9**
very poor	>.150	>30	>3.3

(Lillie, R.A., and J.W. Mason, 1983, Limnological characteristics of Wisconsin lakes: Wisconsin Dept. of Natural Resources Technical Bulletin No 138, 1116 p.)

While these models indicate a very productive system, the good news is that management efforts over the last decade and a half seem to have significantly reduced productivity. Nutrient level were not measured during the study performed in 1976, but Secchi disc depth and chlorophyll α levels indicate a marked improvement in water quality since then. Below is a comparison of these two parameters determined during each study:

SECCHI DISC (feet)	5/5/76 - 3.8	5/6/92 - 9.0
	6/9/76 - 2.7	6/10/92 - 4.0
	8/5/76 - 1.0	8/5/92 - 3.2
	11/4/76 - 2.8	11/6/92 - 9.0
CHLOROPHYLL α (mg/l)	5/17/76 - 23.1	5/6/92 - 4.4
	6/15/76 - 28.3	6/10/92 - 17.7
	8/25/92 - 37.4	8/5/92 - 15.1

While this is encouraging news, keep in mind that Horsehead lake will never be a crystal-clear, swimming lake. Natural factor make that unfeasible if not impossible. However, aeration and drawdown seem to be improving the system notably. The heavy use by anglers attests to that.

Macrophyte growth on Horsehead poses an unusual situation in terms of management strategies. Usually, if an exotic species is relatively dominant as *Potamogeton crispus* is, efforts are made to eradicate it. On Horsehead however, *P. crispus* provides cover in a lake with little other macrophyte growth and also acts to bind some nutrients which may otherwise be available for algal growth. This species does quite well in the low-light conditions present on Horsehead, so it probably exhibits healthy growth any given year. According to Fassett (1957), it is relatively beneficial as food for ducks and food, shelter and shade for fish. Its growth should be monitored by lake residents to ensure it does not become a nuisance as this species is capable of choking growth. (*P. crispus* was not present in the lake in 1976.) Also, residents may want to clear areas in years of good light penetration (low algae growth) to give native species an opportunity to re-inhabit the more favorable substrate. This could be discussed further with a fisheries specialist.

While the water quality of Horsehead Lake does not appear to be threatened by any serious land use problems such as industrial waste or heavy agriculture, it is effected to an extent by man's activities on the lake and in the watershed. Proper "common sense" practices can be as important as high-tech rehabilitation efforts. These are low-tech, low-cost practices by lake residents and users to avoid accelerating the lake aging process. They include the following:

* Maintain naturally vegetated "buffer zones" along the shore,
* Carefully monitor septic system performance; update if necessary,
* Landscape to decrease erosion,
* Divert runoff from construction sites,
* Avoid the use of chemical fertilizers,
* Keep lawn and garden wastes from washing into the lake,
* Avoid burning on the lake,
* Operate motorized water craft slowly in shallow, heavily sedimented areas.

These efforts, while they do not have exhibit the dramatic effects of high tech strategies, provide longer-lasting improvement or preservation of the system. The last thing a lake with naturally high productivity needs is a an avoidable influx of nutrients. Finally, we recommend a long-term, self-help monitoring program. A simple program which can be an extremely effective indicator of changes in aging trends is regular Secchi disc readings. As the graph on page 6 showed, this measurement is often on indicator of nutrient levels. It should be done at regular intervals of about 2 weeks and can be used with or without annual nutrient analysis to track water quality for a minimal cost. Information on establishing a self-help monitoring program is available through the Department of Natural Resources.

APPENDIX A

MACROPHYTE SURVEY

HORSEHEAD LAKE
ONEIDA COUNTY, WISCONSIN

PERFORMED BY: R.T. KRUEGER AND J.L. GESKE

AUGUST 5, 1992

NORTHERN LAKE SERVICE, INC.
400 NORTH LAKE AVENUE
CRANDON, WI 54520

REPORT PREPARED
October 11, 1992

Introduction

On August 5, 1992, a general macrophyte survey was conducted on Horsehead Lake, Oneida County. The survey was performed to determine density, distribution and diversity of aquatic vegetation. General observation were made thoughout the lake, with depth and density measurements made at specific stations. These stations were initially laid out on a grid, but this was highly modified in the actual survey. Many more stations were added along the shoreline and only a few deeper water stations were sampled to assure nothing was growing at these depths. (See the station map for final sampling sites.) I feel the 58 stations we settled upon provide a good representation of the lake as a whole.

Methodology

At each numbered station a 10 foot circle is visualized and divided into 4 quadrants. Macrophytes are then collected, identified, and ranked as follows: 1 if present in 1 quadrant, 2 if present in 2 quadrants, etc... A ranking of 5 signifies complete or near complete dominance by one species, occupying a significant portion of the water column. If a species is observed growing outside the circle, it is given a "p" for present. Species receiving only this designation are not considered when relative frequency, average density, and depth to growth are calculated, but are included on the species list. If a specimen cannot be identified to species it is referred to by the generic name followed by "sp" ("spp" indicates the presence of more than one unidentified species of the given genus.) Water depth, depth to vegetation, percent open water, and bottom type (if depth permits) is also recorded at each station.

Bottom type descriptions are as follows: D=detritus, G=gravel, H=hard, clay like, M=Muck, R=Rocks, S=sand.

Survey Findings

Macrophyte growth on Horsehead Lake is quite limited in both distribution and diversity. Only about 10% of the lake supports any growth. Vegetation was found at 2/3 of the stations 5 feet deep or less but was completely absent at depths greater than 5 feet. Only 13 different species were collected during the survey, of which 4 were floating-leaf, 4 emergent, and 5 submergent. The most diversity was exhibited at the southern end of the lake and the east and west shores of the north lobe. Even in these areas the communities were not particularly diverse. Station 33 supported 8 different species. No other station supported more than 5 species; 16 of the 22 vegetated station supported 3 or fewer species.

Emergent vegetation occurred in one relatively large dense bed near station 17 and several small scattered areas near the outlet. The large bed consisted solely of *Scirpus validus* while the smaller beds were mostly *Typha latifolia* with very little *sagittaria* and *Pontederia cordata*.

Most of the floating leaf vegetation was found in the northern lobe of the lake with the largest bed along the west shore of that lobe. Scattered beds also occurred on the east shore, around the island and near the outlet. The beds consisted of Nuphar variegation, *Nymphaea odorata* and, to a lesser extent, *Polygonum natans*.

Submergent species were absent from the entire north lobe and much of the south. The sediments in these areas are extremely flocculent. This, along with the low light penetration throughout the lake, kept submergent growth minimal. The eastern shore of the southern lobe supports a thin yet dense band of *Potomogeten crispus*, an exotic from Europe generally associated with salty or polluted waters. During the 1976 survey these areas were inhabited by sparse to moderate beds of *Elodea canadensis, Potamogeten pectinatus, P richardsonii, P robbinsii, P. zosteriformis,* and *Vallisneria americana* which were absent during this survey. (*Elodea* and *P. zosteriformis* were present closer to the outlet but the remaining species were not collected at all.) At the time of the earlier study *P. crispus* was not present. Apparently this species was introduced since then and, being quite adaptible to low-light situations, was able to out compete most other macrophytes for the decent growing areas. The only other area that supported dense submerged growth was the far southern end of the lake. Here moderate to dense growth of *Elodea canadensis* and *Ceratophyllum demersum* were common, along with two species of pondweed. One was small-leafed and lacked fruiting bodies, making identification nearly impossible. The other is believed to be stunted *P.*

zosteriformis.

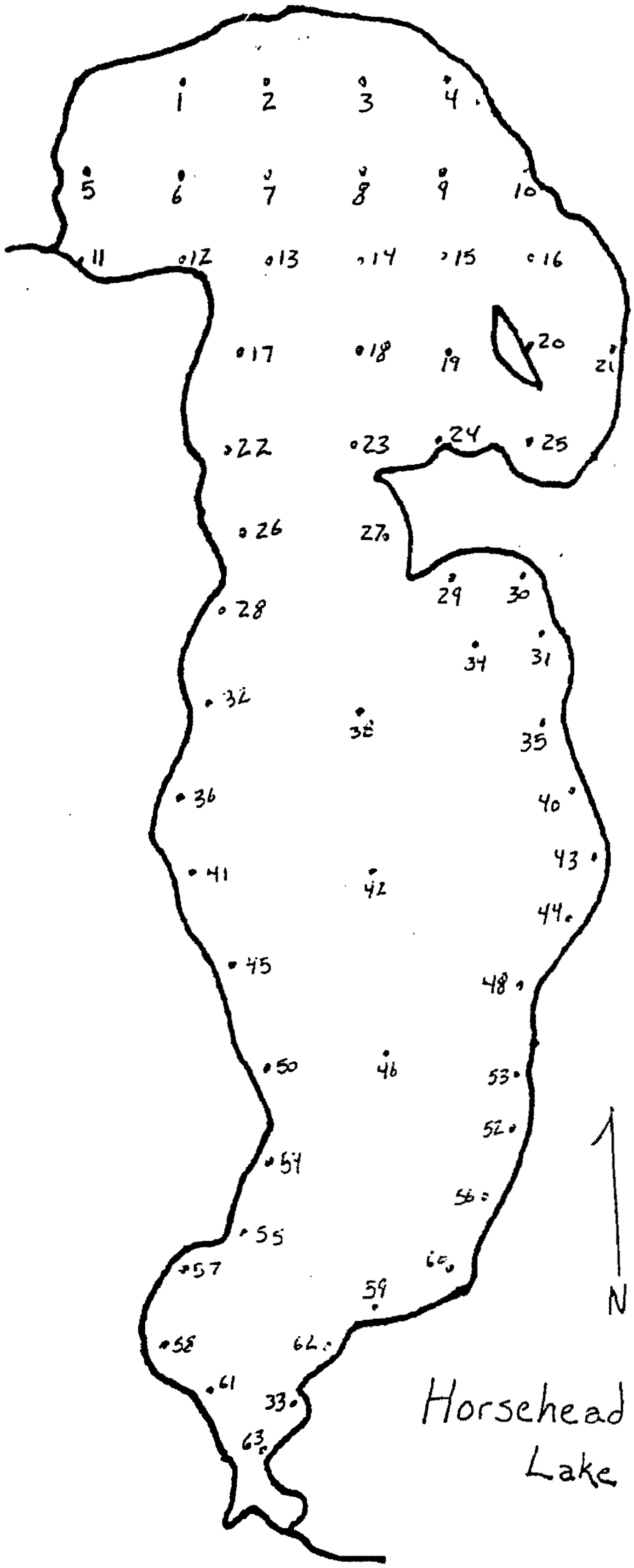
The majority of the sampling sites had a very flocculent muck/detritus bottom - 62 %. Only 10 of these 36 stations supported vegetation and the vast majority of the vegetation consisted of plants with very large, tuberous roots well adapted to that type of sediment. Twenty of the 58 stations were sand, gravel or a combination of the two. Of these, 10 sites supported *P.crispus*; 8 of the remaining 9 supported no macrophyte growth.

Summary

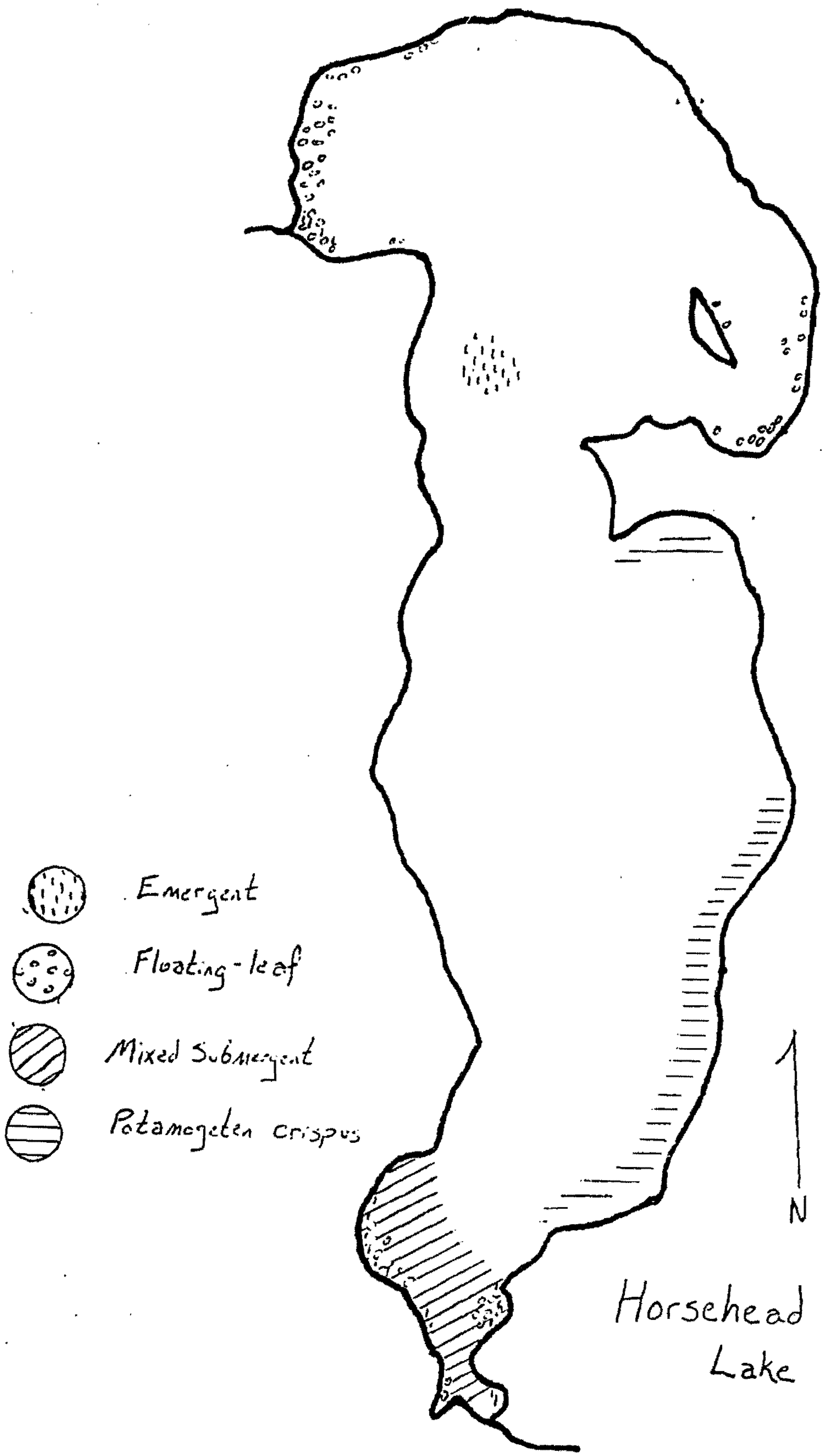
Macrophyte growth on Horsehead Lake is quite limited due to low light penetration and extremely loose sediments over much of the bottom. Growth is limited almost exclusively to 5 general areas: floating leaf communities in the east and west bays of the north basin, one bed of emergents in the narrows, a very narrow strip of submergents along the east shore of the southern basin and mixed vegetation on the far southern end. Diversity, already somewhat lacking during the study in 1976 has been further depleted due to the introduction of *Potamogeten crispus*, an exotic which thrives in otherwise adverse conditions. While this growth is quite dense it is not extensive: in most places the band of growth is only about 20-30 feet wide. Residents may want to consider raking these areas free of *P. crispus*, thus opening the best substrate for possible re-establishment of native flora.

horse.doc

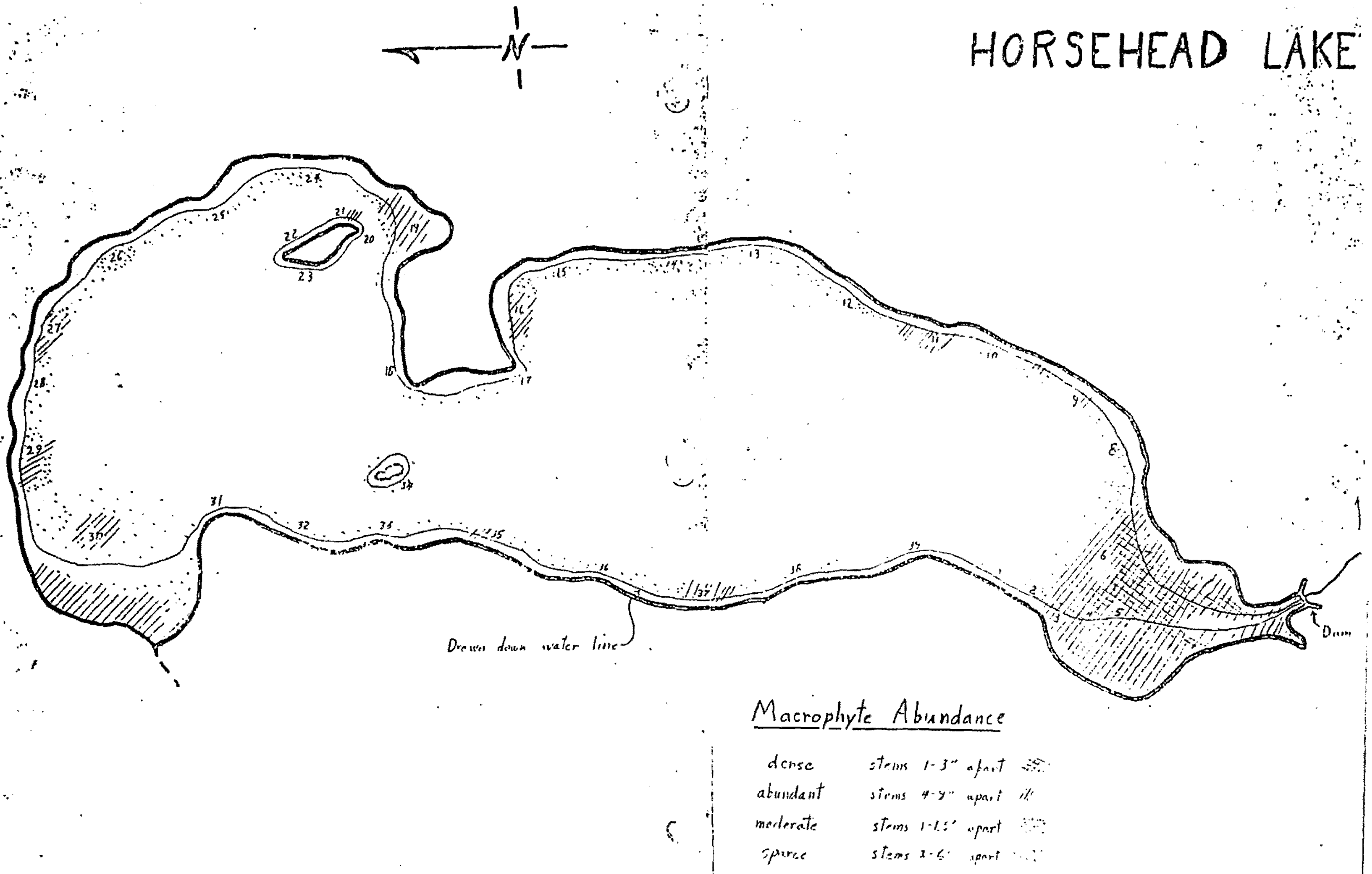
Survey Stations

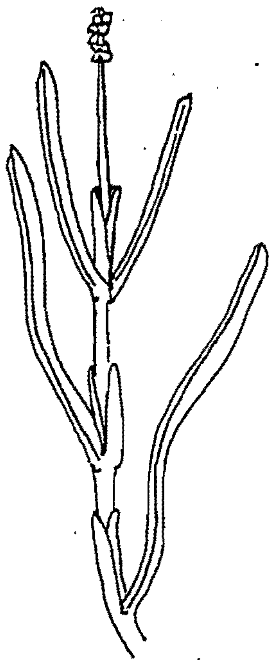


Macrophyte Communities

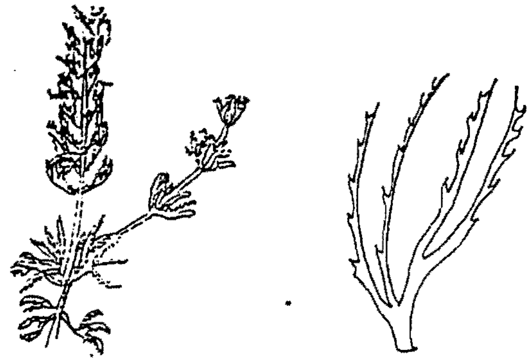


HORSEHEAD LAKE

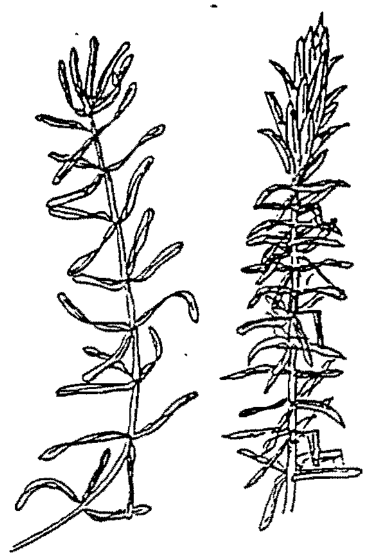




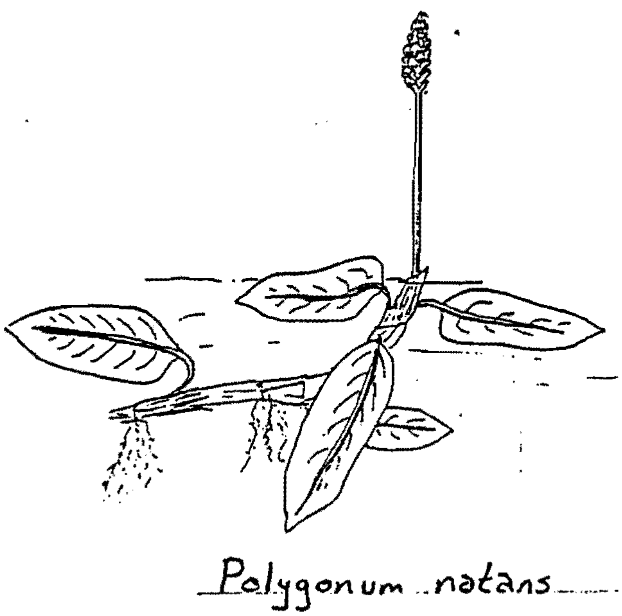
Potamogeten zosteriformis



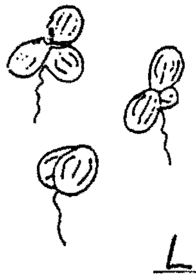
Ceratophyllum demersum



Elodea canadensis



Polygonum natans



Lemna minor

Potamogeten crispus

APPENDIX B

HORSEHEAD LAKE CHLOROPHYLL RESULTS

ORTH

ate	CCα	Pheo α	TCα	TCb	TCc
/06/92	4.35	2.56	6.04	.349	.744
/10/93	16.31	3.47	16.81	1.05	.821
/05/92	13.86	-.55	14.09	-.73	1.03

OUTH

/06/92	3.45	1.26	4.32	.288	.490
/10/92	17.68	3.03	20.18	8.77	1.09
/05/92	15.09	-6.71	15.68	.94	.99

ey

Cα	=	Corrected α
heo α	=	Pheophytin α
Cα	=	Trichromatic chlorophyll α
Cb	=	Trichromatic chlorophyll b
Cc	=	Trichromatic chlorophyll c
nits	=	ug/l

ORSEHEAD LAKE DISSOLVED OXYGEN/TEMPERATURE RESULTS

OUTH BASIN

epth	5/6/92	6/10/92	8/5/92	11/6/92
.1 meters	10.1/11.5	12.0/22.2°	7.7/21.6°	12.1/1.7°
meters	11.1/10.4°	9.0/20.9°	7.8/21.6°	12.0/1.7°
meters	10.9/10.2°	8.6/20.2°	7.8/21.6°	11.5/1.7°
meters	10.9/10.1°	7.1/19.2°	7.7/21.6°	11.1/1.7°
meters	3.5 bottom	3.75 bottom	7.3/21.6° 4.25 bottom	3.5 bottom

ORTH BASIN

.1 meters	10.2/11.1°	12.3/22.7°	9.5/22.8°	12.4/1.4°
meters	10.0/11.0°	12.6/21.6°	9.5/22.6°	12.4/1.4°
meters	10.2/10.7°	12.3/20.5°	9.1/21.6°	12.0/1.4°
meters	2.5 bottom	9.6/19.9° 3.25 bottom	8.7/21.2° 3.25 bottom	2.75 bottom

issolved oxygen units: mg/l
emperature units: °C

HORSEHEAD LAKE ANALYTICAL RESULTS

Parameter	Units	5/6/92	6/10/92	8/3/92	11/6/92
NORTH BASIN					
Alkalinity	mg/l	28	40	46	56
Chloride	mg/l	1	5	4	2
Chlorophyll α	ug/l	4.35	16.31	13.86	--
Conductivity	umho@25C	89	113	120	100
pH	s.u.	7.4	8.8	9.1	7.6
Kjeldahl-N	mg/l	0.12	0.57	0.79	0.66
NO2+NO3	mg/l	0.10	<0.05	<0.05	0.13
Ammonia-N	mg/l	<0.05	<0.05	0.06	0.10
Tot. Phosph.	mg/l	0.020	0.066	0.060	0.036
Secchi disc	feet	bottom	4.0	3.1	bottom
SOUTH BASIN					
Alkalinity	mg/l	28	40	46	60
Chloride	mg/l	7	4	2	2
Chlorophyll α	ug/l	3.45	17.68	15.09	--
Conductivity	umho@25C	87	109	110	100
pH	s.u.	7.6	8.9	9.2	7.7
Kjeldahl-N	mg/l	0.38	0.73	1.07	0.76
NO2+NO3	mg/l	0.05	<0.05	<0.05	0.19
Ammonia-N	mg/l	<0.05	0.06	0.05	0.08
Tot. Phosph.	mg/l	0.022	0.036	0.048	0.027
Secchi disc	feet	9.0	4.0	3.2	9.0

/midres.doc