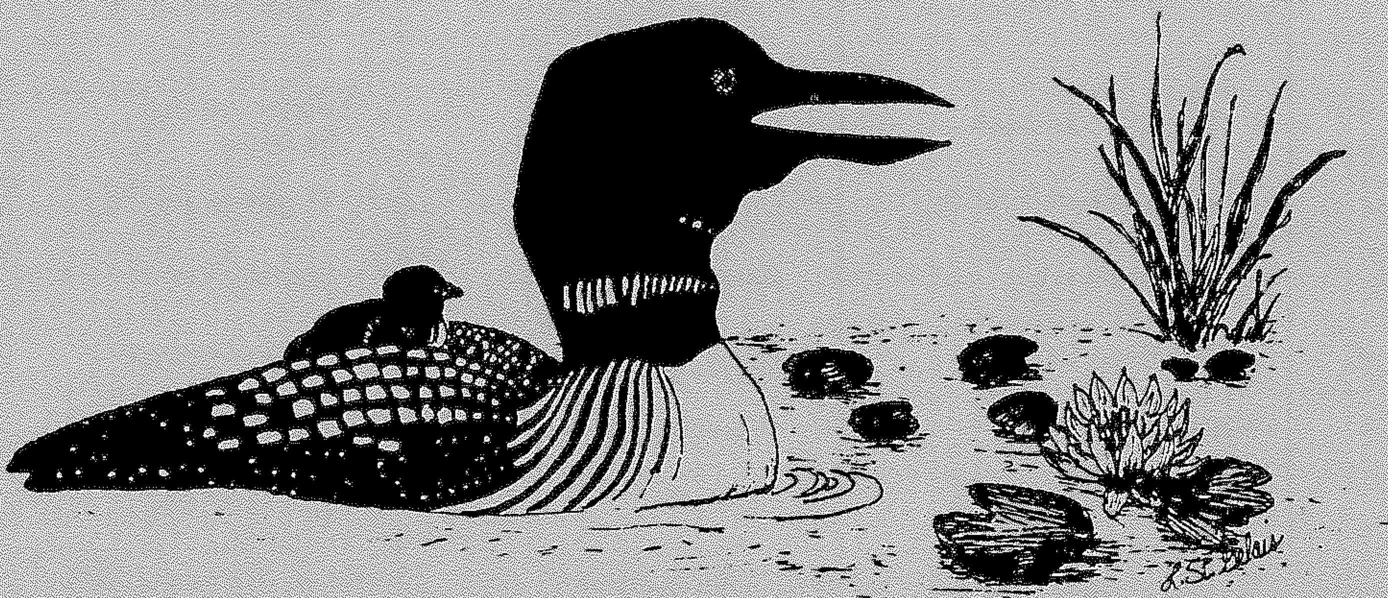
# THE PEMAQUID LAKES
# 1994
## NH LAKES LAY MONITORING PROGRAM



NEW HAMPSHIRE LAKES LAY MONITORING PROGRAM

NH LLMP


by
Robert Craycraft
&
Jeffrey Schloss

edited by
Dr. Alan Baker
&
Dr. James Haney

*FRESHWATER BIOLOGY GROUP*
University of New Hampshire
Durham

UNIVERSITY OF NEW HAMPSHIRE COOPERATIVE EXTENSION
Helping You To Put Knowledge and Research To Work

To obtain more information about the NH Lakes Lay Monitoring Program (NH LLMP) contact the Coordinator (J.Schloss) at (603) 862-3848
Dr. Baker at 862-3845 or Dr. Haney at 862-2106

# PARAMETERS SAMPLED

## NH LAKES LAY MONITORING PROGRAM

**LAY MONITORS**

- **BASIC PROGRAM**
  - Secchi Disk Depth
  - Temperature Profile
  - Chlorophyll a
  - Dissolved Color
  - Total Alkalinity
  - Total Phosphorus
- **ADVANCED OPTIONS**
  - pH
  - Metalimnetic Chlorophyll a
  - Specific Conductivity
  - Hypolimnetic Total Phosphorus
  - Dissolved Oxygen
  - Bacteria
  - Fish Condition
  - Rainfall & pH
  - Aquatic Vegetation Surveys
  - Motorboat Effects
  - Watershed NPS Surveys
  - Road Salt Runoff
- **STREAM MONITORING**
  - Observational Surveys
  - Temperature
  - Specific Conductivity
  - Total Alkalinity
  - Total Phosphorus
  - Stream Flow
  - Macro-Invertebrates
  - Storm Event Sampling
  - Bacteria

Freshwater Biology Group (FBG) corroboration with the lay monitor data includes assessment of 1) physical parameters (water transparency, temperature profiles, light transmission profiles and water color); 2) chemical parameters (dissolved oxygen profiles, "free" carbon dioxide, total alkalinity, pH, total phosphorus and specific conductivity profiles); 3) biological parameters (chlorophyll a, phytoplankton community and zooplankton community). Note: in addition to the above parameters, other measurements are often collected at the discretion of the FBG or at the request of the lake association.

# PREFACE

This report contains the findings of a water quality survey of the ponds in the **Pemaquid Watershed Association (PWA)**, towns of Breman, Bristol, Damariscotta, Nobelboro and Waldoboro, Maine, conducted in the summer of 1994 by the **Freshwater Biology Group (FBG)** of the University of New Hampshire and the **Pemaquid Watershed Association**.

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1994 results as well as more detailed "Introduction" and "Discussion" sections. Graphic display of data is included, in addition to listings of data in appendices, to aid visual perspective.

# ACKNOWLEDGMENTS

1994 was the seventh year of participation in the **Lakes Lay Monitoring Program (LLMP)** for the **Pemaquid Watershed Association** monitors. Peter Fischer again undertook the formidable task of coordinating the multi-lake study and acted as the liaison to the **FBG**.

**Table 1. 1994 Pemaquid Watershed Association Volunteer Monitors:**

| Monitor Name | Lake Monitored |
|---|---|
| Scott Gigvere | Biscay |
| Peter Fischer | Boyd |
| David Libby | Duckpuddle |
| Albert "Mac" Rogers | McCurdy |
| Steve O'Bryan | Paradise |
| David McLeod | Pemaquid |

**The Freshwater Biology Group (FBG)** congratulates the Lay Monitors on the quality of their work, and the time and effort put forth. We encourage other interested members of the **Pemaquid Watershed Association** to continue monitoring during the 1995 sampling season. Financial support for the monitoring effort was provided by the towns of Bremen, Bristol, Damariscotta and Nobelboro. Additional support was supplied by the Great Salt Bay Sanitary District, which provided lab space and personnel who performed bacteriological analysis, the Mobile Glass Company of Bristol which assisted in equipment repair, and Gilliam's Fish Market in Damariscotta, which acted as a collection point for water quality samples. We would also like to acknowledge the previous support of the GTE Telephone Company (grant for digital thermometers) and the Science Source of Waldboro (equipment donation) through whose contributions data collection has become much more efficient.

The **Freshwater Biology Group** is a not-for-profit research program co-supervised by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the FBG summer field team included, Robert Craycraft (laboratory and field coordinator), Neim Hoang Dang, Tracy Grazia, Sean Proll and John Raifsnider. Other **FBG** staff assisting in the fall included Jessica Chappel and Rick Falzone while Lisa St. Gelais helped design our 1994 report format and the 1994 report cover.

The **FBG** acknowledges the University of New Hampshire Cooperative Extension for funding and furnishing office, laboratory and storage space. The College of Life Sciences and Agriculture provided accounting support and the UNH Office of Computer Services provided computer time and data storage allocations.

Participating groups in the **LLMP** include: The Center Harbor Bay Conservation Commission, Derry Conservation Commission, Dublin Garden Club, Governor's Island Club Inc., Meredith Bay Rotary Club, Nashua Regional Planning Commission, The New Hampshire Audubon Society, Society for Protection of Lakes and Streams, Walker's Pond Conservation Society, United Associations of Alton, the associations of Baboosic Lake, Berry Bay, Bow Lake Camp Owners, Caanan Street, Canobie Lake, Chalk Pond, Chesham Pond, Lake Chocorua, Cun-

ningham Pond, Crystal Lake, Dublin Lake, Glines Island, Goose Pond, Great East Lake, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Lovell Lake, March's Pond, Mendum's Pond, Merrymeeting Lake, Milton Ponds Lake Lay Monitoring, Mirror Lake (Tuftonboro), Moultonborough Bay, Lake Winnipesaukee, Naticook Lake, Newfound Lake, Nippo Lake, Pea Porridge Pond, Pemaquid Watershed, Silver Lake (Madison), Silver Lake (Tilton), Squam Lakes, Sunset Lake, Wentworth Lake and the towns of Alton, Amherst, Enfield, Errol, Madison, Meredith, Merrimack, Milan, Strafford and Wolfeboro.

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# INTRODUCTION

## The New Hampshire Lakes Lay Monitoring Program

1994 marked the seventeenth year of operation for the **NH Lakes Lay Monitoring Program (LLMP).** The **LLMP** has grown from a university class project on Chocorua Lake and pilot study on the Squam Lakes to a comprehensive state-wide program with over 500 volunteer monitors and more than 100 lakes participating. Originally developed to establish a data-base for determining long-term trends of lake water quality for science and management, the program has expanded by taking advantage of the many resources that citizen monitors can provide. The **NH LLMP** has an international reputation as a successful cooperative monitoring, education and research program. Current projects include: use of volunteer generated data for non-point pollution studies using high tech analysis system (Geographic Information Systems and Satellite Remote Sensing), intensive watershed monitoring for the development of lake nutrient budgets, and investigations of water quality and indicator organisms (food web analysis, fish condition, and stream invertebrates). The key ingredients responsible for the success of the program include innovative funding and cost reduction, assurance of credible data, practical sampling protocols and, most importantly, the interest and motivation of our volunteer monitors.

The 1994 sampling season was another exciting year for the **New Hampshire Lakes Lay Monitoring Program**. National recognition for the high quality of work by you, the volunteer monitors, continued with awards, requests for program information and invitations to speak at national conferences (Figure 1). Our Geographic

**Figure 1. Awards and Recognition.**

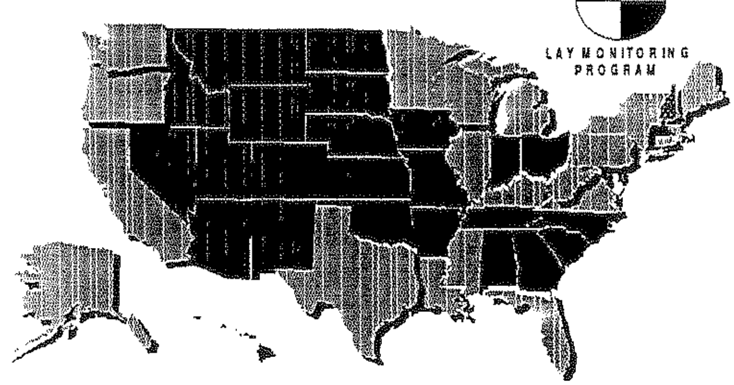
AWARDS

and


1983 - NH Environmental Law Council
1984 - Governor's Volunteerism Award
1985 - CNN Science & Technology Today
1988 - Governor's 'Gift' request funded
1990 - New Hampshire Journal on PBS
1991 - Renew America Success Award
- Environmental Success Index
- UN Environmental Programme
- Soviet Embassy Reception
- White House Environment Briefing
1992 - EPA Administrators Award
- Environmental Exchange Network
1993 - NH Lakes Association
1994 - Fourth National Citizens' Volunteer Monitoring Conference

NH LLMP Directly Involved with the Initiation, Expansion or Support of Volunteer Programs in 22 States.

NH LAKES LAY MONITORING PROGRAM



Information System study of Squam Lake was highlighted at the Fourth National Citizens' Volunteer Monitoring Conference held last April in Portland, Oregon. We were also invited to highlight our **NH LLMP** Cooperative Extension relationship at a southeast regional meeting for US Department of Agriculture water quality staff held in Florida. On the local front, the NH Senate Agricultural and Environment committee and the NH House Resource, Recreation and Development Committee were briefed on **NH LLMP** activities. We continue to be listed as a model citizen monitoring program on the Environmental Success Index of Renew America and on the Environmental Network Clearinghouse and were recently acknowledged by the National Awards Council for Environmental Sustainability. To date, the approach and methods of the **NH LLMP** have been adopted by new or existing programs in twenty two states and nine countries!

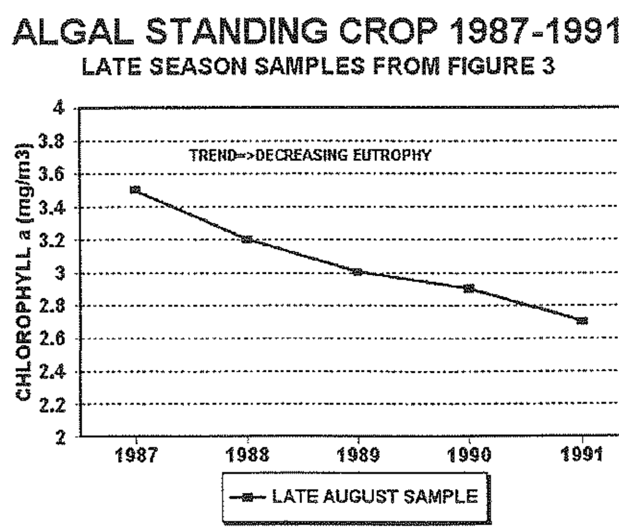
## Importance of Long-term Monitoring

A major goal of a monitoring program is to identify any short or long-term changes in the water quality of the lake. Of major concern is the detection of cultural eutrophication: increases in the productivity of the lake, the amount of algae and plant growth, due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern, as New Hampshire receives large amounts of acid precipitation, yet most of our lakes contain little mineral content to neutralize this type of pollution.

For almost a decade and a half, data collected weekly from lakes participating in the New Hampshire Lakes Lay Monitoring Program have indicated there is quite a variation in water quality indicators through the open water season on the majority of lakes. Short-term differences may be due to variations in weather, lake use, or other chance events. Monthly sampling of a lake during a single summer provides some useful information, but there is a greater chance that important short-term events such as algal blooms the lake response to storm run-off will be missed. These short-term fluctuations may be unrelated to the actual long-term trend of a lake or they may be indicative of the changing status or "health" of a lake.

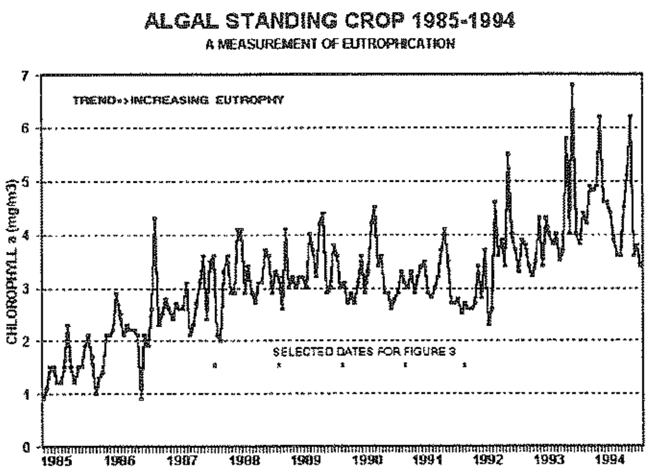
To determine if a change in water quality is occurring, a lake must be sampled on a frequent basis over a substantial amount of time. A poorly designed sampling program may even mislead the investigator away from the actual trend: Consider the hypothetical lake in Figure 2. Sampling only once a year during August from 1987 to 1991 would produce a plot (Fig. 2) suggesting a decrease in eutrophication. The actual

**Figure 2.**



long-term trend of the lake, increasing eutrophy, can only be clearly discerned by sampling additional times a year for a ten year period (Fig. 3). Frequent monitoring carried out over the course of many summers can provide the information required to distinguish between short-term fluctuation ("noise") and long-term trends ("signal"). To that end, the lake must establish a long-term data base.

**Figure 3.**




The number of seasons it takes to distinguish between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long-term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. In addition, different areas of a lake may show a different response. As more data is collected, prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of the lake.

There are also short-term uses for lay monitoring data. The examination of different stations in a lake can disclose the location of specific problems and corrective action can be initiated to handle the situation before it becomes more serious. On a lighter note, some associations post their weekly data for use in determining the best depths for finding fish!

It takes a considerable amount of effort as well as a deep concern for one's lake to be a lay monitor in the **NH Lakes Lay Monitoring Program**. Many times a monitor has to brave inclement weather or heavy boat traffic to collect samples. Sometimes it even may seem that one week's data is just the same as the next. Yet every sampling provides important information on the variability of the lake.

We are pleased with the interest and commitment of our Lay Monitors and are proud that their work is what makes the **NH LLMP** the most extensive, and we believe, the best volunteer program of its kind.

# Purpose and Scope of This Study

1994 was the sixth year that monitoring of Boyd Pond and the seventh year that monitoring of Biscay, Duckpuddle, McCurdy, Paradise and Pemaquid Ponds was undertaken by the **Freshwater Biology Group** and the **Pemaquid Watershed Association** (see figures 4 through 8 for site locations). The program of sampling was designed to continue adding data to the long-term data base established. Sampling emphasis was placed on one open water deep station in each pond while extensive tributary sampling was undertaken on the Glendon Stream tributary system to identify potential problem areas in the Duckpuddle Pond watershed.

**Figure 4. Location of the ponds falling within the Pemaquid Watershed.**

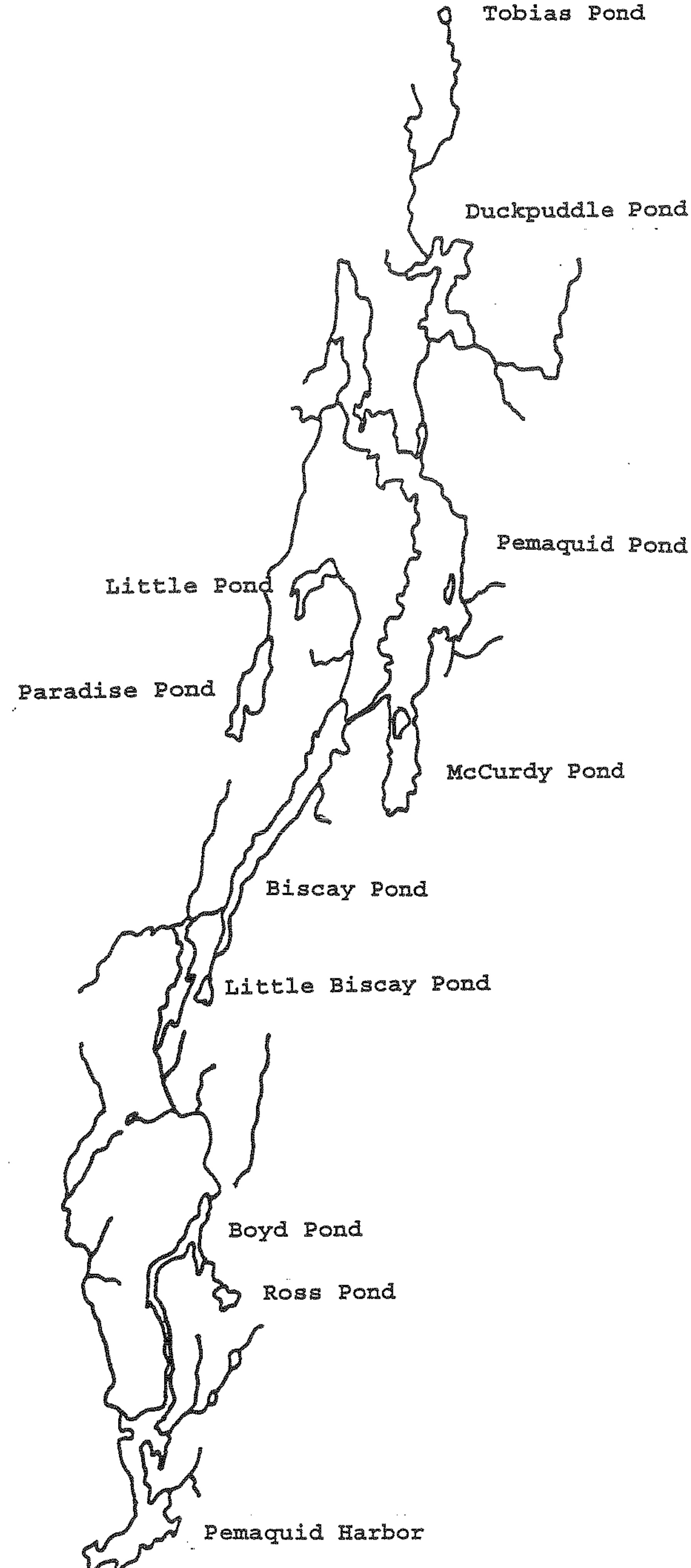

Tobias Pond
Duckpuddle Pond
Pemaquid Pond
Little Pond
Paradise Pond
McCurdy Pond
Biscay Pond
Little Biscay Pond
Boyd Pond
Ross Pond
Pemaquid Harbor

**Figure 5.Location of the deep sampling stations from Duckpuddle Pond; Site 1 Basin, and Pemaquid Pond; Sites 1 Basin and 2 Basin. The location of the Glendon Stream sampling station, which feeds Duckpuddle Pond, is also listed.**

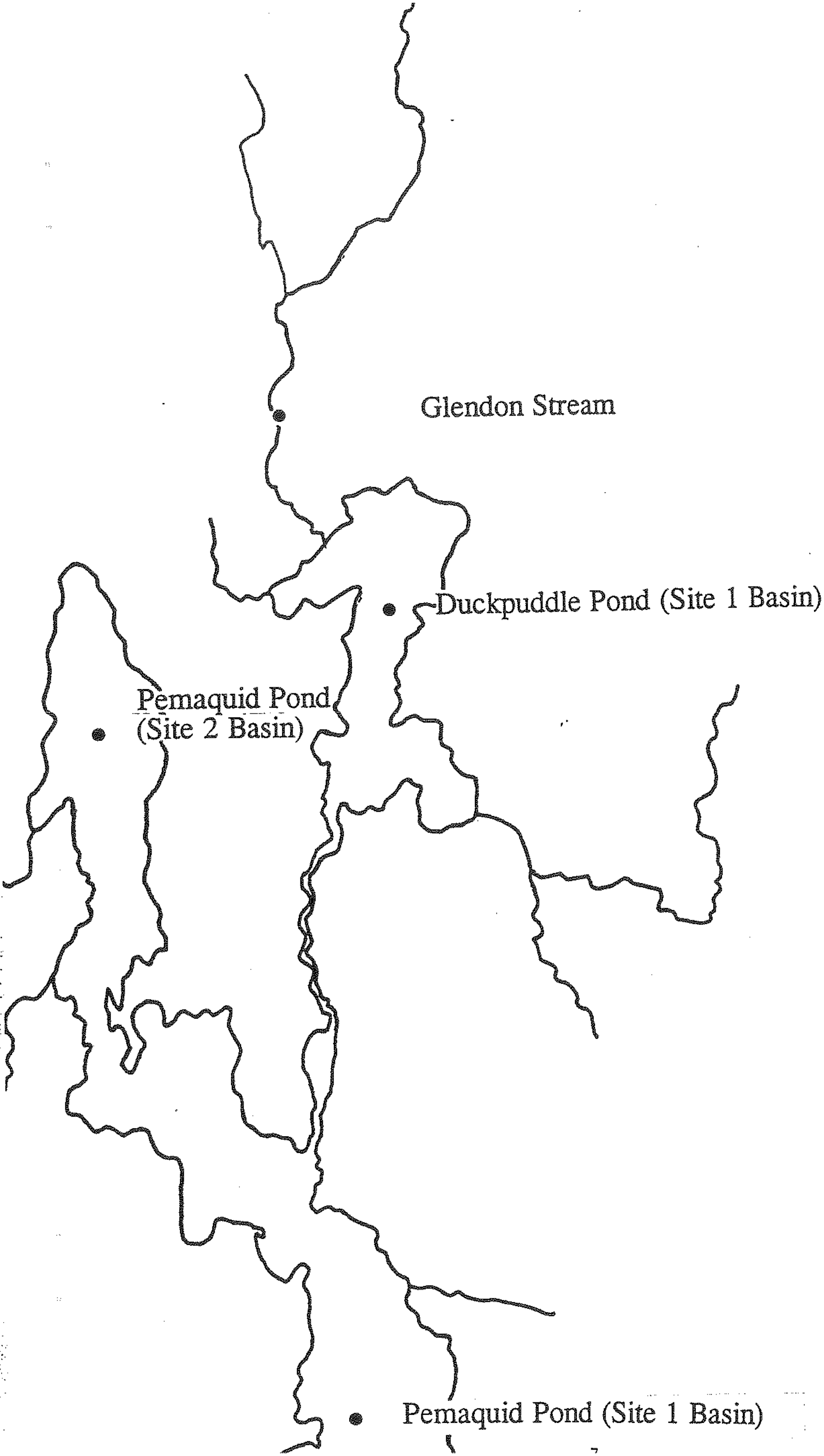

Glendon Stream
Duckpuddle Pond (Site 1 Basin)
Pemaquid Pond
(Site 2 Basin)
Pemaquid Pond (Site 1 Basin)

Figure 6.Location of the deep sampling stations from Biscay Pond; Site 1 North, McCurdy Pond; Site 1 Basin, and Pemaquid Pond; Site 1 Basin. The location of the Biscay Stream (Site 20 Biscay Road) is also included and functions as both the major outlet of Pemaquid Pond and the major inlet to Biscay Pond.

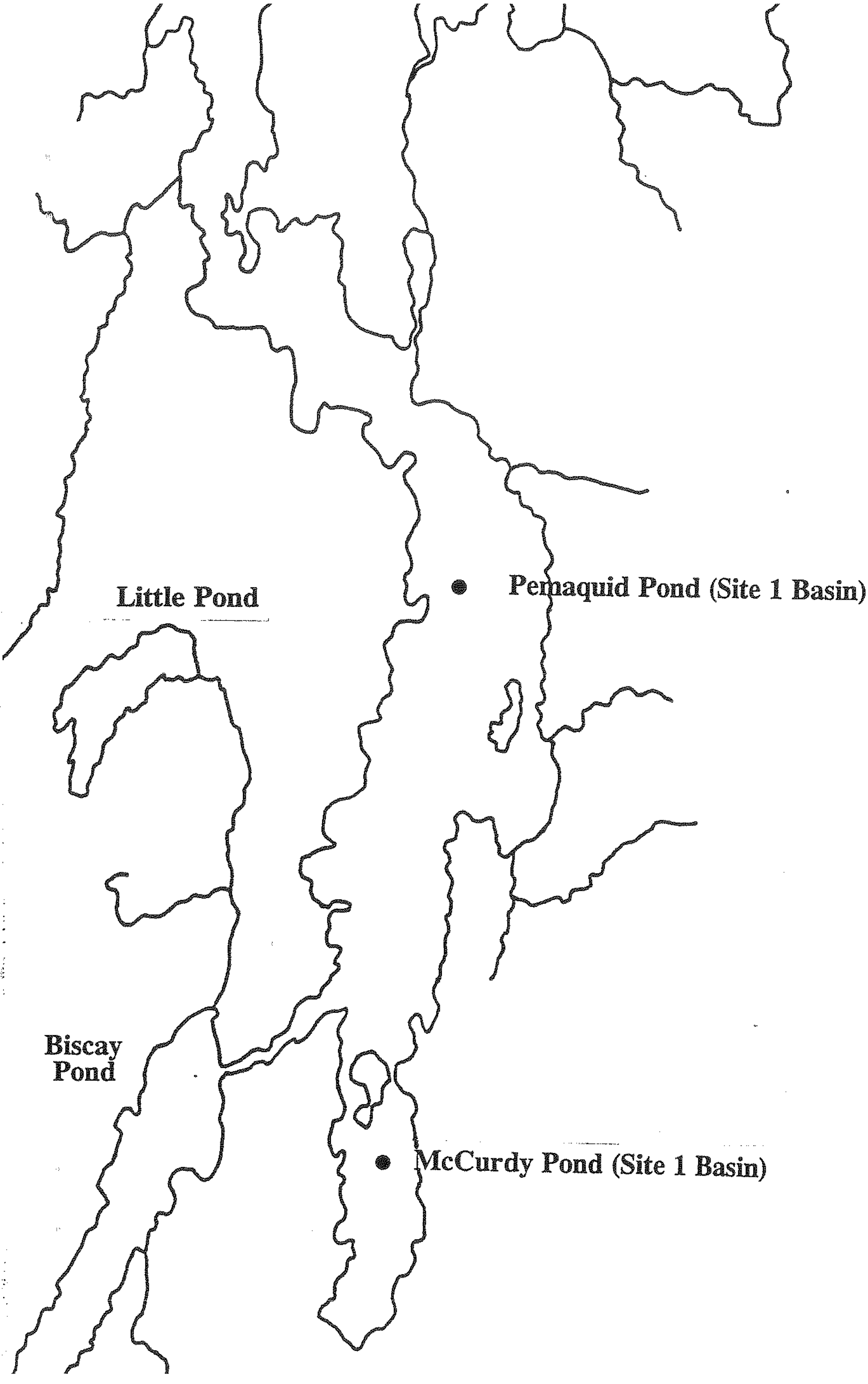

Little Pond
Pemaquid Pond (Site 1 Basin)
Biscay Pond
McCurdy Pond (Site 1 Basin)

**Figure 7.Location of the deep sampling stations from Biscay Pond; Site 1 North, McCurdy Pond; Site 1 Basin, and Paradise Pond; Site 2 North. The location of the Pemaquid River (10 Lesner Road) sampling station, which functions as the major outlet of Biscay Pond, is also included.**

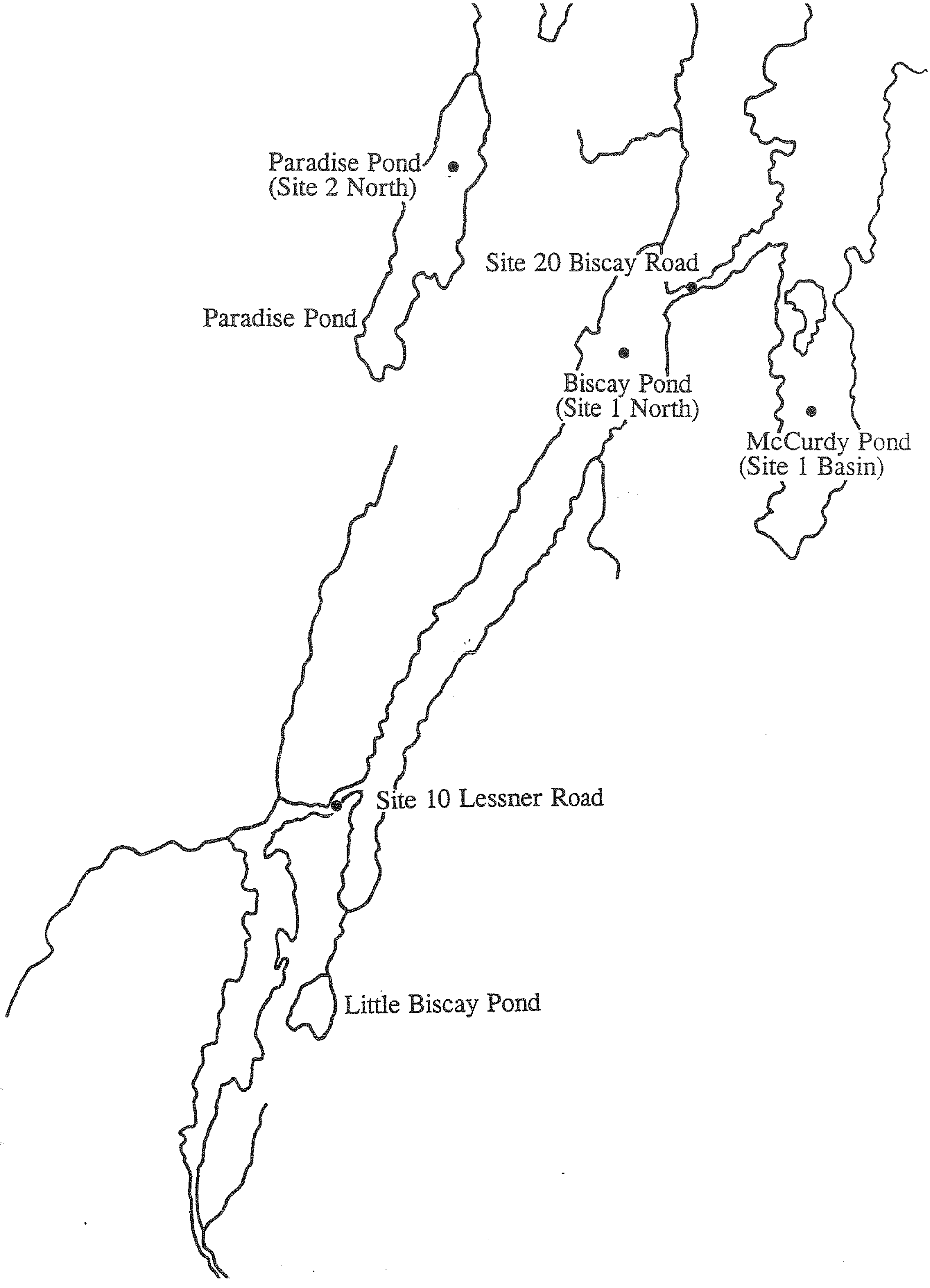
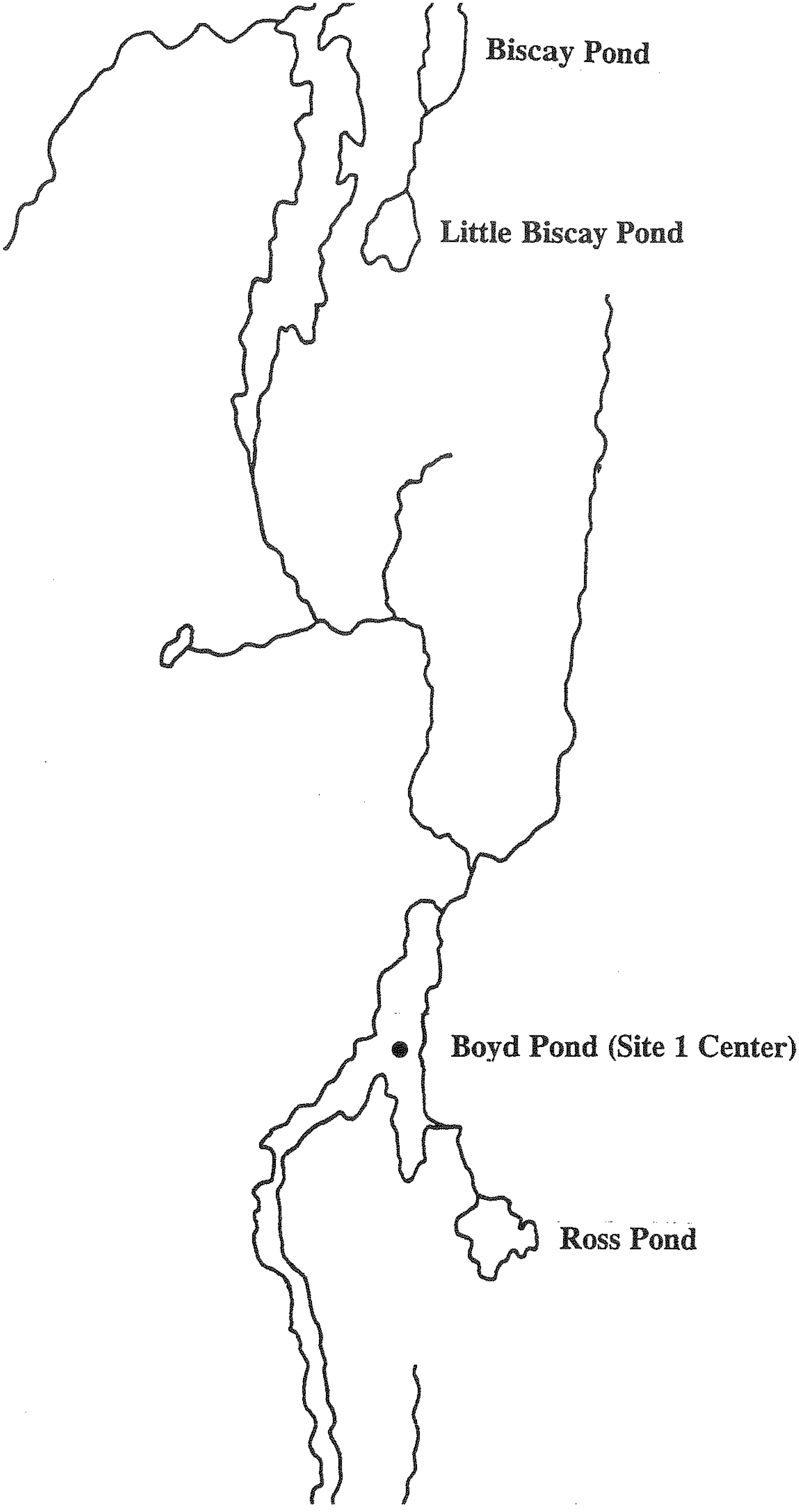

Paradise Pond
(Site 2 North)
Site 20 Biscay Road
Paradise Pond
Biscay Pond
(Site 1 North)
McCurdy Pond
(Site 1 Basin)
Site 10 Lessner Road
Little Biscay Pond

**Figure 8.Location of the deep sampling station from Boyd Pond; Site 1 Center.**



Biscay Pond
Little Biscay Pond
Boyd Pond (Site 1 Center)
Ross Pond

The primary purpose of this report is to discuss results of the 1994 monitoring with emphasis on current conditions of Biscay, Boyd, Duckpuddle, McCurdy, Paradise and Pemaquid Ponds including the extent of eutrophication and the lake's susceptibility to increasing acid precipitation. This information is part of a large data base of historical and more recent data compiled and entered onto computer files for New Hampshire lakes that include New Hampshire Fish and Game surveys of the 1930's, the surveys by the New Hampshire Water Supply and Pollution Control Commission and the **FBG** surveys. Care must be taken when comparing current results with early studies. Many complications arise due to methodological differences of the various testing facilities and technological improvements in testing.

# The General Scenario - 1994

## 1994 Climatic Summary

The winter of 1993-94 was one of the colder on record and included above average precipitation during the winter season. Snowfall was particularly plentiful in the months of January and March when major snowstorms made their way through New Hampshire. The accumulated snowpack resulted in considerable runoff in late March and Early April during the spring snowmelt. For those lakes which were monitored early enough, the winter conditions translated into lower alkalinities (buffering capacities) and lower pH levels in the tributary streams and in some lakes, when compared to results from a few years back; years with little snow pack. Thus, while many lakes had steady or even increasing buffering levels during dry winters (winters with below average snowfall), the heavy snowfall during the winter of 1993-94 indicates that acid rain should still be on of our concerns.

Below average rainfall was documented during the spring months of April and June while the month of May was wetter than normal. The month of July was off to a wet start with precipitation levels exceeding the norm by over one inch, followed by a dry month of August which demonstrated below average rainfall of over one inch, and once again a wetter than normal month in September. The 1994 precipitation levels (through September) were above normal while short term dry spells were encountered; particularly in February, June and August. The summer months were also characterized by a number of localized rainstorms which passed through New Hampshire. Thus, while the general precipitation scenario, described above, summarizes the 1994 precipitation data, the locality of daily precipitation events was highly variable and might not characterize the conditions around your lake.

The 1994 temperature patterns also had an effect on water quality. The below average temperatures in January, February and March maximized snowpack retention until late March when temperature exceeded 32° Fahrenheit and considerable watershed runoff occurred. The temperatures were more characteristic of the normal conditions in April and May while the month of June was characterized by above average temperatures. The above average temperatures in June resulted in the rapid surface water (epilimnetic) warming which is conducive to algal, aquatic plant and bacterial growth. Additional factors which stimulated the elevated algal, aquatic plant and bacterial growth included the influx of nutrients during summer storm events, greater sunlight penetration during clear days, lower lake levels during short term dry spells, as well as, the mobilization of deep-water algal populations into the surface waters and increased growth rates during optimal conditions (discussed below). The above average temperatures, conducive to primary productivity, persisted through July but dipped to near average and below average levels in August and resulted in surface water cooling in our New Hampshire lakes which continued into the fall months.

## 1994 Water Quality Observations

Reduced Secchi Disk transparency readings, relative to 1993, were characteristic of most Hampshire Lakes during the 1994 sampling season. Lakes were less clear due to a combination of factors that included increased dissolved color compounds (dissolved organic matter from the breakdown of vegetation and soils) washed in from surrounding wetland areas, higher algal growth (measured as chlorophyll *a*) in the surface waters, due to increased nutrient runoff and greater suspended sediment levels transported into the lake during storm events and increased bacterial growth. Dissolved water color is not indicative of water quality problems (although large increases in dissolved color sometimes follow large land clearing operations) but in some of our more pristine program lakes, it nevertheless has a large effect on water clarity changes. Likewise, elevated bacterial densities are not necessarily indicative of water quality problems as the majority of these organisms (heterotrophic, not pathogenic) are a natural component of even our cleanest lakes. However, these small organisms can have a profound effect on water quality as they can rapidly absorb and redirect light which will in turn diminish our Secchi Disk readings. If fecal contamination is suspected, future monitoring can include the collection of indicator bacteria data (i.e. E Coli; the New Hampshire indicator bacteria).

As with dissolved color and nutrients, the wet spring brought a greater suspended sediment load to many of our streams and lakes during that period while short term summer storm events resulted in additional sedimentation. If decreased clarity was not the result of increased dissolved color or chlorophyll *a* levels than it was likely due to increased suspended sediment by default. To find out how these water quality indicators inter-relate for your particular lake site, compare the Secchi Disk, chlorophyll *a* and dissolved color graphs enclosed in this report (see figures 9 through 11). Note whether changes in clarity (secchi disk depth) correspond to chlorophyll *a* or dissolved color concentration changes or whether it is a combination of the two. If neither seem to exhibit a consistent effect, then suspended sediment likely plays an important role in your lake's clarity.

Several lakes experienced "algal blooms" during the 1994 sampling season. "Algal blooms" are often "green water events" associated with decreases in water clarity due to their ability to absorb and scatter light within the water column, but can also accumulate near the lake bottom in shallow areas as "mats" or on the water surface as "scums" and "clouds". All types of "algal blooms" were observed in several participating **LLMP** lakes in 1994. The occasional formation of certain "algal blooms" are naturally occurring phenomenon and are not necessarily associated with changes in lake productivity. Increases in the occurrence of "bloom" conditions can be a sign of eutrophication (the "greening" of a lake). Algal blooms of varied extent typically occur even in our most pristine lakes late in the fall and early in the spring as a result of lake mixing, which resuspends nutrients, at those times.

In many lakes, particularly those within the Lakes Region of New Hampshire, cotton-candy like "clouds" of the nuisance green filamentous algae, *mougeotia*, or a related species formed within the weed beds and then drifted freely into shallow areas around the lake. These algae often take advantage of nutrients that leak from particularly active submerged weeds or from bottom areas that have been disturbed by weed removal or other activities.

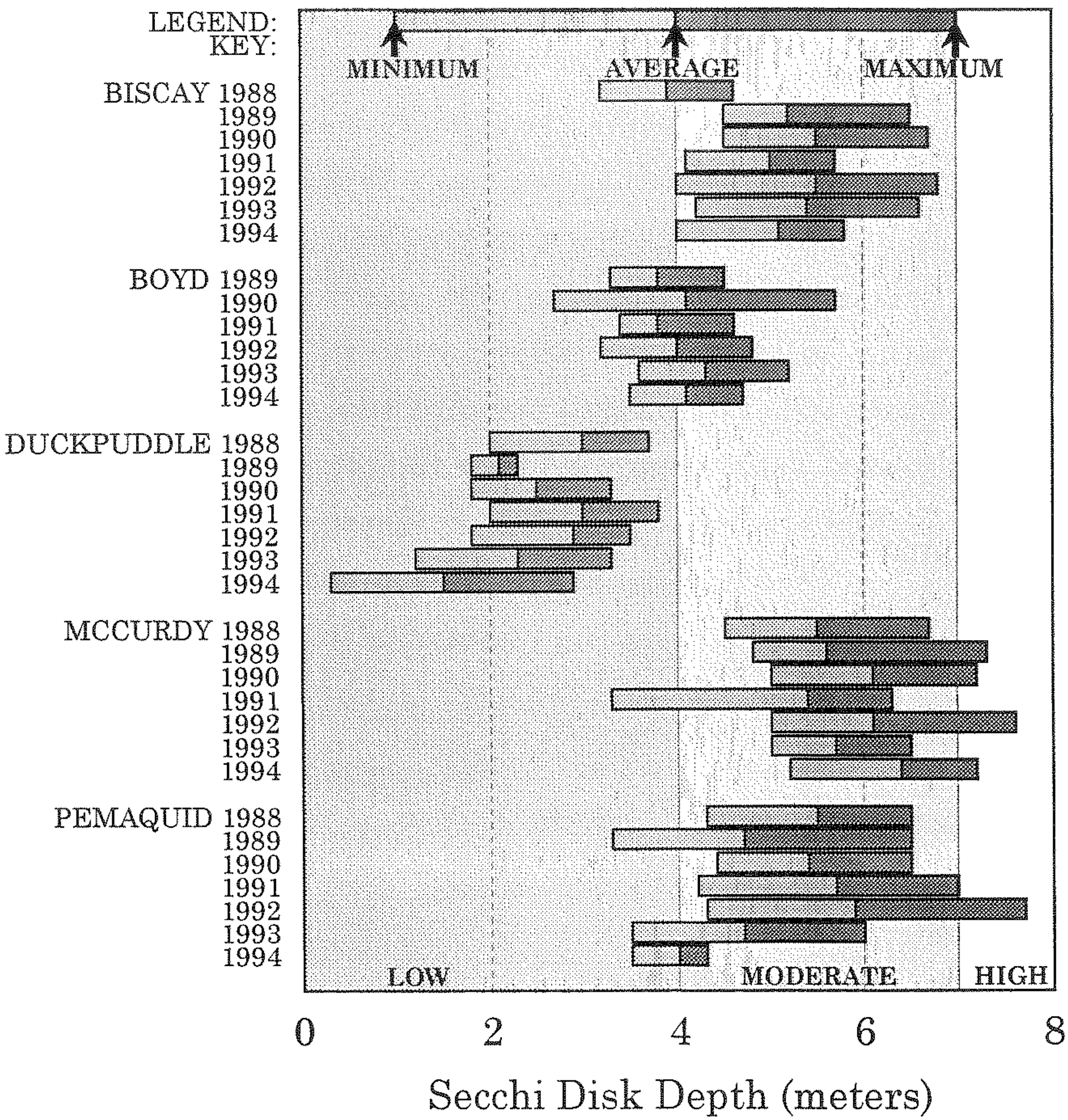
For some lakes, weather conditions became conducive to the formation of "blooms" of other algae species during the summer months when the water temperatures were above average. Unlike 1993, when the algal blooms were short term events (spanning less than a week), the blooms persisted for greater than a month in a handful of sampled lakes. In those lakes which experienced long term algal blooms the types of algae tended to be of the nuisance blue-green bacterial variety (formerly referred to as blue-green algae) and included such nuisance forms as *anabaena*, *lyngbya* and *merismopedia*.

In other lakes, metalimnetic algae, algae which tend to grow in a thin layer along the thermocline gradient in a lake's middle depths, sometimes migrate up towards the lake surface causing a "bloom" event. If these algae are predominantly "nuisance" forms, like certain green or blue-green algae, they can be an early indication nutrient loading. The **LLMP** will continue to monitor "bloom" phenomenon in 1995 as it can be a sign of the changing land use practices and impacts within the lake watershed that can result in a long-term increase in lake productivity. Future monitoring will continue to monitor the frequency of algal blooms in our New Hampshire lakes' and discern whether or not they are signs of short-term perturbations in water quality, the "noise" within the true long-term signal, induced by the weather conditions of this past summer.

Figure 9.Comparison of the 1994 Biscay Pond, Boyd Pond, Duckpuddle Pond, McCurdy Pond and Pemaquid Pond lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP Secchi Disk standards for low, moderate and high water clarities. The higher the Secchi Disk value, the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

# LAY MONITOR SECCHI DISK DATA
# PEMAQUID PONDS

## YEARLY COMPARISONS (1988-1994)

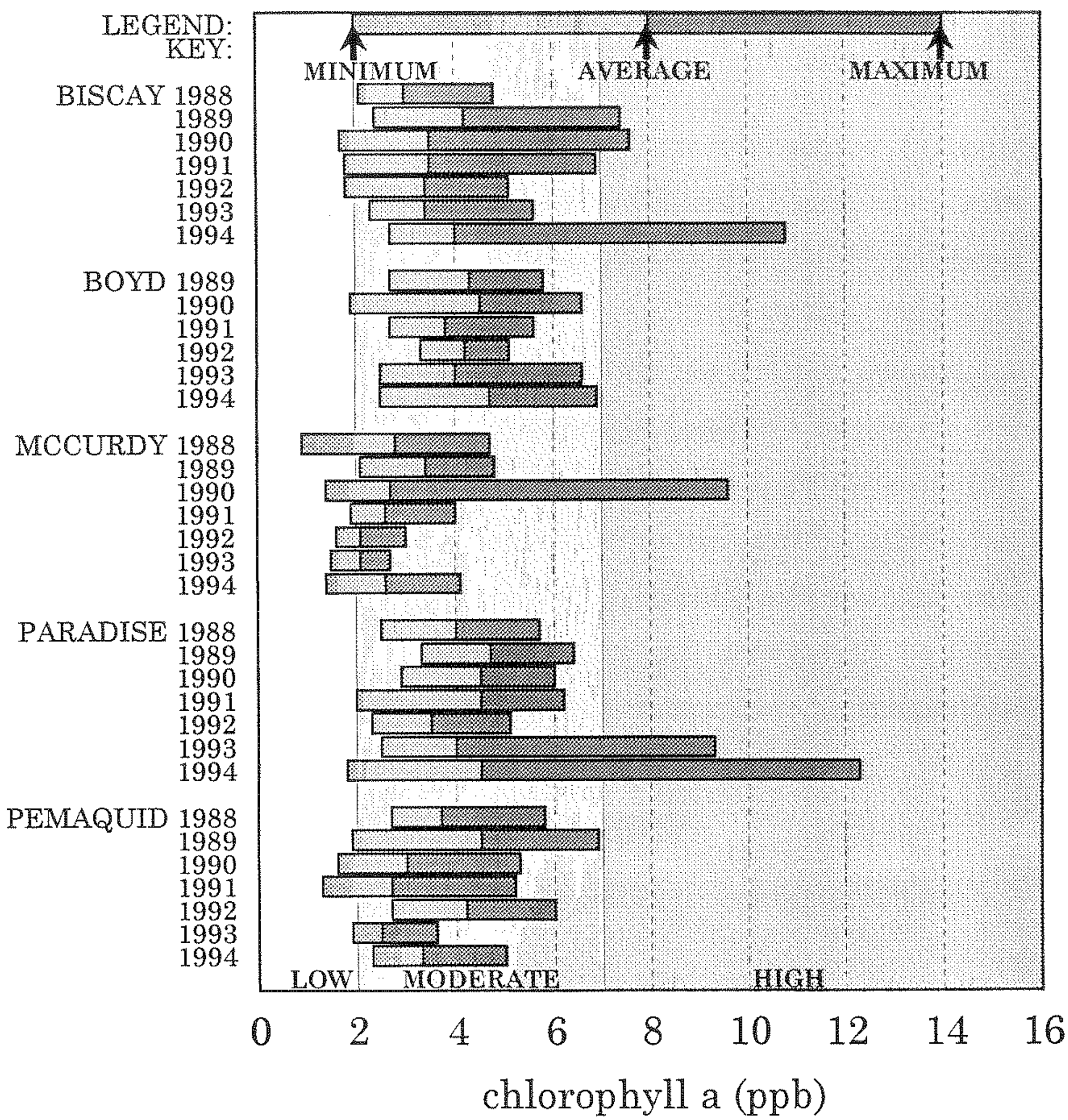



The higher value = clearer water

Figure 10. Comparison of the 1994 Biscay Pond, Boyd Pond, McCurdy Pond, Paradise Pond and Pemaquid Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).

# LAY MONITOR CHLOROPHYLL *a* DATA
# PEMAQUID PONDS

## YEARLY COMPARISONS (1988-1994)

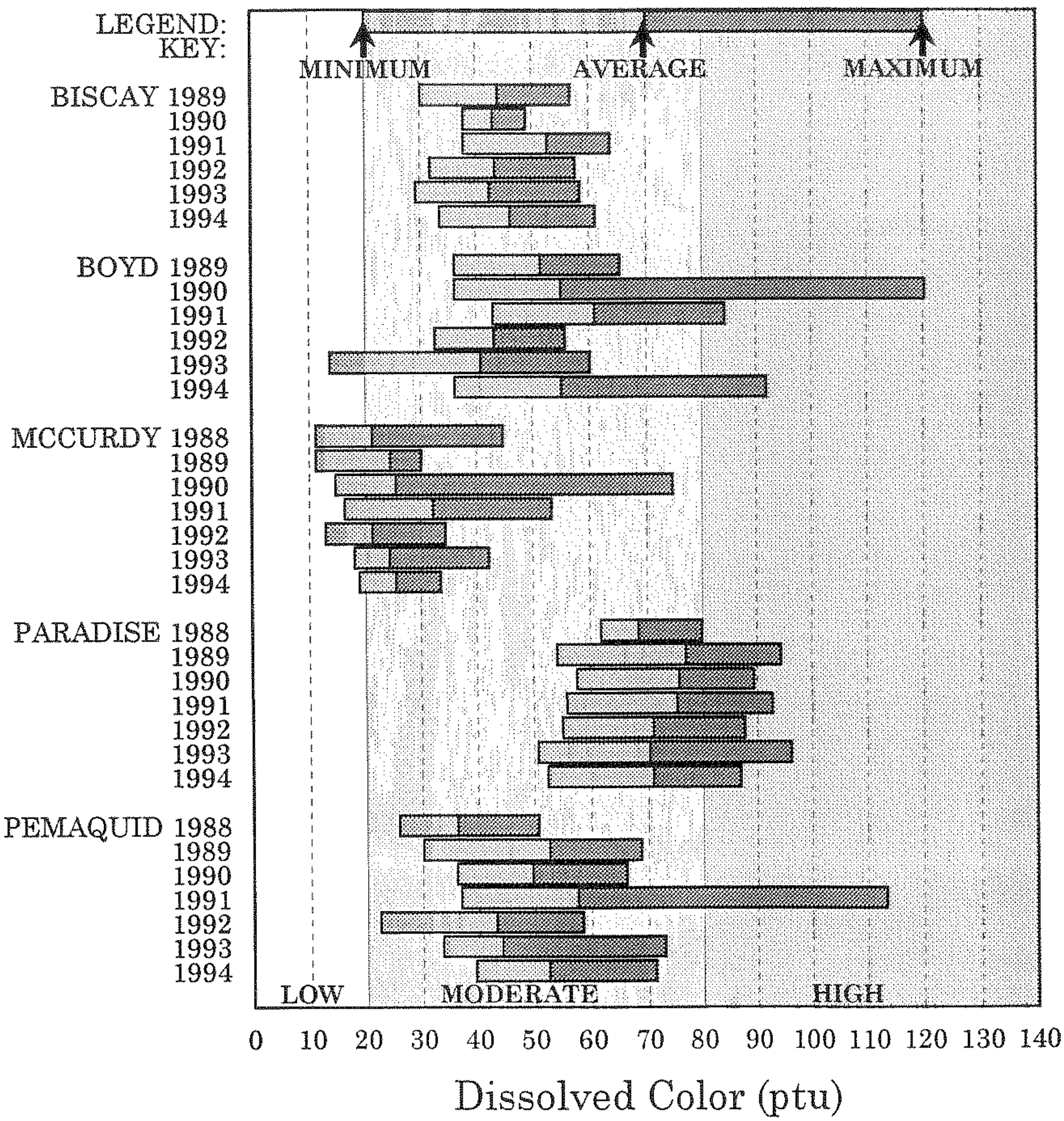



The higher value = more algal growth

Figure 11.Comparison of the 1994 Biscay Pond, Boyd Pond, McCurdy Pond, Paradise Pond and Pemaquid Pond lay monitor Dissolved Color data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderately and highly colored waters. The higher the dissolved color concentration, the more colored the water (i.e. more tea colored). Color data are expressed as chloroplatinate color units (ptu).

# LAY MONITOR DISSOLVED COLOR DATA
# PEMAQUID PONDS

## YEARLY COMPARISONS (1988-1994)




The higher value = more "tea" colored water

## Table 2. Biscay Pond -- trophic indicators, 1994

**Lakes Lay Monitoring Program, U.N.H.**

**[Lay Monitor Data]**

Biscay Pond, Maine
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Average transparency: | 5.1 | (1994: | 7 | values; | 4.0 | - | 5.8 | range) |
| Average chlorophyll: | 4.0 | (1994: | 12 | values; | 2.7 | - | 10.8 | range) |
| Average Lake Phos.: | 11.1 | (1994: | 4 | values; | 6.6 | - | 21.1 | range) |
| Average color, 440: | 46.2 | (1994: | 12 | values; | 33.5 | - | 61.0 | range) |

| Site | Date | Trans-parency (m) | Chl a (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 1 Hypo | 07/30/1994 | ---- | ---- | 21.1 | ---- | ---- | ---- |
| 1 North | 05/07/1994 | 5.8 | 2.8 | ---- | ---- | ---- | 55.8 |
| 1 North | 05/30/1994 | 4.4 | 3.2 | ---- | ---- | ---- | 60.1 |
| 1 North | 06/05/1994 | ---- | 4.3 | ---- | ---- | ---- | 61.0 |
| 1 North | 06/18/1994 | ---- | 2.7 | ---- | ---- | ---- | 48.1 |
| 1 North | 07/02/1994 | 4.0 | 10.8 | ---- | ---- | ---- | 47.2 |
| 1 North | 07/16/1994 | 5.4 | 5.5 | ---- | ---- | ---- | 49.8 |
| 1 North | 07/31/1994 | 5.0 | 3.6 | ---- | ---- | ---- | 42.1 |
| 1 North | 08/13/1994 | ---- | 3.1 | ---- | ---- | ---- | 38.7 |
| 1 North | 08/27/1994 | 5.6 | 2.7 | ---- | ---- | ---- | 37.8 |
| 1 North | 09/09/1994 | ---- | 3.0 | ---- | ---- | ---- | 35.2 |
| 1 North | 09/25/1994 | ---- | 3.1 | ---- | ---- | ---- | 33.5 |
| 1 North | 10/08/1994 | 5.2 | 3.5 | ---- | ---- | ---- | 45.5 |
| 1 Surface | 05/07/1994 | ---- | ---- | 7.7 | ---- | ---- | ---- |
| 1 Surface | 10/29/1994 | ---- | ---- | 9.0 | ---- | ---- | ---- |
| 10 Lessner | 03/27/1994 | ---- | ---- | 6.6 | ---- | ---- | ---- |

<< End of 1994 listing, 16 records >>

# BISCAY POND

# 1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of Biscay Pond was undertaken by the volunteer monitor, Scott Gigvere, from May 7 through October 21, 1994 (see table 2 and figures 12-14). Additional tributary nutrient sampling (phosphorus) was undertaken in the spring to assess the impact of the heavy watershed runoff which occurred at that time. The following data summarize the 1994 conditions of Biscay Pond, and when applicable, historical data are incorporated into the interpretation. A more detailed discussion of the sampled parameters is included in the section of the report titled "Discussion of Lake Monitoring Measurements".

1) The Secchi Disk depth (a measure of water clarity) at Biscay Pond was representative of a moderately productive lake based on the criteria employed by the **Maine Department of Environmental Protection (DEP)**. The seasonal water transparency average of 5.1 meters ( 16.6 feet) is lower than the 1993 Secchi Disk transparency (5.4 meters) but remains well within the range of historical readings.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) in the surface waters of Biscay Pond were moderate in 1994 . The seasonal chlorophyll *a* concentration averaged 4.0 milligrams per cubic meter (4.0 mg $m^{-3}$ equivalent to 4.0 parts chlorophyll *a* per billion parts water) at Site 1 North which falls within the **Maine DEP** criteria for a moderately productive lake. The seasonal average chlorophyll *a* concentration increased in 1994 and a new chlorophyll *a* maximum of 10.8 ppb was documented on July 2 during an algal bloom.

3) Phytoplankton (microscopic plant) samples collected in Biscay Pond during the 1994 sampling season compared well with the chlorophyll *a* concentrations (i.e. as the chlorophyll *a* concentrations increased the number of algal "cells" increased (refer to appendix A). Based on typical phytoplankton densities documented in **NH LLMP** lakes, Biscay Pond falls within the range typical of a moderately productive lake. The high chlorophyll *a* concentration documented on July 2 corresponded to a bloom of the multicellular algae; *Chrysosphaerella* and *Synura*. Blooms of these algal forms are often associated with elevated chlorophyll *a* concentrations but are common genera in even our most pristine systems. The types of phytoplankton present during the 1994 sampling season are a further indication that Biscay Pond is moderately productive system which at times borders on less productive, oligotrophic, conditions.

4) Dissolved lakewater color levels (a measure of naturally occurring "background" color) for Biscay Pond were moderate in 1994, 46.2 platinate color units (ptu) and slightly higher than the 1993 average of 42.4 ptu.

5) Total phosphorus samples (generally considered the limiting nutrient for plant growth in freshwater systems), collected in the surface waters of Biscay Pond, were moderate when sampled both early in the season (May 7), 7.7 parts per billion (ppb), and again late in the season (October 29), 9.0 ppb. Additional bottom water (hypolimnetic) total phosphorus sampling indicates an accumulation of phosphorus near the lakebottom as the summer progresses (21.1 ppb on July 30). The 1994 total phosphorus concentrations are within historical phosphorus concentrations recorded by the **NH LLMP** and the **Maine DEP** and fall within the range characteristic of a moderately productive lake.

6) Temperature profiles collected by the lay monitor indicate the upper mixed layer of water extended to about 6.5 meters during the period of summer thermal stratification, typical of a northern temperate lake. Historical dissolved oxygen data, collected by the **Maine DEP** (1981, 1982, 1988 and 1990), indicate reduced dissolved oxygen concentrations in the bottom (hypolimnetic) waters of Biscay Pond during thermal stratification. Lower hypolimnetic dissolved oxygen concentrations are indicative of accumulating organic matter from both internal (i.e. decaying aquatic animal and vegetative matter) and external (i.e. leaf litter from watershed runoff) sources. As dissolved oxygen concentrations are reduced below 1 milligram per liter the potential for internal nutrient release (nutrients are resuspended from the sediments) increases significantly and might explain the elevated hypolimnetic total phosphorus concentration documented in Biscay Pond during the 1994 sampling season.

7) For all measurements considered and averaged for the season, Biscay Pond is classified as a moderately productive, mesotrophic, lake.

8) The primary purpose of the volunteer monitoring effort on Biscay Pond is to document long term changes in the pond's productivity and identify any land use practices within the watershed that are contributing to water quality degradation. However, "background" variability in seasonal precipitation and temperature patters can actually mask the effects of cultural eutrophication, or in some cases, augment the process, and in turn make trend (eutrophication) detection difficult. Variations in precipitation will often result in increased nutrient loading to a lake that in turn stimulates primary productivity (plant production), but can also result in increased flushing of the aquatic system that can mask the effects of internal nutrient loading (i.e. large precipitation events can reduce nutrient concentrations in highly productive lakes). Increasing temperatures will also effect the aquatic community, as most aquatic organisms will increase their activity (i.e. higher chlorophyll *a* concentrations or decreased Secchi Disk transparencies) during these periods, reflecting the thermal variations but not necessarily variations in available nutrients or other limiting resources that are commonly associated with poor land-use practices. As more data become available, the impact and inter-relationship of these variables can be assessed for the study lake and the impact of land use changes can be evaluated.

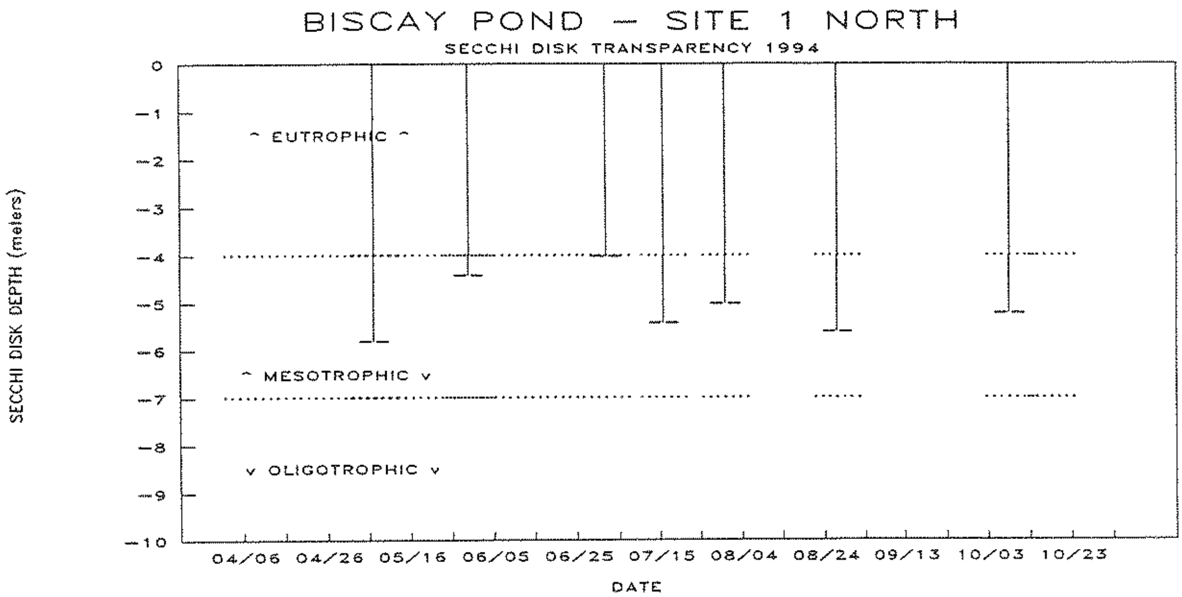
A second important component of trend assessment involves the frequent collection of water quality data. The most basic measurement, the Secchi Disk transparency, is commonly used as an indicator of algal productivity (measured as chlorophyll *a*), although it also reflects the impact of dissolved colored (organic) compounds as well as suspended sediments. Chlorophyll *a* levels undergo daily fluctuations which require frequent monitoring to document short term fluctuations in chlorophyll *a* concentrations. Likewise, the dissolved color and total phosphorus concentrations can vary, particularly early in the season during and following "peak" watershed runoff, as well as, following summer storm events. Only through frequent monitoring can these short term water quality perturbations be documented, which is important since they are often precursors to long term shifts in the trophic state (productivity). We therefore recommend continued monitoring on a frequent basis (bi-weekly or preferably weekly) during the summer months to more accurately identify both short term fluctuations (weekly and at times daily fluctuations) and long term trends in water quality measurements.

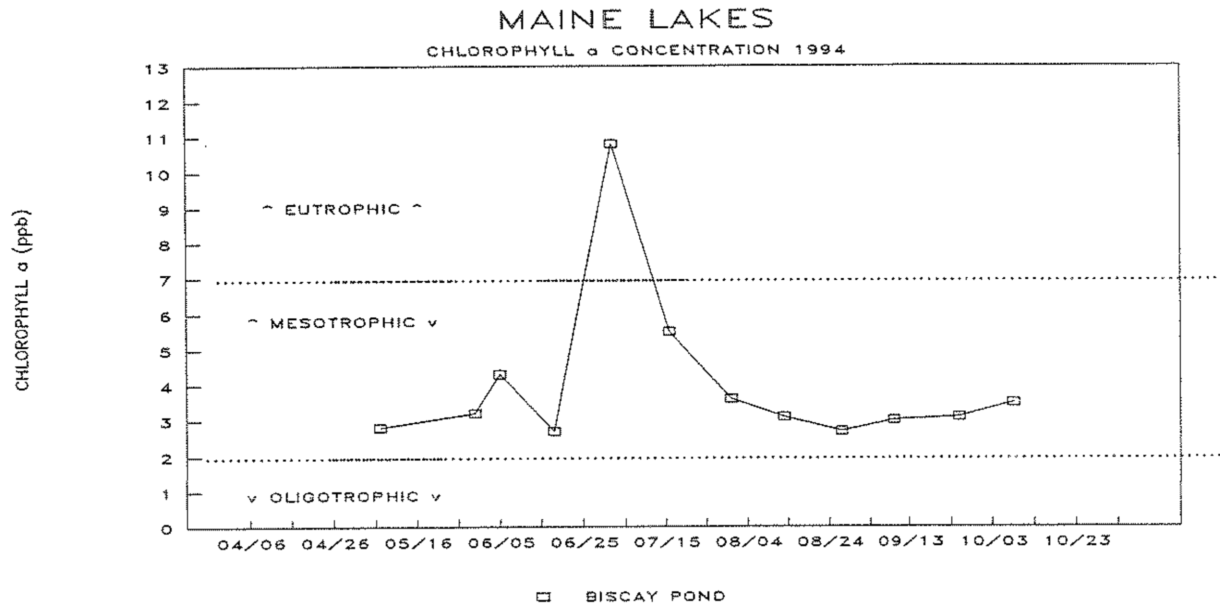
Water quality data collected from the Biscay Pond deep sampling station (representative of the average pond conditions) between 1988 and 1994 indicate variable seasonal average chlorophyll *a* and Secchi Disk levels over the aforementioned time span (see figures 15 and 16). However, the new chlorophyll *a* maximum documented on July 2 (10.8 ppb) could be an early "warning sign" of the lakes' response to improper land use practices within the watershed. On the other hand this atypical reading might be the result variations in precipitation or temperature patters. If localized problems (i.e. improperly installed and failing septic systems, improper soil conservation procedures and practices, excessive fertilizer applications, etc.) are suspected, we recommend performing a shoreline survey of the lake or a watershed survey to locate potential problem areas. We can then expand, or revise, the monitoring program to address more localized regions if the need exists.

Figure 12. Biscay Pond, 1994. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 1 North. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Secchi Disk measurements are reported to the nearest tenth (0.1) of a meter.

Figure 13. Biscay Pond, 1994. Seasonal trends for chlorophyll *a* concentrations of lay monitor Site 1 North. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are reported as parts per billion (ppb) of chlorophyll *a*.

Figure 14. Biscay Pond, 1994. Seasonal trends for dissolved color of lay monitor Site 1 North. The dotted horizontal line represents the dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).


BISCAY POND — SITE 1 NORTH
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


MAINE LAKES
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
BISCAY POND

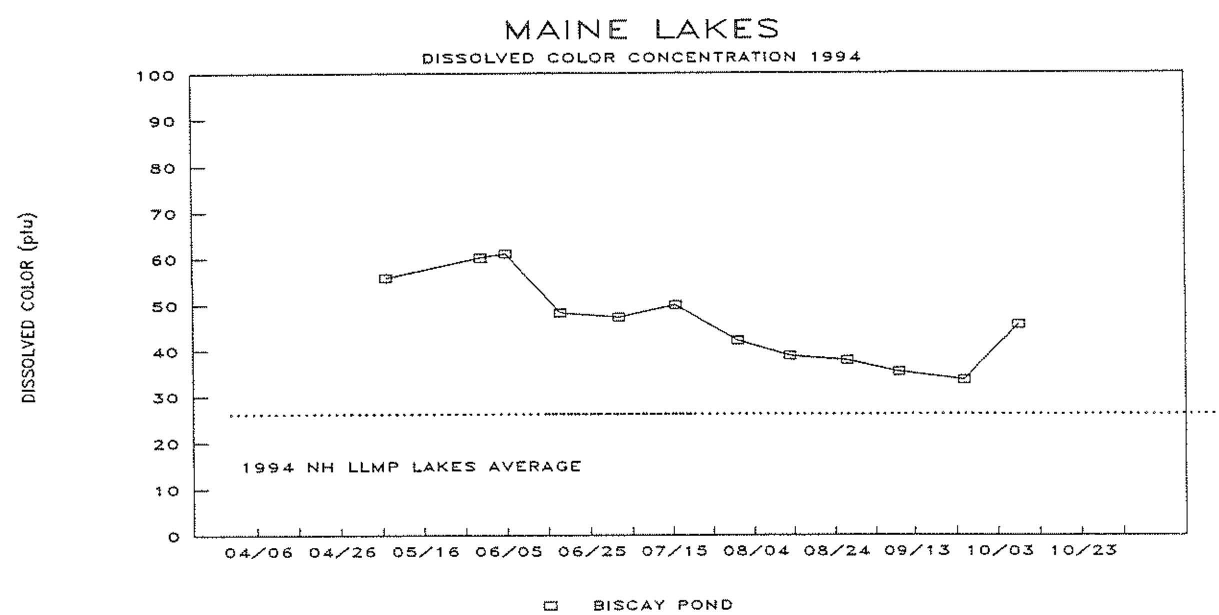
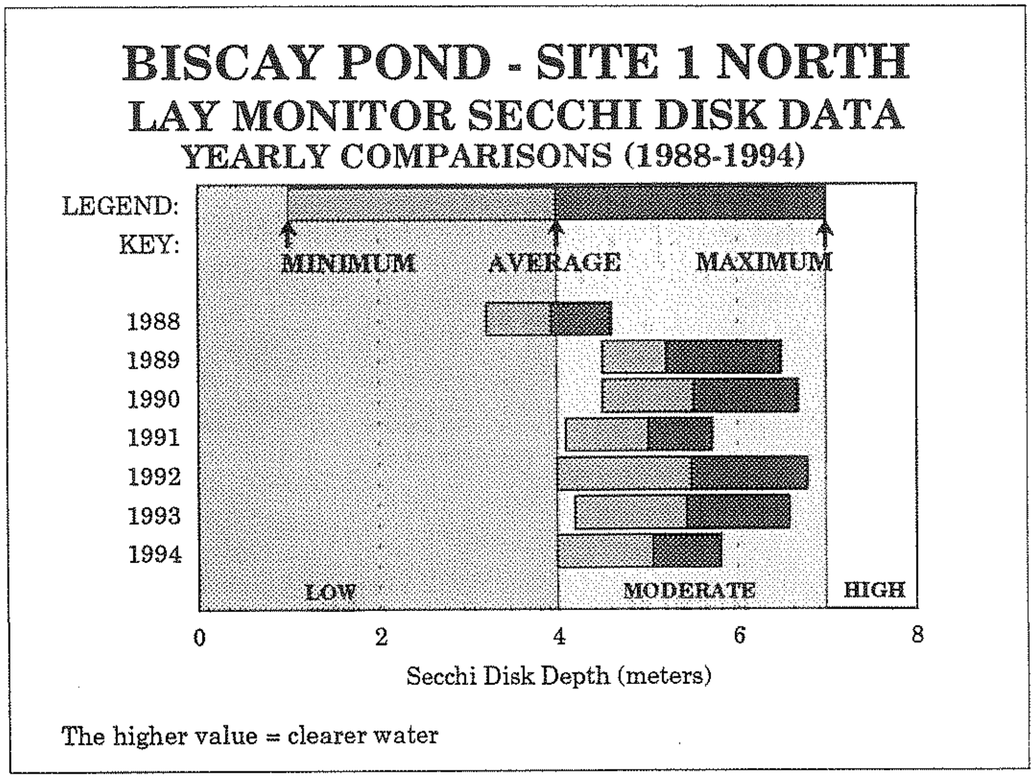
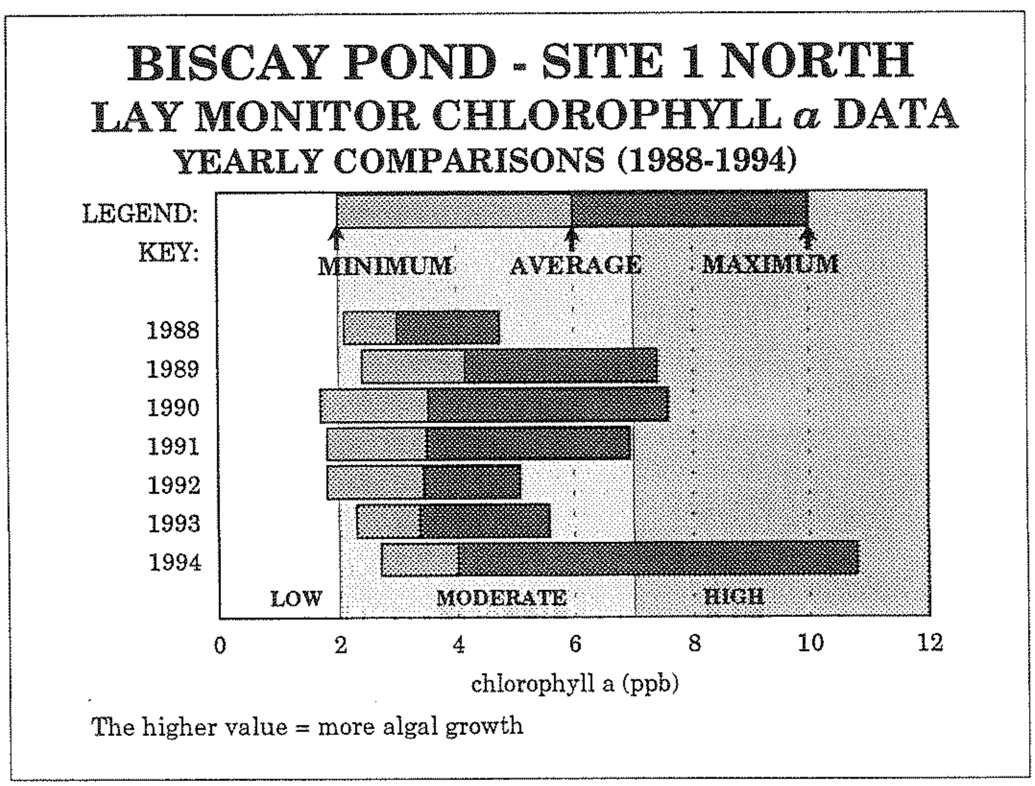

MAINE LAKES
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
100
90
80
70
60
50
40
30
20
10
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
BISCAY POND

Figure 15. Comparison of the 1994 Biscay Pond lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP Secchi Disk standards for low, moderate and high water clarities. The higher the Secchi Disk value, the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 16. Comparison of the 1994 Biscay Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).


BISCAY POND - SITE 1 NORTH
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
Secchi Disk Depth (meters)
The higher value = clearer water


BISCAY POND - SITE 1 NORTH
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
chlorophyll a (ppb)
The higher value = more algal growth

## Table 3. Boyd Pond -- trophic indicators, 1994

**Lakes Lay Monitoring Program, U.N.H.**

**[Lay Monitor Data]**

Boyd Pond, Maine
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Average transparency: | 4.1 | (1994: | 11 | values; | 3.5 | - | 4.7 | range) |
| Average chlorophyll: | 4.7 | (1994: | 12 | values; | 2.5 | - | 6.9 | range) |
| Average Lake Phos.: | 15.7 | (1994: | 6 | values; | 7.3 | - | 39.0 | range) |
| Average color, 440: | 55.1 | (1994: | 10 | values; | 36.1 | - | 91.9 | range) |

| Site | Date | Trans-parency (m) | Chl *a* (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 1 Center | 05/07/1994 | 4.7 | 2.5 | ---- | ---- | ---- | 62.7 |
| 1 Center | 05/22/1994 | 4.5 | 4.0 | ---- | ---- | ---- | 66.1 |
| 1 Center | 06/05/1994 | 3.7 | 5.9 | ---- | ---- | ---- | 57.6 |
| 1 Center | 06/18/1994 | 4.3 | 3.8 | ---- | ---- | ---- | ---- |
| 1 Center | 07/04/1994 | 4.2 | 4.6 | ---- | ---- | ---- | 52.4 |
| 1 Center | 07/16/1994 | 3.5 | 6.9 | ---- | ---- | ---- | ---- |
| 1 Center | 07/31/1994 | ---- | 4.5 | ---- | ---- | ---- | 40.4 |
| 1 Center | 08/14/1994 | 4.6 | 4.8 | ---- | ---- | ---- | 36.1 |
| 1 Center | 09/04/1994 | 3.8 | 5.2 | ---- | ---- | ---- | 36.1 |
| 1 Center | 09/18/1994 | 4.6 | 4.5 | ---- | ---- | ---- | 36.9 |
| 1 Center | 10/02/1994 | 3.7 | 4.3 | ---- | ---- | ---- | 91.9 |
| 1 Center | 10/16/1994 | 3.8 | 4.8 | ---- | ---- | ---- | 70.4 |
| 1 Hypo | 08/14/1994 | ---- | ---- | 39.0 | ---- | ---- | ---- |
| 1 Surface | 05/07/1994 | ---- | ---- | 9.4 | ---- | ---- | ---- |
| 1 Surface | 10/16/1994 | ---- | ---- | 14.0 | ---- | ---- | ---- |
| 7 Ross | 04/10/1994 | ---- | ---- | 7.7 | ---- | ---- | ---- |
| 8 Culvert | 04/10/1994 | ---- | ---- | 16.5 | ---- | ---- | ---- |
| 9 PemRvr | 04/10/1994 | ---- | ---- | 7.3 | ---- | ---- | ---- |

<< End of 1994 listing, 18 records >>

# BOYD POND

# 1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of Boyd Pond was undertaken by the volunteer monitor, Peter Fischer, from May 7 through October 16, 1994 (see table 3 and figures 17-19). Additional tributary nutrient sampling (phosphorus) was undertaken in the spring to assess the impact of the heavy watershed runoff which occurred at that time. The following data summarize the 1994 conditions of Boyd Pond, and when applicable, historical data are incorporated into the interpretation. A more detailed discussion of the sampled parameters is included in the section of the report titled "Discussion of Lake Monitoring Measurements".

1) The Secchi Disk depth (a measure of water clarity) at Boyd Pond was representative of a moderately productive lake bordering on a higher level of productive (eutrophy) based on the criteria employed by the **Maine Department of Environmental Protection (DEP)**. The seasonal water transparency average of 4.1 meters ( 13.3 feet) is lower than the 1993 Secchi Disk transparency (4.3 meters) but remains well within the range of historical readings.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) in the surface waters of Boyd Pond were moderate in 1994 . The seasonal chlorophyll *a* concentration averaged 4.7 milligrams per cubic meter (4.7 mg $m^{-3}$ equivalent to 4.7 parts chlorophyll *a* per billion parts water) at Site 1 Center which falls within the **Maine DEP** criteria for a moderately productive lake. The 1994 seasonal average chlorophyll *a* concentration increased and exceeded the previous seasonal average chlorophyll *a* high of 4.5 ppb documented in 1990. Additionally, an algal bloom on July 16 (measured as chlorophyll *a;* 6.9 ppb) exceeded the previous high of 6.6 ppb measured in 1990 and again in 1993.

3) Dissolved lakewater color levels (a measure of naturally occurring "background" color) for Boyd Pond were moderate in 1994, 55.1 platinate color units (ptu) and higher than the 1993 average of 40.8 ptu.

4) Total phosphorus samples (generally considered the limiting nutrient for plant growth in freshwater systems), collected in the surface waters of Boyd Pond, were moderate to high when sampled early in the season (May 7), 9.4 parts per billion (ppb), and again late in the season (October 16), 14.0 ppb. Additional bottom water (hypolimnetic) total phosphorus sampling indicates an accumulation of phosphorus near the lakebottom as the summer progresses (39.0 ppb on August 14). The 1994 total phosphorus concentrations are within historical phosphorus concentrations recorded by the **NH LLMP** and the **Maine DEP** and fall within the range characteristic of a moderately to highly productive lake.

5) Temperature profiles collected by the Lay Monitor indicate the upper

mixed layer of water extended to about 4.5 meters during the period of summer thermal stratification, typical of a northern temperate lake. Historical dissolved oxygen data, collected by the **Maine DEP** (1990), indicate dissolved oxygen concentrations become reduced in the bottom (hypolimnetic) waters of Boyd Pond during thermal stratification. Low hypolimnetic dissolved oxygen concentrations are indicative of accumulating organic matter from both internal (i.e. decaying aquatic animal and vegetative matter) and external (i.e. leaf litter from watershed runoff) sources. As dissolved oxygen concentrations are reduced below 1 milligram per liter the potential for internal nutrient release (nutrients are resuspended from the sediments) increases significantly and might explain the elevated hypolimnetic total phosphorus concentration documented in Boyd Pond during the 1994 sampling season.

6) For all measurements considered and averaged for the season, Boyd Pond is classified as a moderately productive, mesotrophic, lake. However, total phosphorus and Secchi Disk readings are bordering on more productive, eutrophic, levels.

7) The primary purpose of the volunteer monitoring effort on Boyd Pond is to document long term changes in the pond's productivity and identify any land use practices within the watershed that are contributing to water quality degradation. However, "background" variability in seasonal precipitation and temperature patters can actually mask the effects of cultural eutrophication, or in some cases, augment the process, and in turn make trend (eutrophication) detection difficult. Variations in precipitation will often result in increased nutrient loading to a lake that in turn stimulates primary productivity (plant production), but can also result in increased flushing of the aquatic system that can mask the effects of internal nutrient loading (i.e. large precipitation events can reduce nutrient concentrations in highly productive lakes). Increasing temperatures will also effect the aquatic community, as most aquatic organisms will increase their activity (i.e. higher chlorophyll *a* concentrations or decreased Secchi Disk transparencies) during these periods, reflecting the thermal variations but not necessarily variations in available nutrients or other limiting resources that are commonly associated with poor land-use practices. As more data become available, the impact and inter-relationship of these variables can be assessed for the study lake and the impact of land use changes can be evaluated.

A second important component of trend assessment involves the frequent collection of water quality data. The most basic measurement, the Secchi Disk transparency, is commonly used as an indicator of algal productivity (measured as chlorophyll *a*), although it also reflects the impact of dissolved colored (organic) compounds as well as suspended sediments. Chlorophyll *a* levels undergo daily fluctuations which require frequent monitoring to document short term fluctuations in chlorophyll *a* concentrations. Likewise, the dissolved color and total phosphorus concentrations can vary, particularly early in the season during and following "peak" watershed runoff, as well as, following summer storm events. Only through frequent monitoring can these short term water quality perturbations be documented, which is important since they are often precursors to long term shifts in the trophic state (productivity). We therefore recommend continued monitoring on a frequent basis (bi-weekly or preferably weekly) during the summer months to more accurately identify both short term fluctuations (weekly and at times daily fluctuations) and long term trends in water quality measurements.

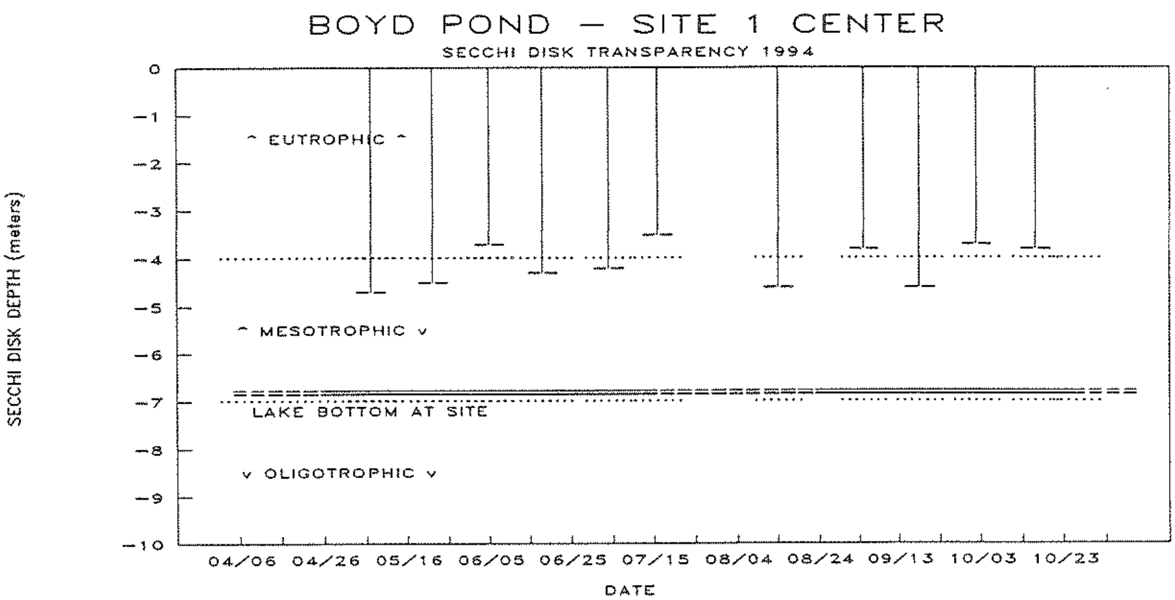
Water quality data collected from the Boyd Pond deep sampling station (representative of the average pond conditions) between 1989 and 1994 indicate relatively constant yearly average chlorophyll *a* and Secchi Disk levels over the six year span (see figures 20 and 21). However, the seasonal chlorophyll *a* and Secchi Disk measurements indicate a high degree of variability.

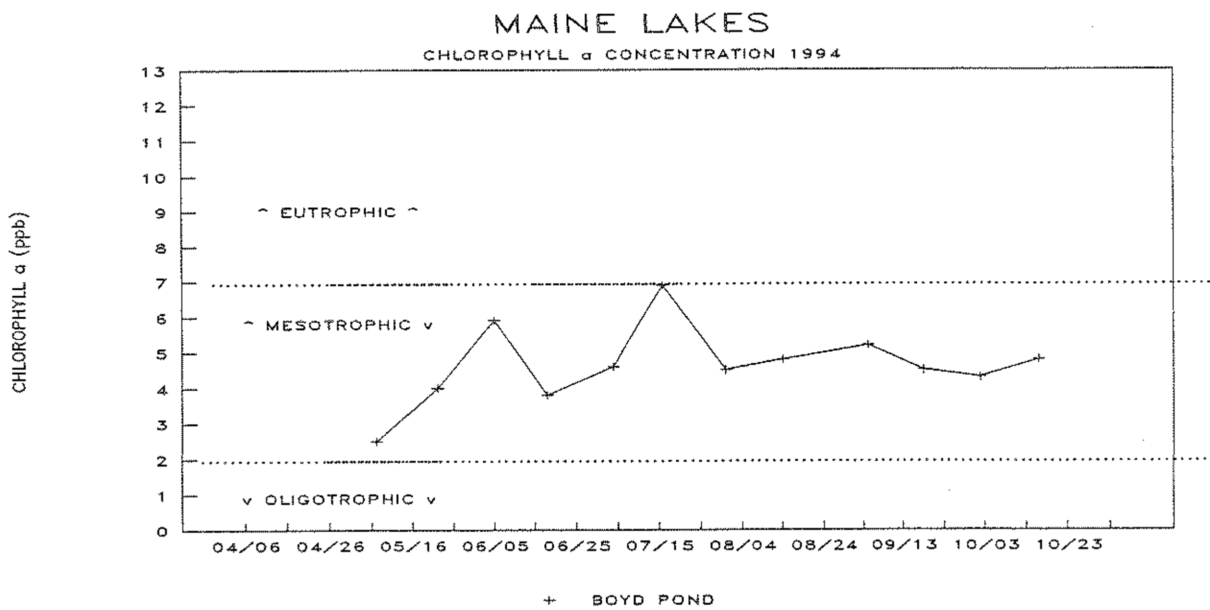
Although the chlorophyll *a* concentrations in Boyd Pond have historically fallen into the classification of a moderately productive lake, the July 16 chlorophyll *a* concentration of 6.9 ppb borders on a higher level of lake productivity (eutrophy). High chlorophyll *a* measurements such as that above can also be an early "warning sign" of the ponds' response to improper land use practices within the watershed. If localized problems (i.e. improperly installed and failing septic systems, improper soil conservation procedures and practices, excessive fertilizer applications, etc.) are suspected, we recommend performing a shoreline survey of the lake or a watershed survey to located potential problem areas. We can than expand, or revise, the monitoring program to address more localized regions if the need exists.

Figure 17. Boyd Pond, 1994. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 1 Center. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes while the double solid horizontal line denotes the maximum site depth. Secchi Disk measurements are reported to the nearest tenth (0.1) of a meter.

Figure 18. Boyd Pond, 1994. Seasonal trends for chlorophyll *a* concentrations of lay monitor Site 1 Center. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are reported as parts per billion (ppb) of chlorophyll *a*.

Figure 19. Boyd Pond, 1994. Seasonal trends for dissolved color of lay monitor Site 1 Center. The dotted horizontal line represents the dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).


BOYD POND — SITE 1 CENTER
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
LAKE BOTTOM AT SITE
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


MAINE LAKES
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
+ BOYD POND

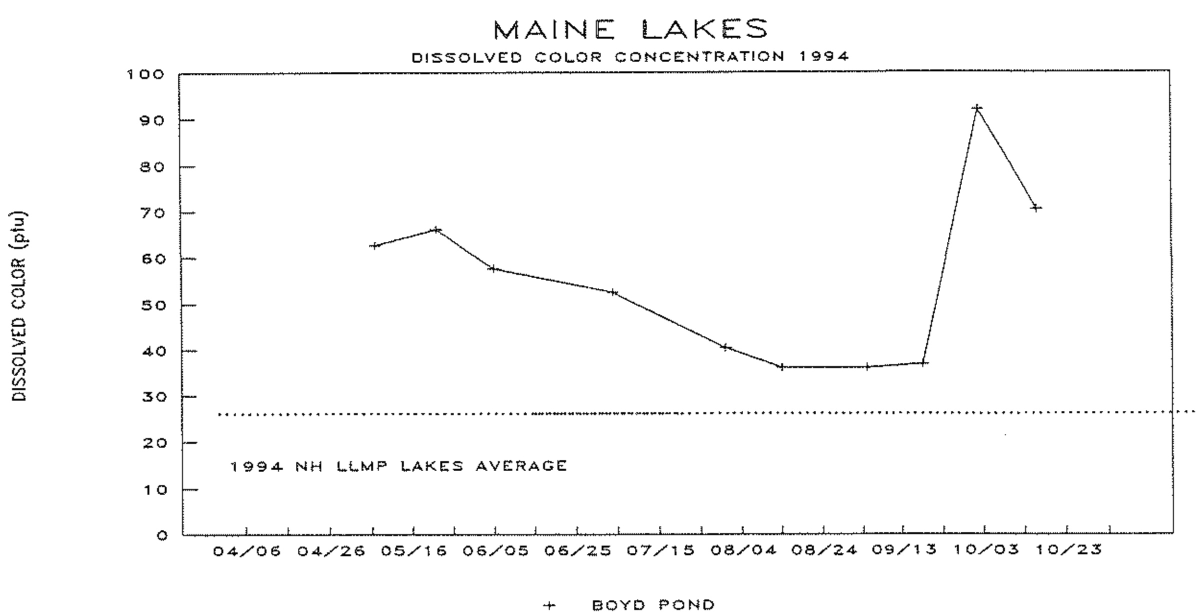
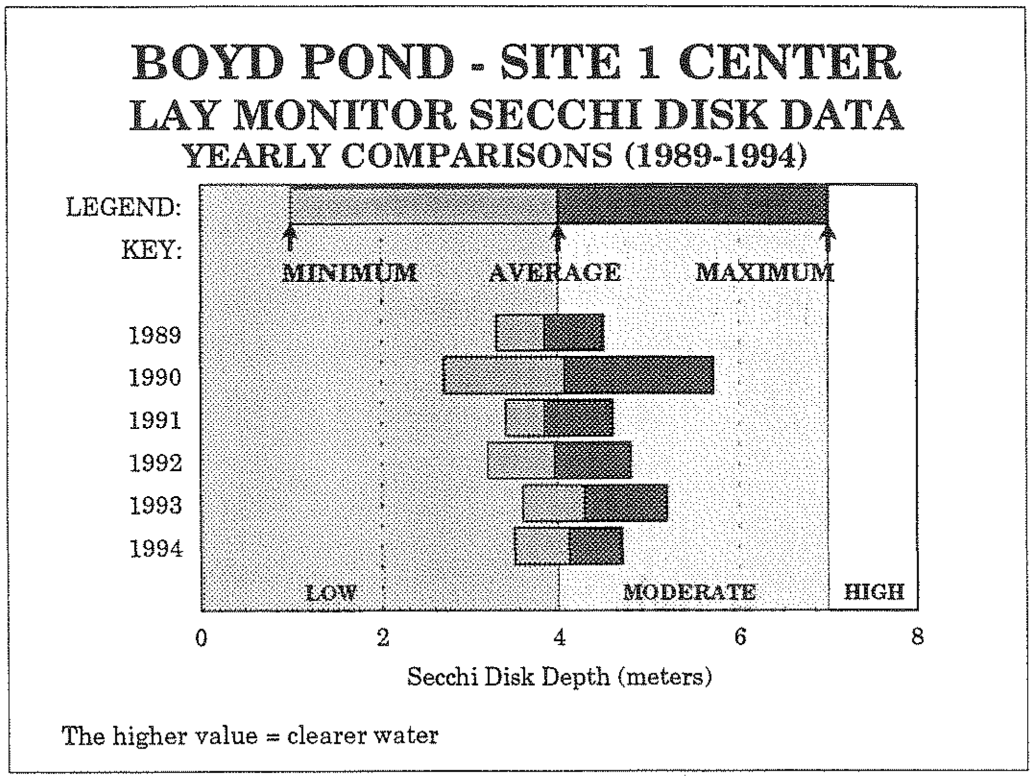
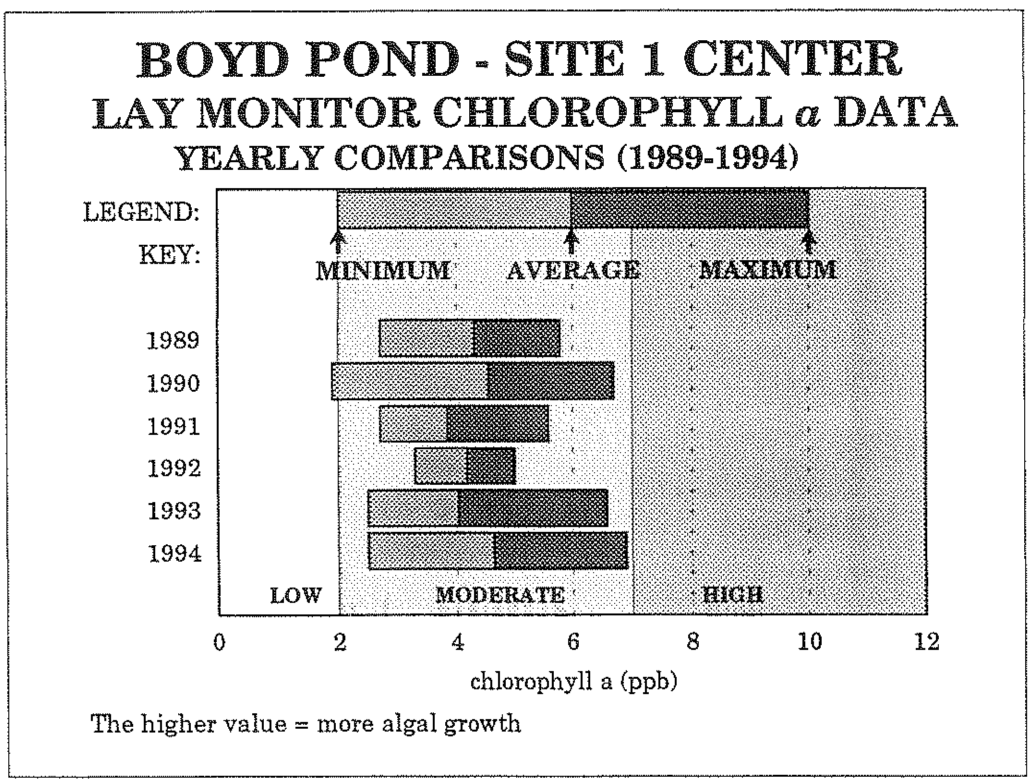

MAINE LAKES
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (plu)
1994 NH LLMP LAKES AVERAGE
100
90
80
70
60
50
40
30
20
10
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
+ BOYD POND

Figure 20. Comparison of the 1994 Boyd Pond lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP Secchi Disk standards for low, moderate and high water clarities. The higher the Secchi Disk value, the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 21. Comparison of the 1994 Boyd Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).


BOYD POND - SITE 1 CENTER
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1989-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
Secchi Disk Depth (meters)
The higher value = clearer water


BOYD POND - SITE 1 CENTER
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1989-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
chlorophyll a (ppb)
The higher value = more algal growth

## Table 4. Duckpuddle Pond -- trophic indicators, 1994

**Lakes Lay Monitoring Program, U.N.H.**

**[Lay Monitor Data]**

Duckpuddle Pond, Maine
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Average transparency: | 1.5 | (1994: | 12 values; | 0.3 | - | 2.9 | range) |
| Average chlorophyll: | 14.6 | (1994: | 14 values; | 5.2 | - | 53.3 | range) |
| Average Lake Phos.: | 91.5 | (1994: | 53 values; | 10.4 | - | 497.6 | range) |
| Average alk (gray): | 6.8 | (1994: | 1 values; | 6.8 | - | 6.8 | range) |
| Average alk (pink): | 7.6 | (1994: | 1 values; | 7.6 | - | 7.6 | range) |
| Average color, 440: | 83.3 | (1994: | 13 values; | 41.2 | - | 122.8 | range) |

| Site | Date | Trans-parency (m) | Chl *a* (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 1 Basin | 05/15/1994 | ---- | 5.2 | ---- | ---- | ---- | ---- |
| 1 Basin | 05/29/1994 | 2.4 | 8.8 | ---- | 6.8 | 7.6 | 113.4 |
| 1 Basin | 06/12/1994 | ---- | 7.6 | ---- | ---- | ---- | 102.2 |
| 1 Basin | 07/04/1994 | 1.5 | 11.3 | ---- | ---- | ---- | 92.8 |
| 1 Basin | 07/17/1994 | 0.6 | 28.3 | ---- | ---- | ---- | 86.8 |
| 1 Basin | 07/31/1994 | 0.3 | 53.3 | ---- | ---- | ---- | 79.9 |
| 1 Basin | 08/06/1994 | 1.0 | 23.8 | 22.7 | ---- | ---- | 122.8 |
| 1 Basin | 08/15/1994 | 1.6 | 13.9 | 29.3 | ---- | ---- | 63.6 |
| 1 Basin | 08/21/1994 | 1.5 | 10.4 | 28.6 | ---- | ---- | 71.3 |
| 1 Basin | 08/28/1994 | 1.3 | 6.2 | 28.8 | ---- | ---- | 67.0 |
| 1 Basin | 09/11/1994 | 1.5 | 12.7 | 25.9 | ---- | ---- | 66.1 |
| 1 Basin | 09/25/1994 | 1.8 | 7.2 | 27.1 | ---- | ---- | 67.9 |
| 1 Basin | 10/23/1994 | 2.1 | 10.3 | 29.5 | ---- | ---- | 108.2 |
| 1 Bottom | 09/11/1994 | ---- | ---- | 24.5 | ---- | ---- | ---- |
| 1 Bottom | 10/23/1994 | ---- | ---- | 40.2 | ---- | ---- | ---- |
| 1 Meta | 07/31/1994 | ---- | ---- | 97.3 | ---- | ---- | ---- |
| 1 Meta | 08/06/1994 | ---- | ---- | 131.4 | ---- | ---- | ---- |
| 1 Meta | 08/15/1994 | ---- | ---- | 99.5 | ---- | ---- | ---- |
| 1 Meta | 08/21/1994 | ---- | ---- | 52.5 | ---- | ---- | ---- |
| 1 Meta | 08/28/1994 | ---- | ---- | 49.1 | ---- | ---- | ---- |
| 1 Surface | 05/15/1994 | ---- | ---- | 19.1 | ---- | ---- | ---- |
| 1 Surface | 07/31/1994 | ---- | ---- | 37.0 | ---- | ---- | ---- |
| 1 Surface | 08/06/1994 | ---- | ---- | 31.9 | ---- | ---- | ---- |
| 1 Surface | 08/15/1994 | ---- | ---- | 23.5 | ---- | ---- | ---- |
| 14 Outlet | 08/06/1994 | 2.9 | 6.0 | 16.7 | ---- | ---- | 41.2 |
| 15 BeavBrk | 05/22/1994 | ---- | ---- | 16.5 | ---- | ---- | ---- |
| 15 BeavBrk | 08/08/1994 | ---- | ---- | 24.9 | ---- | ---- | ---- |
| 15 BeavBrk | 10/04/1994 | ---- | ---- | 26.1 | ---- | ---- | ---- |
| 17 Outlet | 03/27/1994 | ---- | ---- | 25.1 | ---- | ---- | ---- |
| 17 Outlet | 05/22/1994 | ---- | ---- | 19.8 | ---- | ---- | ---- |
| 17 Outlet | 08/08/1994 | ---- | ---- | 23.7 | ---- | ---- | ---- |
| 17 Outlet | 10/04/1994 | ---- | ---- | 23.2 | ---- | ---- | ---- |
| 18 Glendon | 05/22/1994 | ---- | ---- | 104.1 | ---- | ---- | ---- |
| 18 Glendon | 08/08/1994 | ---- | ---- | 163.4 | ---- | ---- | ---- |
| 18 Glendon | 10/04/1994 | ---- | ---- | 58.1 | ---- | ---- | ---- |
| 19 Glendon | 03/27/1994 | ---- | ---- | 46.5 | ---- | ---- | ---- |
| 19 Glendon | 04/08/1994 | ---- | ---- | 30.5 | ---- | ---- | ---- |
| 19 Glendon | 05/07/1994 | ---- | ---- | 62.2 | ---- | ---- | ---- |

| Site | Date | Trans-parency (m) | Chl *a* (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 19 Glendon | 08/07/1994 | ---- | ---- | 168.4 | ---- | ---- | ---- |
| 19 Glendon | 09/28/1994 | ---- | ---- | 68.2 | ---- | ---- | ---- |
| 21 Glendon | 03/27/1994 | ---- | ---- | 21.2 | ---- | ---- | ---- |
| 21 Glendon | 04/08/1994 | ---- | ---- | 10.4 | ---- | ---- | ---- |
| 21 Glendon | 05/07/1994 | ---- | ---- | 17.7 | ---- | ---- | ---- |
| 21 Glendon | 08/07/1994 | ---- | ---- | 50.6 | ---- | ---- | ---- |
| 21 Glendon | 09/29/1994 | ---- | ---- | 29.3 | ---- | ---- | ---- |
| 22 Glendon | 03/27/1994 | ---- | ---- | 146.6 | ---- | ---- | ---- |
| 22 Glendon | 04/08/1994 | ---- | ---- | 81.1 | ---- | ---- | ---- |
| 22 Glendon | 05/07/1994 | ---- | ---- | 174.2 | ---- | ---- | ---- |
| 22 Glendon | 08/07/1994 | ---- | ---- | 271.5 | ---- | ---- | ---- |
| 22 Glendon | 09/29/1994 | ---- | ---- | 247.1 | ---- | ---- | ---- |
| 23 Glendon | 05/07/1994 | ---- | ---- | 195.1 | ---- | ---- | ---- |
| 23 Glendon | 08/07/1994 | ---- | ---- | 241.5 | ---- | ---- | ---- |
| 24 Glendon | 03/27/1994 | ---- | ---- | 191.6 | ---- | ---- | ---- |
| 24 Glendon | 05/07/1994 | ---- | ---- | 226.8 | ---- | ---- | ---- |
| 24 Glendon | 08/07/1994 | ---- | ---- | 279.5 | ---- | ---- | ---- |
| 25 Glendon | 05/07/1994 | ---- | ---- | 223.1 | ---- | ---- | ---- |
| 25 Glendon | 08/07/1994 | ---- | ---- | 497.6 | ---- | ---- | ---- |
| 26 Glendon | 05/07/1994 | ---- | ---- | 67.0 | ---- | ---- | ---- |
| 27 | 09/29/1994 | ---- | ---- | 200.9 | ---- | ---- | ---- |

<< End of 1994 listing, 59 records >>

# DUCKPUDDLE POND

# 1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of Duckpuddle Pond was undertaken by the volunteer monitor, David Libby, from May 15 through October 23, 1994 (see table 4 and figures 23-25). Additional tributary nutrient sampling (phosphorus) was undertaken during the 1994 sampling season to discern potential problem areas in the watershed with a focus on the Glendon Stream tributary system. The following data summarize the 1994 conditions of Duckpuddle Pond, and when applicable, historical data are incorporated into the interpretation. A more detailed discussion of the sampled parameters is included in the section of the report titled "Discussion of Lake Monitoring Measurements".

1) The Secchi Disk depth (a measure of water clarity) at Duckpuddle Pond, Site 1 Basin, was representative of a highly productive lake based on the criteria employed by the **Maine Department of Environmental Protection (DEP)**. The seasonal water transparency average of 1.4 meters ( 4.6 feet) is the lowest seasonal average on record since participation in the **NH LLMP** was initiated in 1988. A new minimum Secchi Disk value was also documented on July 31 (0.3 meters) and is indicative of highly turbid waters.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) in the surface waters of Duckpuddle Pond were high in 1994. The seasonal chlorophyll *a* concentration averaged 15.3 milligrams per cubic meter (15.3 mg $m^{-3}$ equivalent to 15.3 parts chlorophyll *a* per billion parts water) at Site 1 Basin which is the highest seasonal average chlorophyll *a* concentration recorded since participation in the **NH LLMP** began and falls within the **Maine DEP** criteria for a highly productive lake. Both the seasonal average chlorophyll *a* concentration and the highest reading of 53.3 ppb (documented on the July 31 sampling date) were new maximum values documented for Duckpuddle Pond. The high chlorophyll *a* concentrations documented through the 1994 sampling season are indicative of excessive algal growth in Duckpuddle Pond and suggest high total phosphorus concentrations (discussed below) in the lake.

3) Phytoplankton (microscopic plant) samples collected in Duckpuddle Pond during the 1994 sampling season were inconsistent with the chlorophyll *a* data (i.e. as the chlorophyll *a* concentrations increased the number of algal "cells" displayed no consistent pattern). However, the phytoplankton densities were consistently indicative of a highly productive system with the single exception of an August 28 sample which was characteristic of unproductive to moderately productive conditions; possibly the result of a dying algal population (see Appendix A). The algal density peaked at 8250 "cells" per milliliter on July 31 and corresponded to the maximum chlorophyll *a* concentration documented in 1994. During the algal bloom,

which spanned the months of July and August, the dominant algal form was of the genus *anabaena*, a form of blue-green bacteria (formerly referred to as blue-green algae) which tends to do well in highly productive systems. While there are various treatments which can eliminate algal populations (including chemical treatments) they are costly and can have detrimental side effects on the aquatic environment. The best means of reducing such phytoplankton populations is to reduce the phosphorus load into Duckpuddle Pond which is the limiting nutrient for their growth. This is by no means an immediate solution but is ecologically safe and will treat the source of the problem (high nutrient inputs) rather than the symptoms (algal growth).

4) Dissolved lakewater color levels (a measure of naturally occurring "background" color) for Duckpuddle Pond were high in 1994, 86.8 platinate color units (ptu) and higher than the 1993 average of 80.3 ptu.

5) In-lake total phosphorus samples (generally considered the limiting nutrient for plant growth in freshwater systems), collected in the surface waters of Duckpuddle Pond, Site 1 Basin, were high when sampled during the 1994 sampling season and ranged from 19.1 parts per billion (ppb) to 37.0 ppb. Additional sampling near the lakebottom (metalimnion) during the period of summer thermal stratification indicates a significant buildup of phosphorus, relative to the surface layer, which ranged from 49.1 ppb to 131.4 ppb in 1994. The 1994 total phosphorus concentrations are near historical maximum values recorded by the **NH LLMP** and the **Maine DEP** and fall within the range characteristic of a highly productive lake.

6) Tributary total phosphorus samples were collected from the Glendon Stream and Beaverdam Brook inlets as well as the Duckpuddle Stream outlet (see fig 22 for site locations). The highest total phosphorus readings were documented in the Glendon Stream tributary system; Site 24 on March 27 (191.6 ppb) and May 7 (226.8 ppb) and Site 25 (497.6 ppb) on August 7. Total phosphorus samples collected at the western sampling location along the railroad tracks were consistently lower (range: 10.4 - 50.6 ppb) than samples collected at the eastern sampling location along the railroad tracks (81.1 - 247.1 ppb). Note: no streamflow measurements were collected from the respective sampling locations, therefore phosphorus loading data are not available. Additional total phosphorus samples collected at the Beaverdam Brook sampling station (Site 15) ranged from 16.5 to 26.1 ppb while total phosphorus samples collected at the Duckpuddle Stream outlet (Site 17) ranged from 19.8 to 25.1 ppb. The total phosphorus concentrations measured in the Beaverdam brook are marginally high and should be investigated further while the total phosphorus concentrations documented at the eastern segment of the Glendon Stream (Sites 20 through 26) are excessive and warrant immediate attention.

7) Temperature profiles collected by the lay monitor indicate the upper mixed layer of water extended to about 4.0 meters during the period of summer thermal stratification, typical of a northern temperate lake. Dissolved oxygen data, collected by the volunteer monitor, indicate the deeper waters become anoxic following the development of thermal stratification (see figures 26 to 28). By mid July (July 17) the dis-

solved oxygen concentration was reduced below 3 parts per million (the minimum dissolved oxygen concentration required for the successful growth and reproduction of most warmwater fish) at about 4 meters, which is similar to the 1993 data. Furthermore, by July 17 dissolved oxygen concentrations in the bottom meter of Duckpuddle were near 1 milligram per liter; at which time the potential for internal nutrient loading increases and can lead to a buildup of phosphorus in the deeper waters. The dissolved oxygen concentrations continued to decline through at least August 15, at which time anoxic (without oxygen) conditions were evident in the lower one and a half meters of the water column. The lack of dissolved oxygen in the lower portion of Duckpuddle pond was conducive to internal nutrient release during most of July and August and likely contributed to the elevated total phosphorus concentrations which were documented in the bottom waters. Lower dissolved oxygen concentrations near the lakebottom are indicative of accumulating organic matter from both internal (i.e. decaying aquatic animal and vegetative matter) and external (i.e. leaf litter from watershed runoff) sources.

8) For all measurements considered and averaged for the season, Duckpuddle Pond is classified as a highly productive, eutrophic, lake.

9) The primary purpose of the volunteer monitoring effort on Duckpuddle Pond is to document long term changes in the pond's productivity and identify any land use practices within the watershed that are contributing to water quality degradation. However, "background" variability in seasonal precipitation and temperature patters can actually mask the effects of cultural eutrophication, or in some cases, augment the process, and in turn make trend (eutrophication) detection difficult. Variations in precipitation will often result in increased nutrient loading to a lake that in turn stimulates primary productivity (plant production), but can also result in increased flushing of the aquatic system that can mask the effects of internal nutrient loading (i.e. large precipitation events can reduce nutrient concentrations in highly productive lakes). Increasing temperatures will also effect the aquatic community, as most aquatic organisms will increase their activity (i.e. higher chlorophyll *a* concentrations or decreased Secchi Disk transparencies) during these periods, reflecting the thermal variations but not necessarily variations in available nutrients or other limiting resources that are commonly associated with poor land-use practices. As more data become available, the impact and interrelationship of these variables can be assessed for the study lake and the impact of land use changes can be evaluated.

A second important component of trend assessment involves the frequent collection of water quality data. The most basic measurement, the Secchi Disk transparency, is commonly used as an indicator of algal productivity (measured as chlorophyll *a*), although it also reflects the impact of dissolved colored (organic) compounds as well as suspended sediments. Chlorophyll *a* levels undergo daily fluctuations which require frequent monitoring to document short term fluctuations in chlorophyll *a* concentrations. Likewise, the dissolved color and total phosphorus concentrations can vary, particularly early in the season during and following "peak" watershed runoff, as well as, following summer storm events. Only through frequent monitoring can these short term water quality perturbations be documented, which is important since they are often precursors to long term shifts in the trophic state (productivity). We therefore recommend continued monitoring on a frequent basis (bi-weekly or preferably weekly) during the summer months to more accurately identify both short term fluctuations (weekly and at times daily fluctuations) and long term trends in water quality measurements.

Secchi Disk transparency data collected from the Duckpuddle Pond deep sampling station (representative of the average pond conditions) between 1988 and 1990 are variable while the Secchi Disk data collected between 1991 and 1994 indicate a trend of decreasing water clarity over that span (figure 29). Chlorophyll *a* data are more variable and do not follow a discernible pattern at this time (figure 30). While variable, the chlorophyll *a* data are indicative of a highly productive system which was characterized by a bloom of cyanobacteria (formerly known as blue-green algae) during the 1994 sampling season. Additional in-lake and tributary data indicate that both internal nutrients (nutrients released from the sediments) and external nutrients (i.e. high phosphorus from Glendon Brook) are sources of high phosphorus concentrations that can contribute to the high productivity levels in Duckpuddle Pond. The high total phosphorus concentrations in Glendon Brook (documented through extensive tributary sampling) suggest potential problem areas within the Duckpuddle Pond watershed. Possible phosphate sources include failing and improperly installed septic systems, improper soil conservation procedures and practices, excessive fertilizer applications, as well as, agricultural practices. We recommend conducting a watershed survey to locate potential problem areas within the watershed. We can than expand the monitoring program to investigate more localized problematic areas.

**Figure 22.Location of the 1994 Duckpuddle Pond inlet and outlet sampling stations.**

# DUCKPUDDLE POND
## TRIBUTARY ASSESSMENT 1994

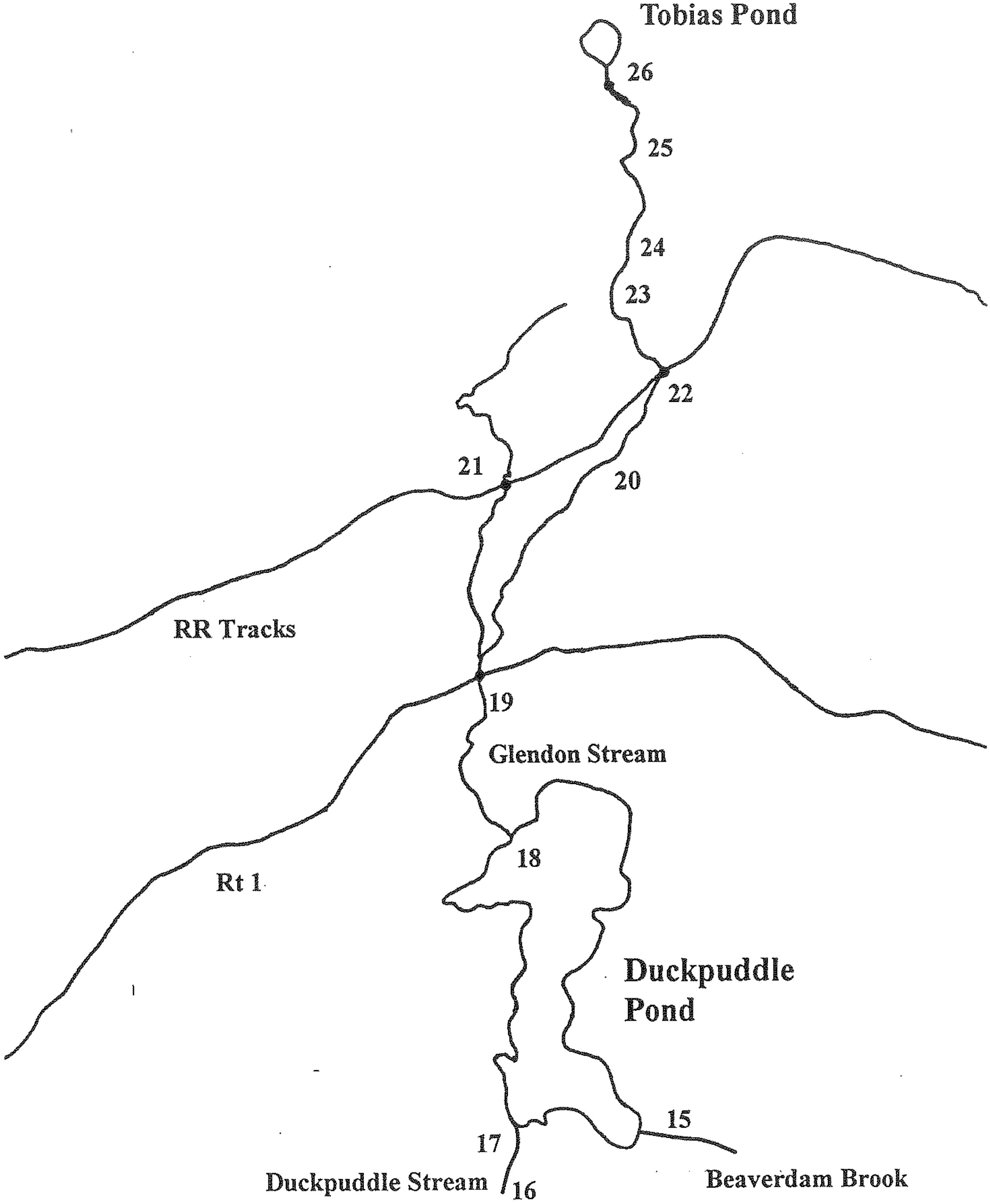
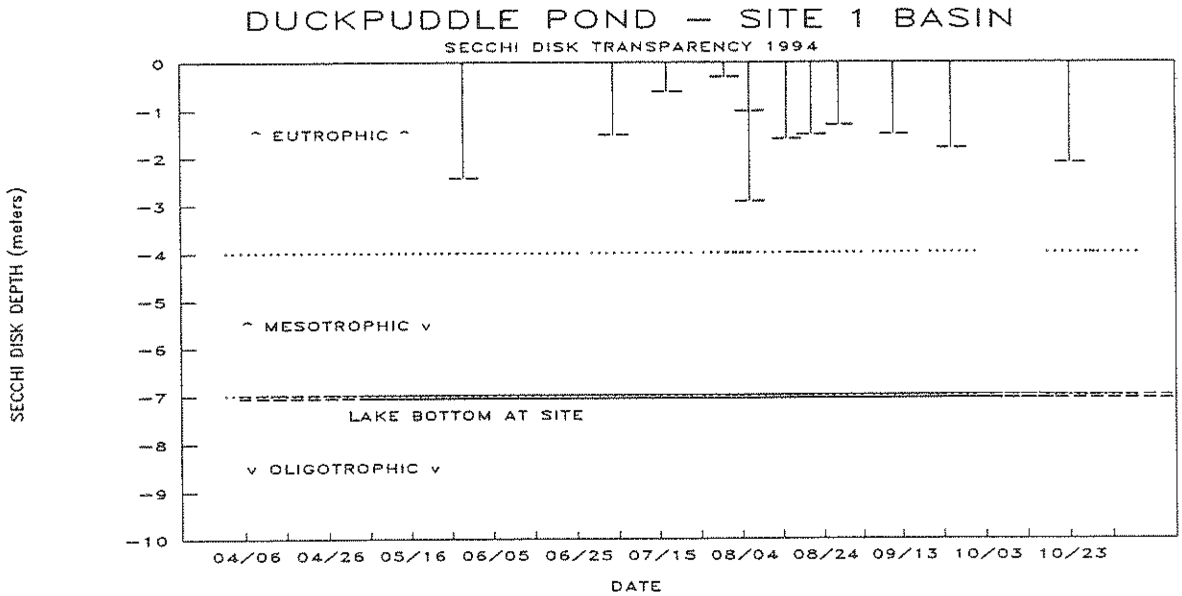
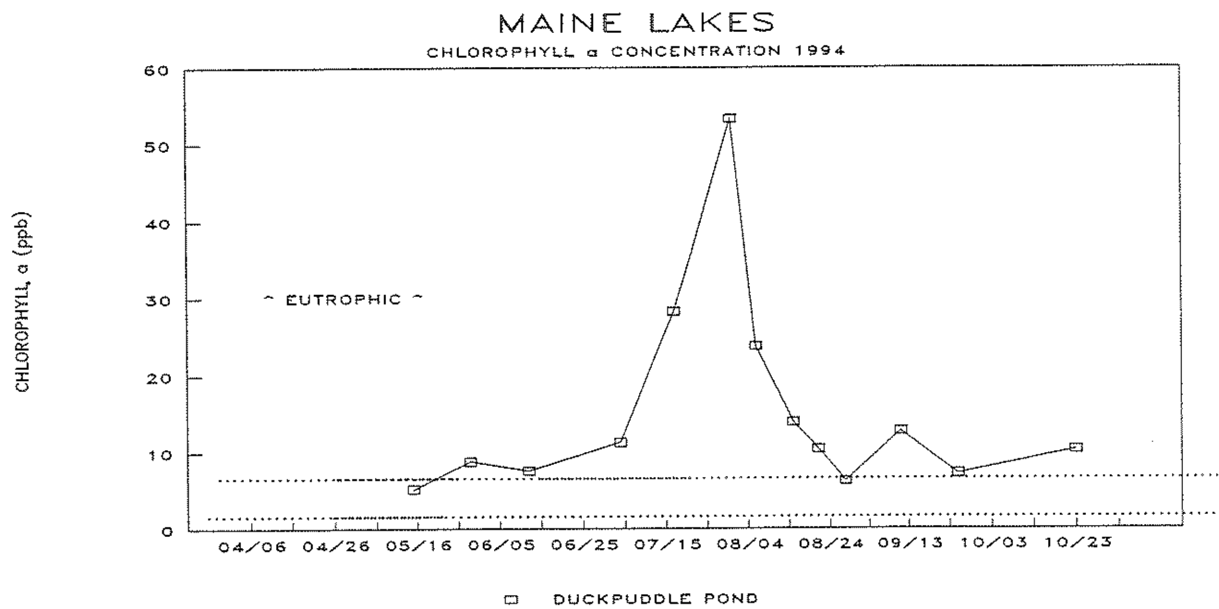


Figure 23. Duckpuddle Pond, 1994. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 1 Basin. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes while the double solid horizontal line denotes the maximum site depth. Secchi Disk measurements are reported to the nearest tenth (0.1) of a meter.

Figure 24. Duckpuddle Pond, 1994. Seasonal trends for chlorophyll *a* concentrations of lay monitor Site 1 Basin. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are reported as parts per billion (ppb) of chlorophyll *a*.

Figure 25. Duckpuddle Pond, 1994. Seasonal trends for dissolved color of lay monitor Site 1 Basin. The dotted horizontal line represents the dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).


DUCKPUDDLE POND — SITE 1 BASIN
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
LAKE BOTTOM AT SITE
v OLIGOTROPHIC v
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


MAINE LAKES
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
60
50
40
30
20
10
0
^ EUTROPHIC ^
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DUCKPUDDLE POND

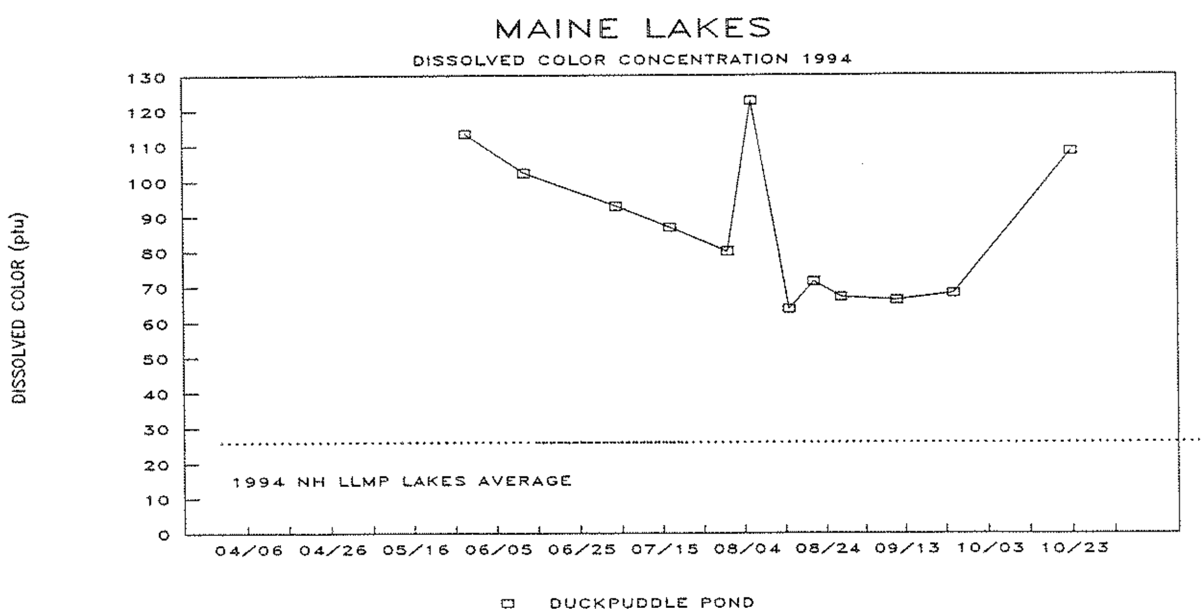
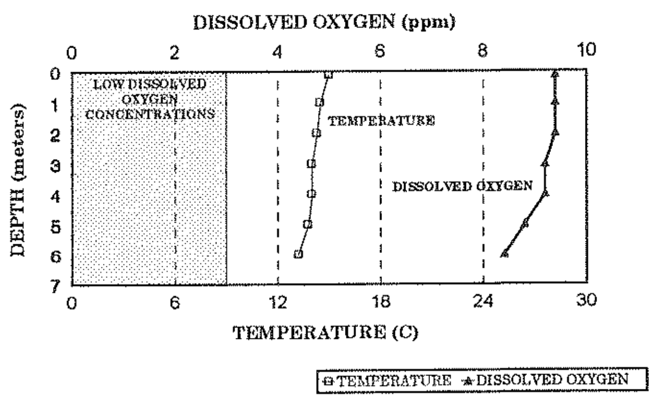
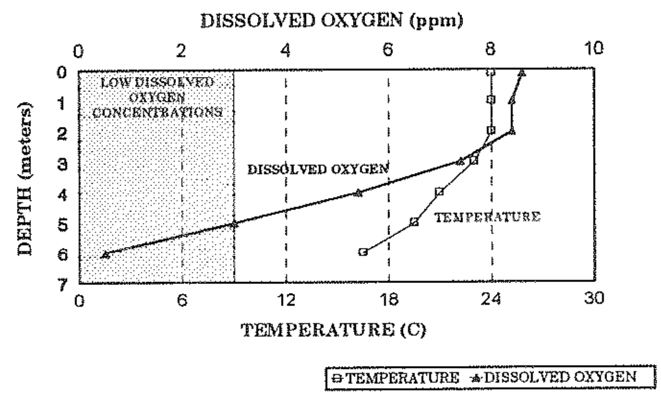

MAINE LAKES
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1994 NH LLMP LAKES AVERAGE
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DUCKPUDDLE POND

**Figure 26.** Temperature and dissolved oxygen profiles collected in Duckpuddle Pond, Site 1 Basin. The collection data and units of measurement are as indicated on the respective graphs. Dissolved oxygen and temperature were measured at one meter intervals.

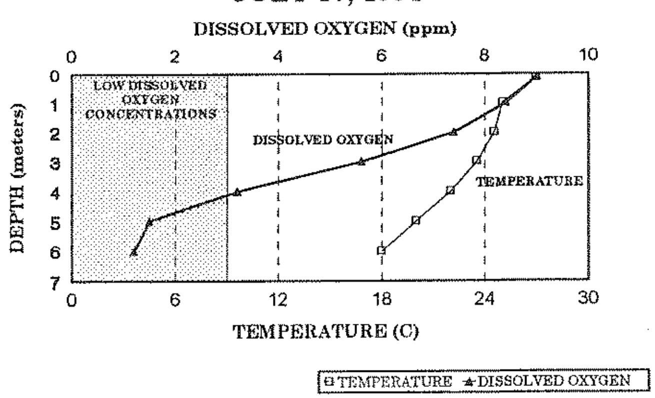
## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### MAY 29, 1994




## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### JULY 04, 1994




## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### JULY 17, 1994




## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### JULY 31, 1994

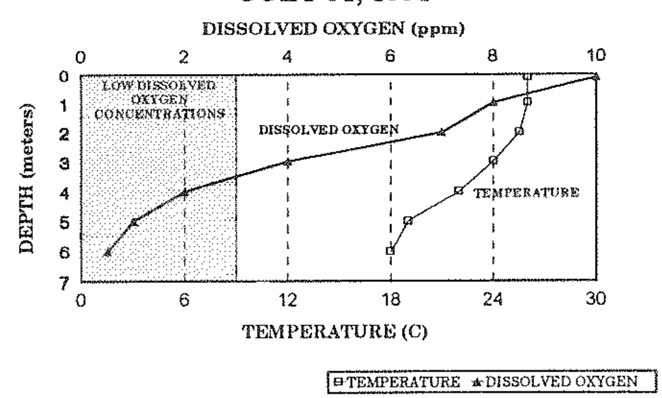
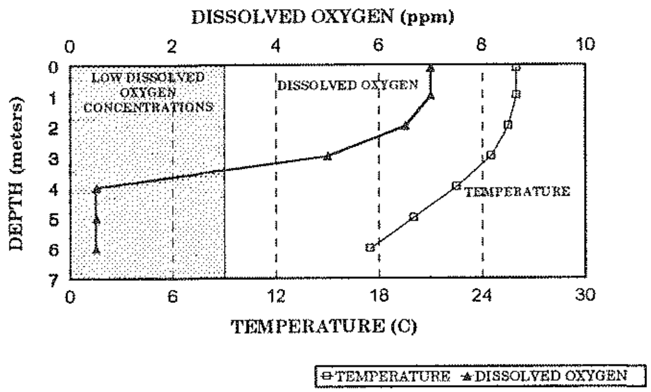
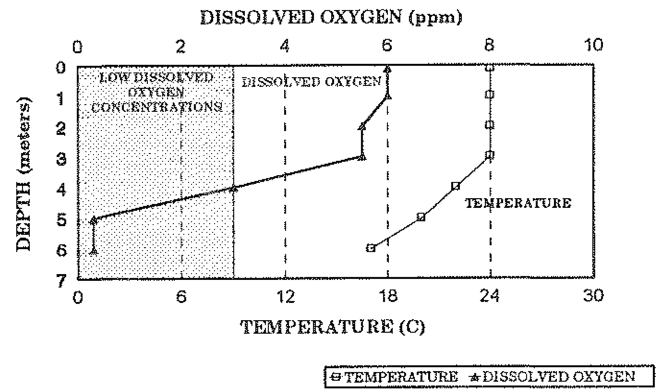


**Figure 27.** Temperature and dissolved oxygen profiles collected in Duckpuddle Pond, Site 1 Basin. The collection data and units of measurement are as indicated on the respective graphs. Dissolved oxygen and temperature were measured at one meter intervals.

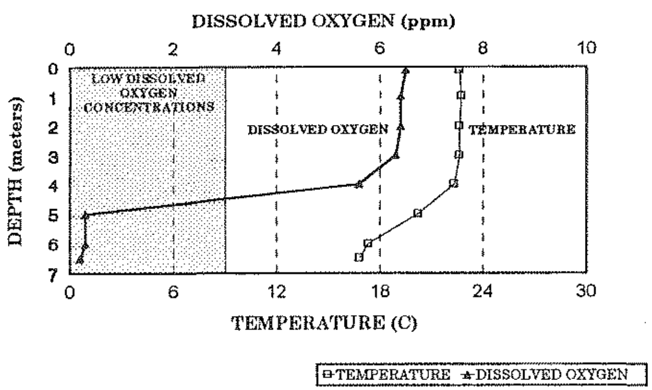
## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### AUGUST 03, 1994




## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### AUGUST 06, 1994




## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### AUGUST 15, 1994




## DUCKPUDDLE POND - SITE 1 BASIN
### TEMPERATURE - DISSOLVED OXYGEN PROFILES
### AUGUST 21, 1994

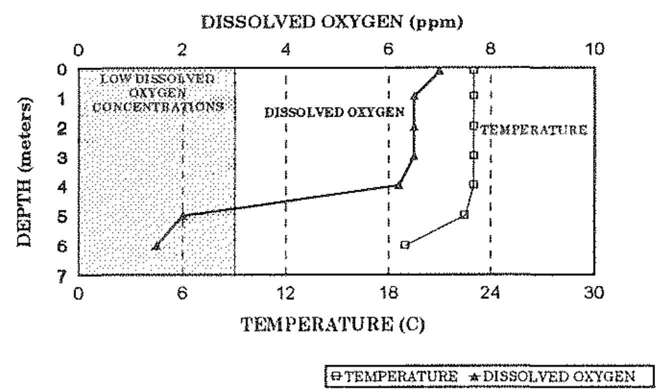
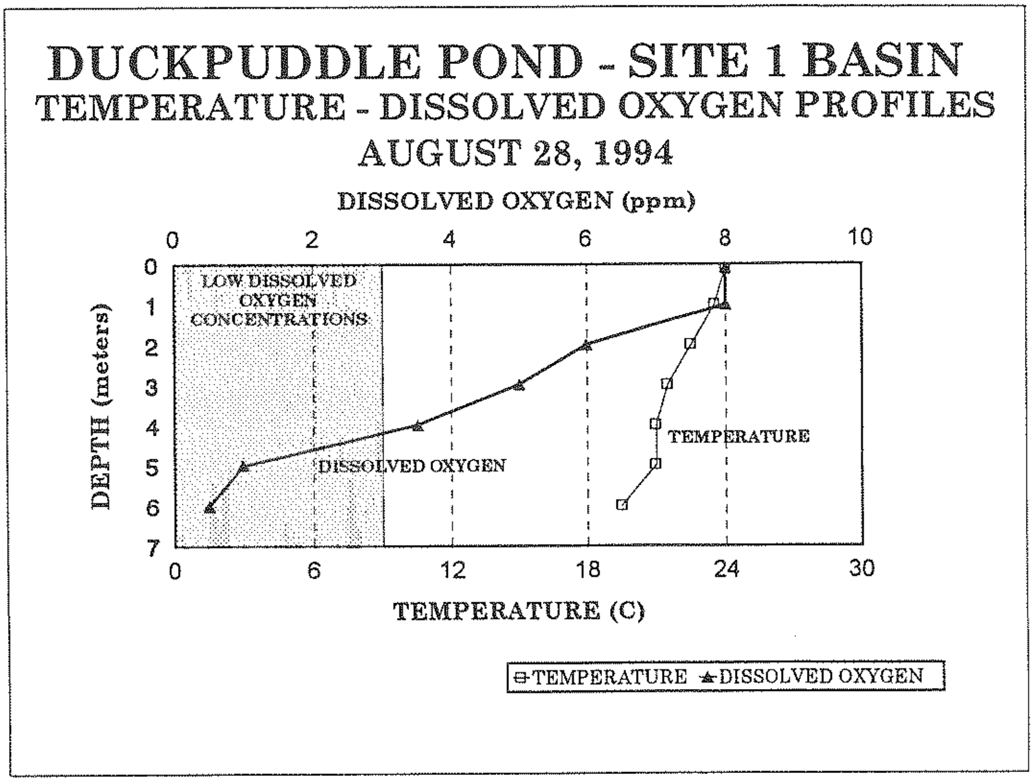


**Figure 28. Temperature and dissolved oxygen profiles collected in Duckpuddle Pond, Site 1 Basin. The collection data and units of measurement are as indicated on the respective graphs. Dissolved oxygen and temperature were measured at one meter intervals.**


DUCKPUDDLE POND - SITE 1 BASIN
TEMPERATURE - DISSOLVED OXYGEN PROFILES
AUGUST 28, 1994
DISSOLVED OXYGEN (ppm)
0
2
4
6
8
10
LOW DISSOLVED OXYGEN CONCENTRATIONS
DISSOLVED OXYGEN
TEMPERATURE
DEPTH (meters)
0
1
2
3
4
5
6
7
0
6
12
18
24
30
TEMPERATURE (C)
TEMPERATURE
DISSOLVED OXYGEN

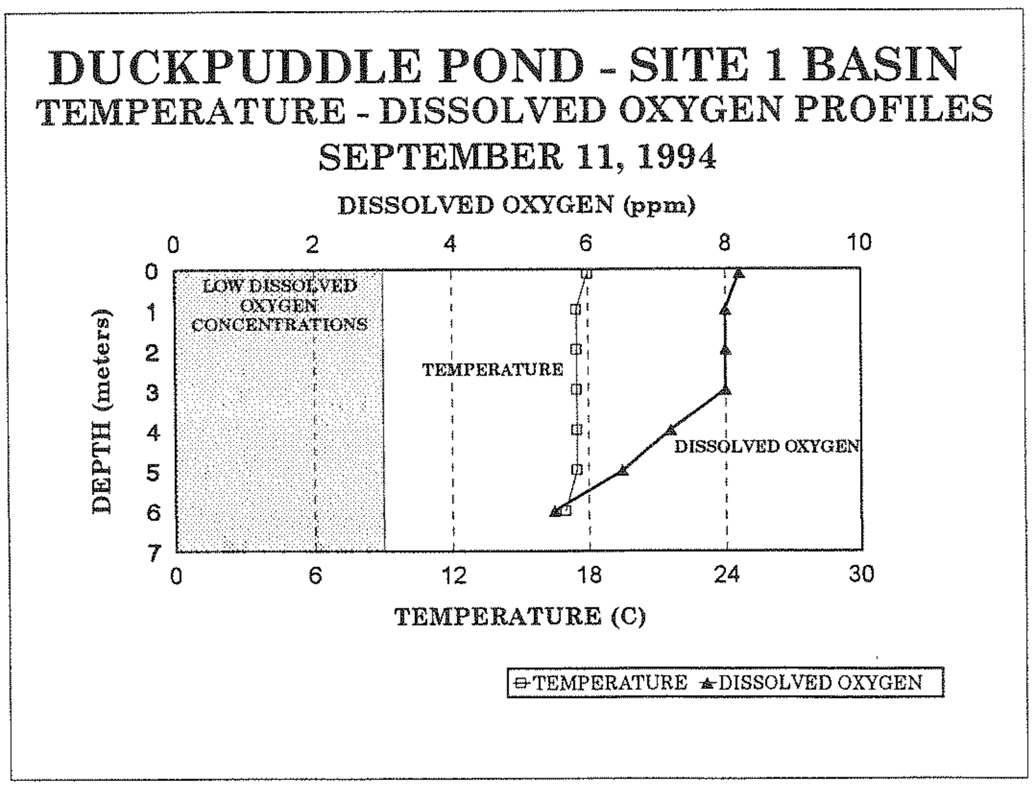
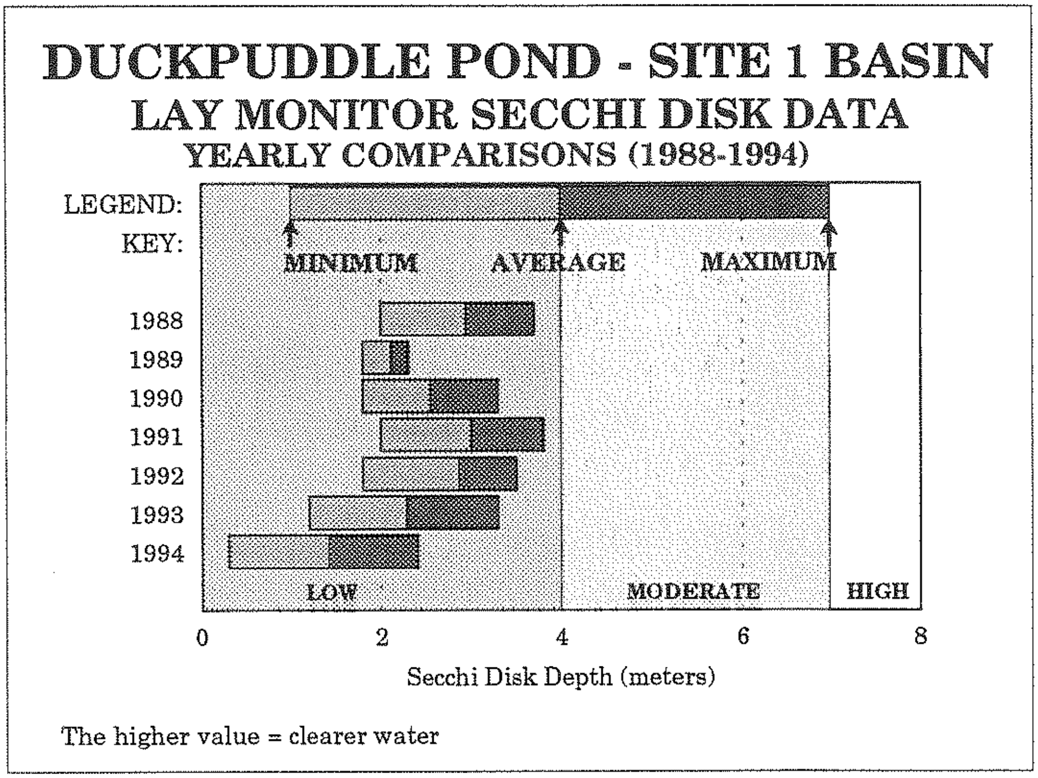
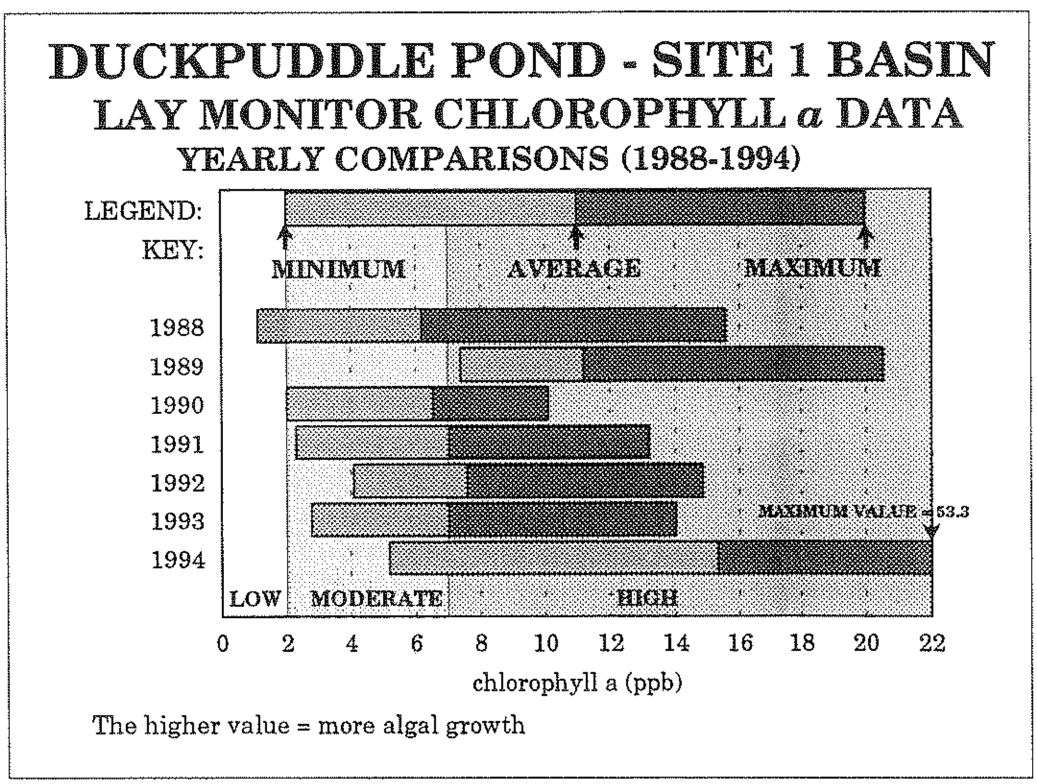

DUCKPUDDLE POND - SITE 1 BASIN
TEMPERATURE - DISSOLVED OXYGEN PROFILES
SEPTEMBER 11, 1994
DISSOLVED OXYGEN (ppm)
0
2
4
6
8
10
LOW DISSOLVED OXYGEN CONCENTRATIONS
TEMPERATURE
DISSOLVED OXYGEN
DEPTH (meters)
0
1
2
3
4
5
6
7
0
6
12
18
24
30
TEMPERATURE (C)
TEMPERATURE
DISSOLVED OXYGEN

Figure 29. Comparison of the 1994 Duckpuddle Pond lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP Secchi Disk standards for low, moderate and high water clarities. The higher the Secchi Disk value, the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter

Figure 30. Comparison of the 1994 Duckpuddle Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).


DUCKPUDDLE POND - SITE 1 BASIN
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
Secchi Disk Depth (meters)
The higher value = clearer water


DUCKPUDDLE POND - SITE 1 BASIN
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
MAXIMUM VALUE = 53.3
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
14
16
18
20
22
chlorophyll a (ppb)
The higher value = more algal growth

## Table 5. McCurdy Pond -- trophic indicators, 1994

**Lakes Lay Monitoring Program, U.N.H.**

**[Lay Monitor Data]**

McCurdy Pond, Maine
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Average transparency: | 6.4 | (1994: | 11 | values; | 5.2 | - | 7.2 | range) |
| Average chlorophyll: | 2.6 | (1994: | 11 | values; | 1.4 | - | 4.1 | range) |
| Average Lake Phos.: | 21.1 | (1994: | 3 | values; | 6.5 | - | 49.9 | range) |
| Average color, 440: | 25.5 | (1994: | 11 | values; | 18.9 | - | 33.5 | range) |

| Site | Date | Trans-parency (m) | Chl a (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 1 Basin | 05/07/1994 | 5.2 | 3.1 | ---- | ---- | ---- | 30.9 |
| 1 Basin | 05/21/1994 | 7.2 | 1.4 | ---- | ---- | ---- | 33.5 |
| 1 Basin | 06/04/1994 | 6.5 | 4.1 | ---- | ---- | ---- | 31.8 |
| 1 Basin | 06/18/1994 | 5.6 | 1.9 | ---- | ---- | ---- | 28.3 |
| 1 Basin | 07/01/1994 | 6.6 | 3.2 | ---- | ---- | ---- | 27.5 |
| 1 Basin | 07/16/1994 | 6.3 | 2.9 | ---- | ---- | ---- | 25.8 |
| 1 Basin | 07/30/1994 | 6.5 | 2.6 | ---- | ---- | ---- | 20.6 |
| 1 Basin | 08/15/1994 | 6.2 | 2.7 | ---- | ---- | ---- | 22.3 |
| 1 Basin | 08/28/1994 | 6.2 | 2.3 | ---- | ---- | ---- | 22.3 |
| 1 Basin | 09/10/1994 | 6.9 | 2.3 | ---- | ---- | ---- | 18.9 |
| 1 Basin | 09/25/1994 | 6.8 | 2.3 | ---- | ---- | ---- | 18.9 |
| 1 Hypo | 07/30/1994 | ---- | ---- | 49.9 | ---- | ---- | ---- |
| 1 Surface | 05/07/1994 | ---- | ---- | 6.5 | ---- | ---- | ---- |
| 1 Surface | 09/25/1994 | ---- | ---- | 7.0 | ---- | ---- | ---- |

<< End of 1994 listing, 14 records >>

# MCCURDY POND

# 1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of McCurdy Pond was undertaken by the volunteer monitor, Albert Rogers, from May 7 through September 25, 1994 (see table 5 and figures 31-33). The following data summarize the 1994 conditions of McCurdy Pond, and when applicable, historical data are incorporated into the interpretation. A more detailed discussion of the sampled parameters is included in the section of the report titled "Discussion of Lake Monitoring Measurements".

1) The Secchi Disk depth (a measure of water clarity) at McCurdy Pond was representative of a moderately productive lake based on the criteria employed by the **Maine Department of Environmental Protection (DEP)**. The seasonal water transparency average of 6.4 meters (20.8 feet) is the highest seasonal average recorded since participation in the **NH LLMP** was initiated in 1988.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) in the surface waters of McCurdy Pond were moderate in 1994. The seasonal chlorophyll *a* concentration averaged 2.6 milligrams per cubic meter (2.6 mg $m^{-3}$ equivalent to 2.6 parts chlorophyll *a* per billion parts water) at Site 1 Basin which falls within the **Maine DEP** criteria for a moderately productive lake.

3) Phytoplankton (microscopic plant) samples collected in McCurdy Pond during the 1994 sampling season compared well with the chlorophyll *a* concentrations (i.e. as the chlorophyll *a* concentrations increased the number of algal "cells" increased (refer to Appendix A). Based on typical phytoplankton densities documented in **NH LLMP** lakes, McCurdy Pond falls within the range typical of a borderline unproductive to moderately productive lake. The types of phytoplankton present during the 1994 sampling season are an indication of a moderately productive system that borders on less productive, oligotrophic, conditions.

4) Dissolved lakewater color levels (a measure of naturally occurring "background" color) for McCurdy Pond were moderate in 1994, 25.5 platinate color units (ptu) and higher than the 1993 average of 24.3 ptu. McCurdy Pond is the least colored of the participating **Pemaquid Watershed Association** pond's, translating into higher water clarities in the former pond.

5) Total phosphorus samples (generally considered the limiting nutrient for plant growth in freshwater systems), collected in the surface waters of McCurdy Pond, both early (May 7) and again late (September 25) in the season were moderate, 6.5 parts per billion (ppb) and 7.0 ppb, respectively, and bordered less productive levels. Additional bottom water (hypolimnetic) total phosphorus sampling indicates an accumulation of phosphorus near the lakebottom as the summer progresses (49.9 ppb on July 30). The 1994 total

phosphorus concentrations are within historical total phosphorus concentrations recorded by the **NH LLMP** and the **Maine DEP** and fall within the range characteristic of a moderately productive lake bordering on a less productive, oligotrophic, level.

6) Temperature profiles collected by the lay monitor indicate the upper mixed layer of water extended to about 6.5 meters during the period of summer thermal stratification, typical of a northern temperate lake. Historical dissolved oxygen data, collected by the **Maine DEP** (1985), indicate dissolved oxygen concentrations become reduced in the bottom (hypolimnetic) waters of McCurdy Pond during thermal stratification. Low hypolimnetic dissolved oxygen concentrations are indicative of accumulating organic matter from both internal (i.e. decaying aquatic animal and vegetative matter) and external (i.e. leaf litter from watershed runoff) sources. As dissolved oxygen concentrations are reduced below 1 milligram per liter the potential for internal nutrient release (nutrients are resuspended from the sediments) increases significantly and might explain the elevated hypolimnetic total phosphorus concentration documented in McCurdy Pond during the 1994 sampling season.

7) For all measurements considered and averaged for the season, McCurdy Pond is classified as a moderately productive, mesotrophic, lake bordering a less productive, oligotrophic, conditions.

8) The primary purpose of the volunteer monitoring effort on McCurdy Pond is to document long term changes in the pond's productivity and identify any land use practices within the watershed that are contributing to water quality degradation. However, "background" variability in seasonal precipitation and temperature patters can actually mask the effects of cultural eutrophication, or in some cases, augment the process, and in turn make trend (eutrophication) detection difficult. Variations in precipitation will often result in increased nutrient loading to a lake that in turn stimulates primary productivity (plant production), but can also result in increased flushing of the aquatic system that can mask the effects of internal nutrient loading (i.e. large precipitation events can reduce nutrient concentrations in highly productive lakes). Increasing temperatures will also effect the aquatic community, as most aquatic organisms will increase their activity (i.e. higher chlorophyll *a* concentrations or decreased Secchi Disk transparencies) during these periods, reflecting the thermal variations but not necessarily variations in available nutrients or other limiting resources that are commonly associated with poor land-use practices. As more data become available, the impact and interrelationship of these variables can be assessed for the study lake and the impact of land use changes can be evaluated.

A second important component of trend assessment involves the frequent collection of water quality data. The most basic measurement, the Secchi Disk transparency, is commonly used as an indicator of algal productivity (measured as chlorophyll *a*), although it also reflects the impact of dissolved colored (organic) compounds as well as suspended sediments. Chlorophyll *a* levels undergo daily fluctuations which require frequent monitoring to document short term fluctuations in chlorophyll *a* concentrations. Likewise, the dissolved color and total phosphorus concentrations can vary, particularly early in the season during and following "peak" watershed runoff, as well as, following summer storm events. Only through frequent monitoring can these short term water quality perturbations be documented, which is important since they are often precursors to long term shifts in the trophic state (productivity). We therefore recommend continued monitoring on a frequent basis (bi-weekly or preferably weekly) during the summer months to more accurately identify both short term fluctuations (weekly and at times daily fluctuations) and long term trends in water quality measurements.

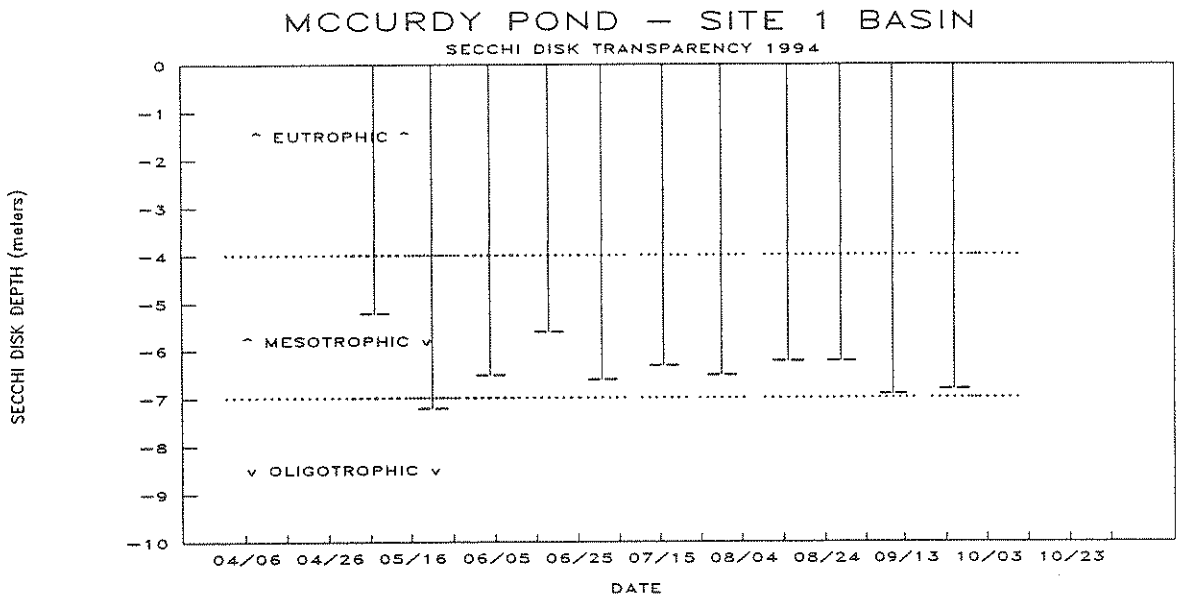
Seasonal average water quality data collected from the McCurdy Pond deep sampling station (representative of the average pond conditions) between 1988 and 1994 indicate a trend of increasing Secchi Disk depth while the chlorophyll *a* data, through 1993, illustrated a trend of decreasing chlorophyll *a* concentrations (see figures 34 and 35). However the 1994 seasonal average chlorophyll *a* concentration increased, a shift from the trend of decreasing chlorophyll *a* concentrations.

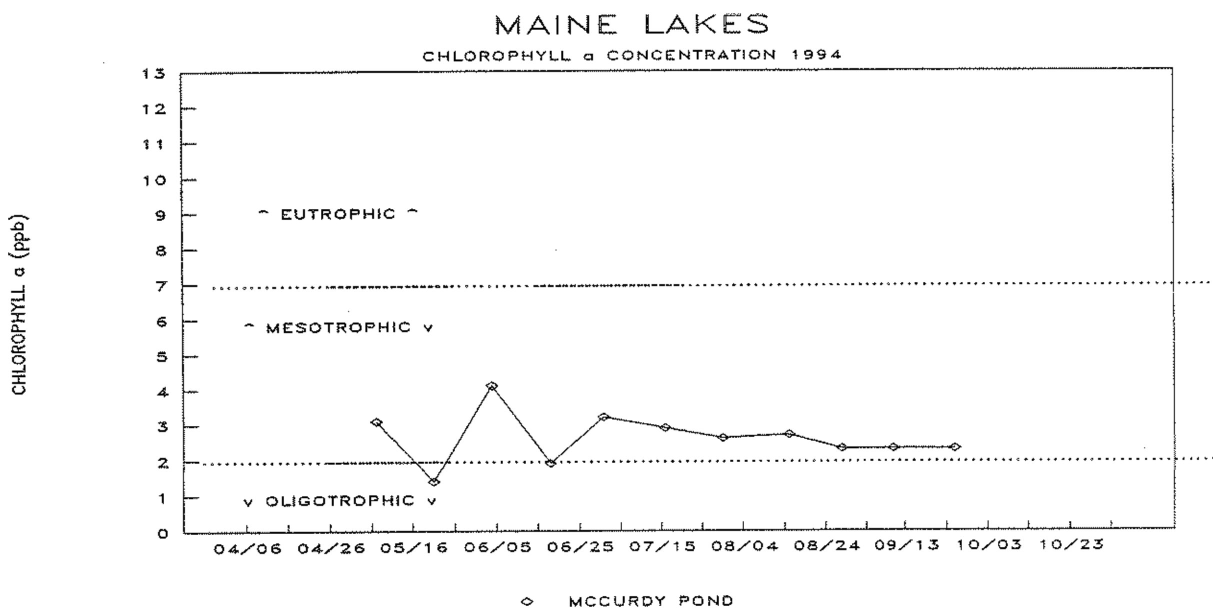
Based on the current and historical water quality data, McCurdy Pond exhibits the highest water quality of the participating **Pemaquid Watershed Association** Ponds. While data collected from the deep sampling station, Site 1 Center, indicate continued high water quality, more localized problems (i.e. improperly installed and failing septic systems, improper soil conservation procedures and practices, excessive fertilizer applications, etc.) might be overlooked in the shallows and in more embayed areas of McCurdy Pond. If such problem areas are a concern, we recommend performing a shoreline survey of the lake or a watershed survey to located potential problem areas. We can than expand, or revise, the monitoring program to address more localized regions if the need exists.

Figure 31. McCurdy Pond, 1994. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 1 Basin. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Secchi Disk measurements are reported to the nearest tenth (0.1) of a meter.

Figure 32. McCurdy Pond, 1994. Seasonal trends for chlorophyll *a* concentrations of lay monitor Site 1 Basin. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are reported as parts per billion (ppb) of chlorophyll *a*.

Figure 33. McCurdy Pond, 1994. Seasonal trends for dissolved color of lay monitor Site 1 Basin. The dotted horizontal line represents the dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).


MCCURDY POND — SITE 1 BASIN
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


MAINE LAKES
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
◇ MCCURDY POND

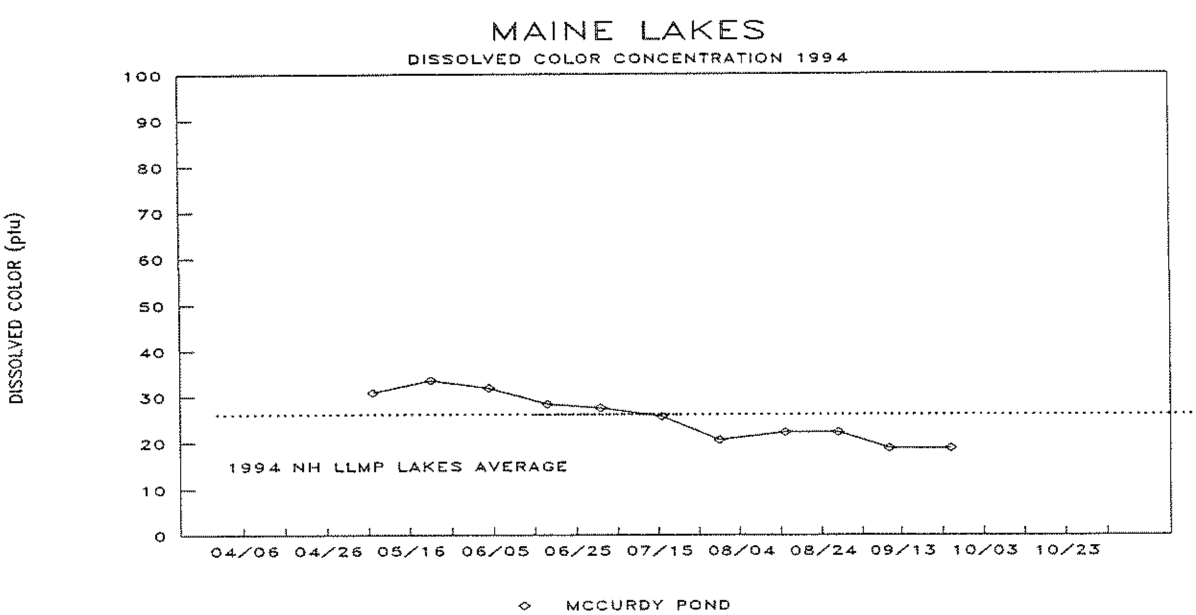
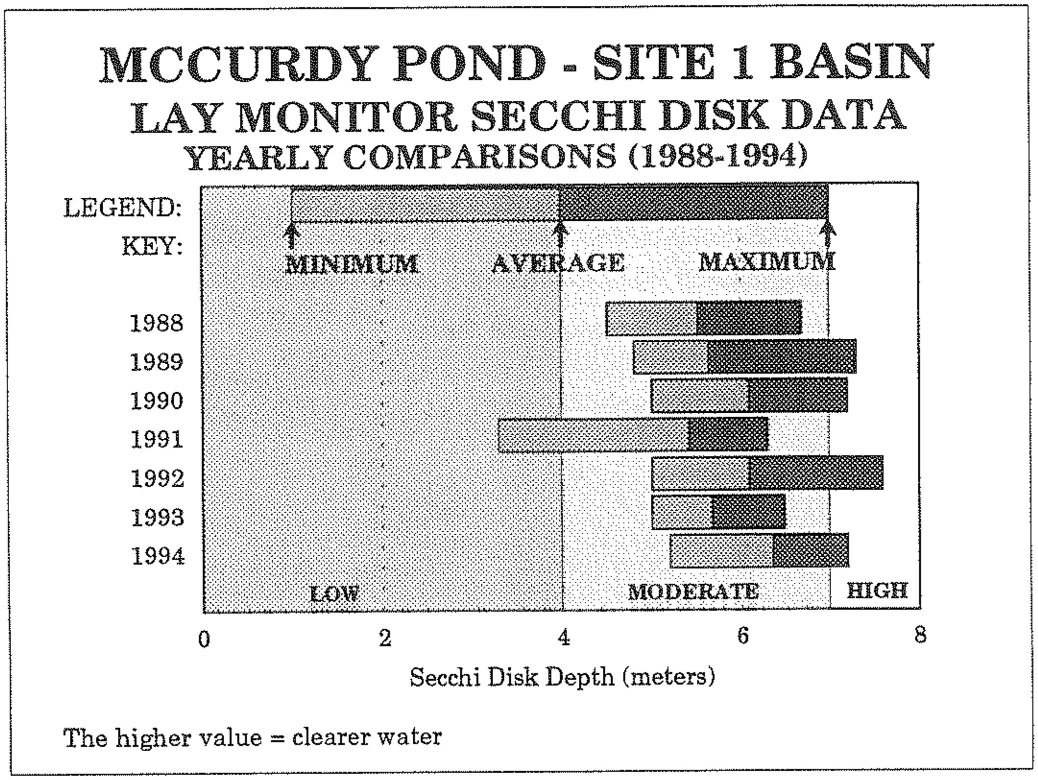
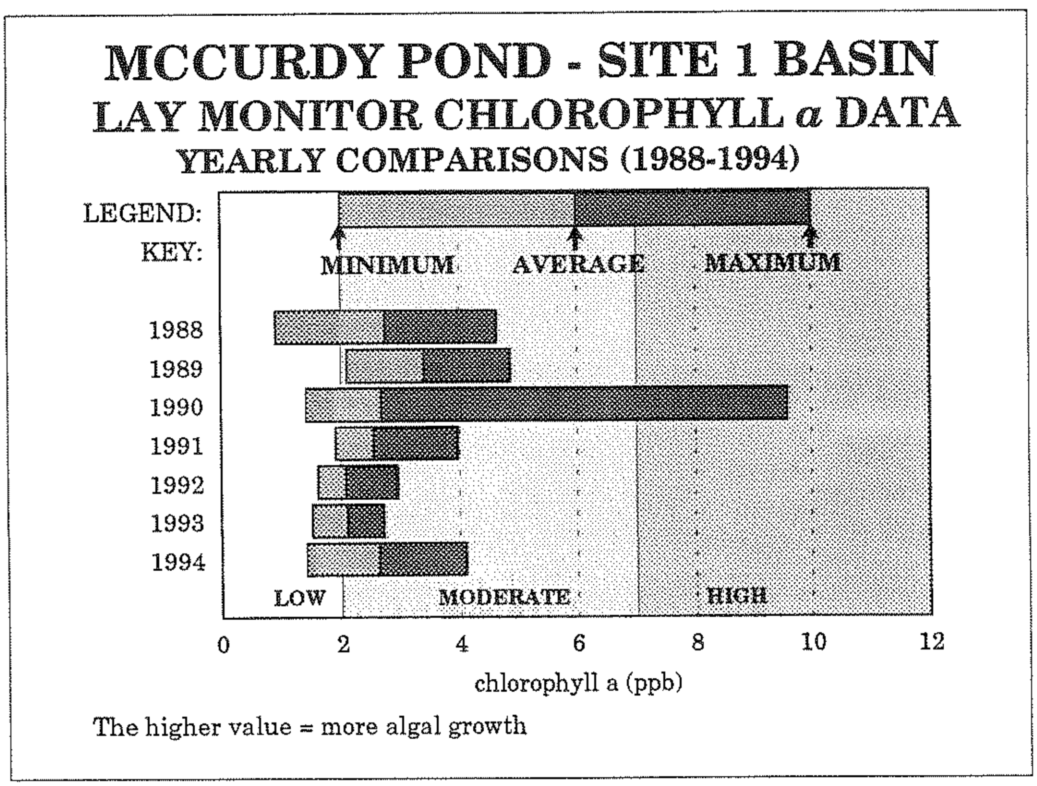

MAINE LAKES
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
100
90
80
70
60
50
40
30
20
10
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
◇ MCCURDY POND

Figure 34. Comparison of the 1994 McCurdy Pond lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP Secchi Disk standards for low, moderate and high water clarities. The higher the Secchi Disk value, the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 35. Comparison of the 1994 McCurdy Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).



MCCURDY POND - SITE 1 BASIN
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
Secchi Disk Depth (meters)
The higher value = clearer water

MCCURDY POND - SITE 1 BASIN
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
chlorophyll a (ppb)
The higher value = more algal growth

## Table 6. Paradise Pond -- trophic indicators, 1994

**Lakes Lay Monitoring Program, U.N.H.**

**[Lay Monitor Data]**

Paradise Pond, Maine
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Average transparency: | 3.3 | (1994: | 4 | values; | 3.1 | - | 3.6 | range) |
| Average chlorophyll: | 4.5 | (1994: | 13 | values; | 1.8 | - | 12.3 | range) |
| Average Lake Phos.: | 22.1 | (1994: | 3 | values; | 14.8 | - | 33.2 | range) |
| Average color, 440: | 71.0 | (1994: | 13 | values; | 52.4 | - | 86.8 | range) |

| Site | Date | Trans- parency (m) | Chl a (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 1 Bottom | 08/13/1994 | ---- | ---- | 33.2 | ---- | ---- | ---- |
| 1 North | 05/07/1994 | 3.2 | 12.3 | ---- | ---- | ---- | 86.8 |
| 1 North | 05/22/1994 | 3.1 | 4.9 | ---- | ---- | ---- | 85.9 |
| 1 North | 06/05/1994 | 3.6 | 3.8 | ---- | ---- | ---- | 73.0 |
| 1 North | 06/19/1994 | 3.4 | 6.3 | ---- | ---- | ---- | 80.7 |
| 1 North | 07/04/1994 | bottom | 7.5 | ---- | ---- | ---- | 73.0 |
| 1 North | 07/14/1994 | ---- | 4.3 | ---- | ---- | ---- | 75.6 |
| 1 North | 07/31/1994 | bottom | 4.9 | ---- | ---- | ---- | 67.0 |
| 1 North | 08/13/1994 | bottom | 2.3 | ---- | ---- | ---- | 70.4 |
| 1 North | 08/28/1994 | bottom | 2.6 | ---- | ---- | ---- | 61.8 |
| 1 North | 09/11/1994 | bottom | 2.1 | ---- | ---- | ---- | 58.4 |
| 1 North | 09/25/1994 | bottom | 2.4 | ---- | ---- | ---- | 52.4 |
| 1 North | 10/09/1994 | bottom | 3.3 | ---- | ---- | ---- | 59.3 |
| 1 North | 10/23/1994 | bottom | 1.8 | ---- | ---- | ---- | 79.0 |
| 1 Surface | 05/07/1994 | ---- | ---- | 18.4 | ---- | ---- | ---- |
| 1 Surface | 10/23/1994 | ---- | ---- | 14.8 | ---- | ---- | ---- |

<< End of 1994 listing, 16 records >>

# PARADISE POND

# 1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of Paradise Pond was undertaken by the volunteer monitor, Steve O'Bryan, from May 7 through October 23, 1994 (see table 6 and figures 36-38). The following data summarize the 1994 conditions of Paradise Pond, and when applicable, historical data are incorporated into the interpretation. A more detailed discussion of the sampled parameters is included in the section of the report titled "Discussion of Lake Monitoring Measurements".

1) The Secchi Disk depth (a measure of water clarity) at Paradise Pond ranged from 3.1 to 4.1 meters (at which time the Secchi Disk rested on the lake-bottom). Due to the shallowness of the pond, water clarity measurements cannot be classified based on the criteria employed by the **Maine Department of Environmental Protection (DEP)**.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) in the surface waters of Paradise Pond were moderate in 1994. The seasonal chlorophyll *a* concentration averaged 4.5 milligrams per cubic meter (4.5 mg $m^{-3}$ equivalent to 4.5 parts chlorophyll *a* per billion parts water) at Site 2 North which falls within the **Maine DEP** criteria for a moderately productive lake. A new chlorophyll *a* high of 12.3 ppb was documented on May 5 is most likely the result of the flushing of nutrient during the period of heavy watershed runoff as well as the result of resuspension of nutrient off the lakebottom. While algal blooms are common in the spring and fall, increasing chlorophyll *a* concentrations during those periods, relative to previous years of sampling, can be an early indication of increasing lake productivity.

3) Phytoplankton (microscopic plant) samples collected in Paradise Pond during the 1994 sampling season were inconsistent with the chlorophyll *a* concentrations (i.e. as the chlorophyll *a* concentrations increased the number of algal "cells" were highly variable). The inconsistencies between the two parameters might be the result of the lack of thermal stratification in Paradise Pond. Particulate matter (including algal cells and chlorophyllous material) is easily resuspended into the water column and can bias the results of our analysis (in this case reducing the significance of the relationship between chlorophyll *a* concentrations and the number of phytoplankton "cells"). Based on typical phytoplankton densities documented in **NH LLMP** lakes, Paradise Pond falls within the range typical of a moderately productive lake bordering less productive, oligotrophic, conditions. The types of phytoplankton present during the 1994 sampling season are a further indication of a borderline unproductive/moderately productive system (see Appendix A).

4) Dissolved lakewater color levels (a measure of naturally occurring "background" color) for Paradise Pond were moderate in 1994, 71.0 platinate

color units (ptu) and similar to the 1993 average of 70.3 ptu. Paradise Pond, like Duckpuddle Pond, is surrounded by wetlands which contribute to the high dissolved color levels.

5) Total phosphorus samples (generally considered the limiting nutrient for plant growth in freshwater systems), collected in the surface waters of Paradise Pond, both early (May 7) and again late (October 23) in the season were high, 18.4 parts per billion (ppb) and 14.8 ppb, respectively. Additional bottom water total phosphorus sampling indicates an accumulation of phosphorus near the lakebottom (33.2 ppb on August 13). The 1994 total phosphorus concentrations are within historical phosphorus concentrations recorded by the **NH LLMP** and the **Maine DEP** and fall within the range characteristic of a highly productive lake.

6) Temperature profiles collected by the lay monitor indicate Paradise Pond remained mixed (i.e. no thermal stratification) throughout the summer sampling season, typical of shallow water bodies. With the lack of temperature stratification, the pond remains well oxygenated. However, during periods of inclement weather, there is a greater chance of resuspending matter accumulated on the bottom of Paradise Pond than would occur in a deeper, stratified lake or pond (i.e. Biscay Pond and McCurdy Pond). The resuspension of particulate matter can diminish water clarity and mobilize nutrients, which adhere to the sediments and detrital (decaying organic matter) particles, and can than be utilized by certain algal forms.

7) For all measurements considered and averaged for the season, Paradise Pond is classified as a moderately productive, mesotrophic, lake. However, total phosphorus concentrations border on a higher level of productivity; eutrophy.

8) The primary purpose of the volunteer monitoring effort on Paradise Pond is to document long term changes in the pond's productivity and identify any land use practices within the watershed that are contributing to water quality degradation. However, "background" variability in seasonal precipitation and temperature patters can actually mask the effects of cultural eutrophication, or in some cases, augment the process, and in turn make trend (eutrophication) detection difficult. Variations in precipitation will often result in increased nutrient loading to a lake that in turn stimulates primary productivity (plant production), but can also result in increased flushing of the aquatic system that can mask the effects of internal nutrient loading (i.e. large precipitation events can reduce nutrient concentrations in highly productive lakes). Increasing temperatures will also effect the aquatic community, as most aquatic organisms will increase their activity (i.e. higher chlorophyll *a* concentrations or decreased Secchi Disk transparencies) during these periods, reflecting the thermal variations but not necessarily variations in available nutrients or other limiting resources that are commonly associated with poor land-use practices. As more data become available, the impact and interrelationship of these variables can be assessed for the study lake and the impact of land use changes can be evaluated.

A second important component of trend assessment involves the frequent collection of water quality data. The most basic measurement, the Secchi

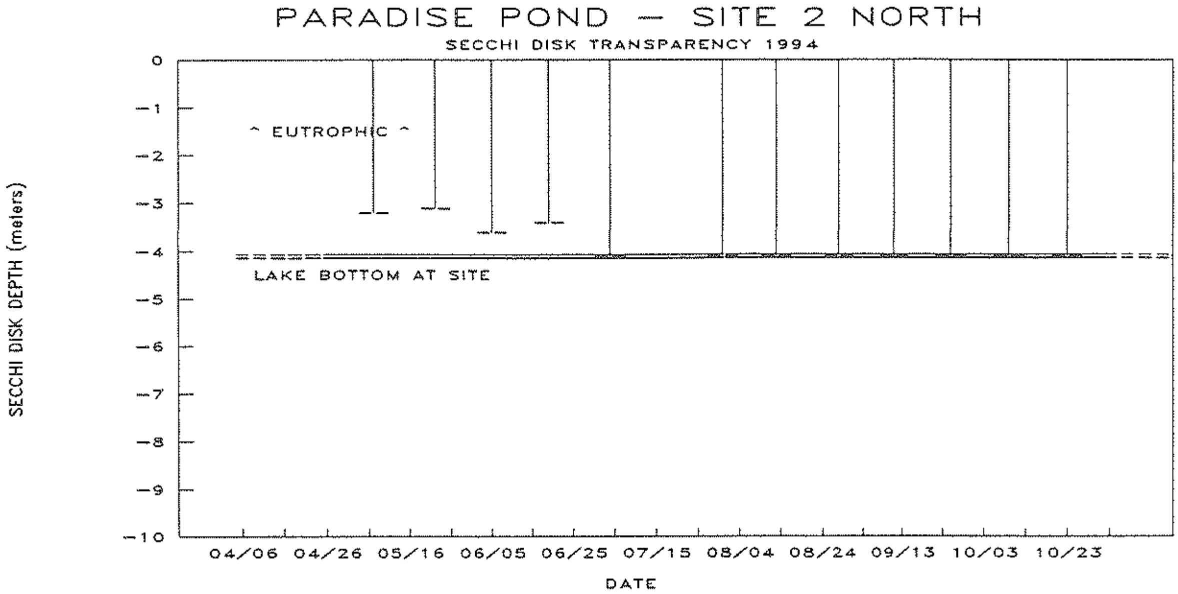
Disk transparency, is commonly used as an indicator of algal productivity (measured as chlorophyll *a*), although it also reflects the impact of dissolved colored (organic) compounds as well as suspended sediments. Chlorophyll *a* levels undergo daily fluctuations which require frequent monitoring to document short term fluctuations in chlorophyll *a* concentrations. Likewise, the dissolved color and total phosphorus concentrations can vary, particularly early in the season during and following "peak" watershed runoff, as well as, following summer storm events. Only through frequent monitoring can these short term water quality perturbations be documented, which is important since they are often precursors to long term shifts in the trophic state (productivity). We therefore recommend continued monitoring on a frequent basis (bi-weekly or preferably weekly) during the summer months to more accurately identify both short term fluctuations (weekly and at times daily fluctuations) and long term trends in water quality measurements.

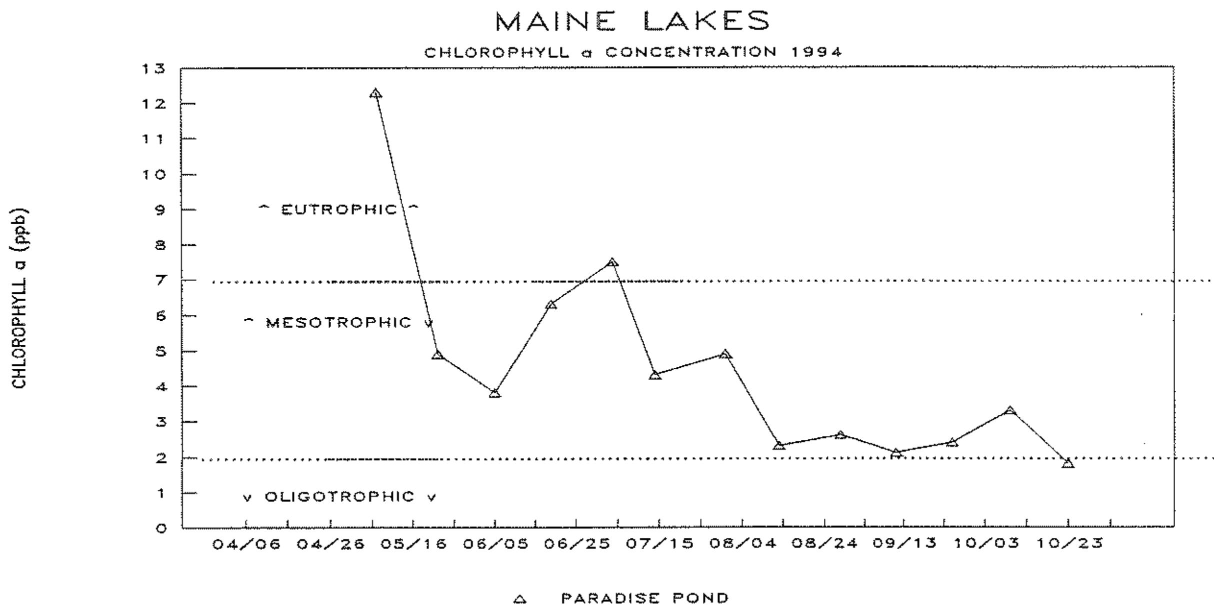
Water quality data collected from the Paradise Pond deep sampling station (representative of the average pond conditions) between 1988 and 1994 (see figure 39) indicate variable chlorophyll *a* concentrations over the seven year span but a trend of increasing chlorophyll *a* concentrations over the last three (1992-1994) sampling seasons (note: the Paradise Pond sampling station shifted from 1 Reed Island (1988-1990) to 2 North (1991-1994) and might contribute to the differences in chlorophyll *a* concentrations between the two sampling locations). While the increase in chlorophyll *a* concentrations over the past three years might be a response to changing weather patterns (i.e. precipitation and temperature) these changes can also be an early "warning sign" of the lakes response to improper land use practices within the watershed. If localized problems (i.e. improperly installed and failing septic systems, improper soil conservation procedures and practices, excessive fertilizer applications, etc.) are suspected, we recommend performing a shoreline survey of the lake or a watershed survey to located potential problem areas. We can than expand, or revise, the monitoring program to address more localized regions if the need exists.

Figure 36. Paradise Pond, 1994. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 2 North. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes while the double solid horizontal line denotes the maximum site depth. Secchi Disk measurements are reported to the nearest tenth (0.1) of a meter.

Figure 37. Paradise Pond, 1994. Seasonal trends for chlorophyll *a* concentrations of lay monitor Site 2 North. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are reported as parts per billion (ppb) of chlorophyll *a*.

Figure 38. Paradise Pond, 1994. Seasonal trends for dissolved color of lay monitor Site 2 North. The dotted horizontal line represents the dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).


PARADISE POND — SITE 2 NORTH
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
LAKE BOTTOM AT SITE
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


MAINE LAKES
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
△ PARADISE POND

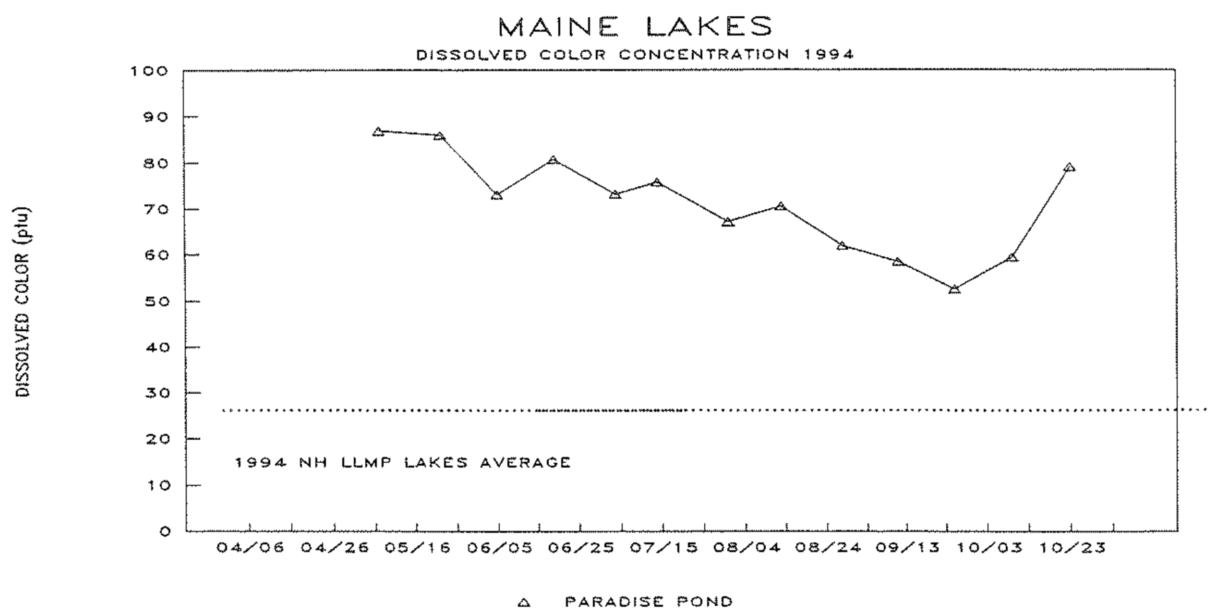
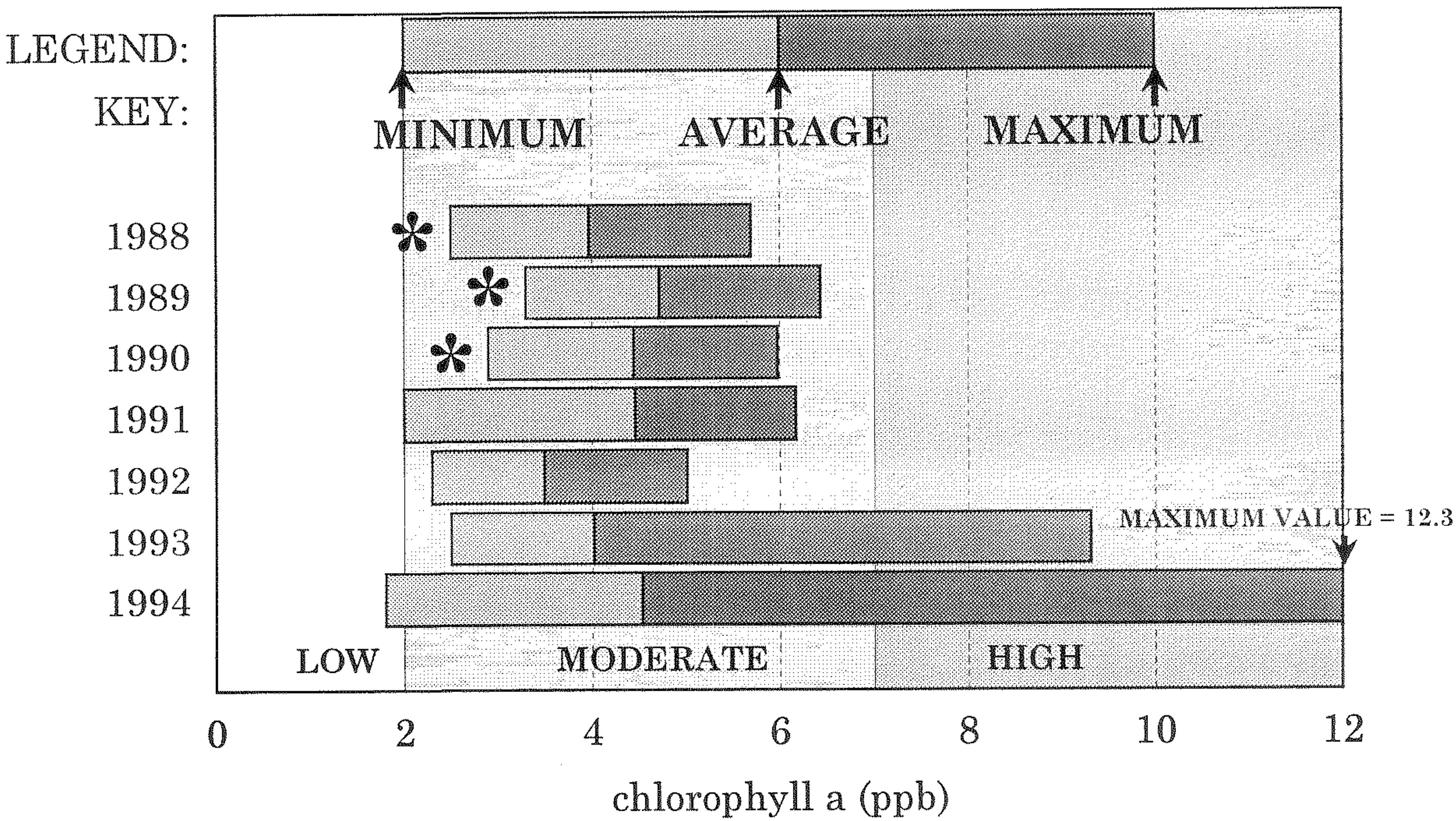

MAINE LAKES
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
△ PARADISE POND

Figure 39.Comparison of the 1994 Paradise Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).

# PARADISE POND - SITE 2 NORTH
## LAY MONITOR CHLOROPHYLL *a* DATA
### YEARLY COMPARISONS (1988-1994)




The higher value = more algal growth

* DATA COLLECTED BETWEEN 1988 AND 1990 WERE COLLECTED AT A MORE SOUTHERLY SAMPLING STATION; SITE 1 REED ISLAND.

## Table 7. Pemaquid Pond -- trophic indicators, 1994

**Lakes Lay Monitoring Program, U.N.H.**

**[Lay Monitor Data]**

Pemaquid Pond, Maine
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Average transparency: | 4.0 | (1994: | 8 values; | 3.5 | - | 4.3 | range) |
| Average chlorophyll: | 3.3 | (1994: | 8 values; | 2.3 | - | 5.0 | range) |
| Average Lake Phos.: | 12.9 | (1994: | 4 values; | 7.5 | - | 18.2 | range) |
| Average color, 440: | 52.5 | (1994: | 8 values; | 39.5 | - | 71.3 | range) |

| Site | Date | Trans-parency (m) | Chl *a* (ppb) | Total Phos (ppb) | Alk. (gray) ph 5.1 | Alk. (pink) ph 4.6 | Color Pt-Co units |
|---|---|---|---|---|---|---|---|
| 1 Basin | 05/23/1994 | 4.3 | 3.2 | ---- | ---- | ---- | 71.3 |
| 1 Basin | 06/15/1994 | 4.1 | 3.9 | ---- | ---- | ---- | 54.1 |
| 1 Basin | 06/27/1994 | 3.9 | 2.6 | ---- | ---- | ---- | 55.0 |
| 1 Basin | 07/13/1994 | 4.3 | 3.8 | ---- | ---- | ---- | 53.3 |
| 1 Basin | 08/15/1994 | 4.2 | 2.3 | ---- | ---- | ---- | 53.3 |
| 1 Basin | 09/02/1994 | 3.8 | 3.1 | ---- | ---- | ---- | 49.0 |
| 1 Basin | 09/15/1994 | 3.5 | 2.8 | ---- | ---- | ---- | 44.7 |
| 1 Basin | 10/05/1994 | 3.6 | 5.0 | ---- | ---- | ---- | 39.5 |
| 1 Hypo | 08/15/1994 | ---- | ---- | 16.7 | ---- | ---- | ---- |
| 1 Surface | 05/15/1994 | ---- | ---- | 9.0 | ---- | ---- | ---- |
| 1 Surface | 10/05/1994 | ---- | ---- | 18.2 | ---- | ---- | ---- |
| 20 BisStr | 03/27/1994 | ---- | ---- | 7.5 | ---- | ---- | ---- |

<< End of 1994 listing, 12 records >>

# PEMAQUID POND

# 1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of Pemaquid Pond was undertaken by the volunteer monitor, David McLeod, from May 23 through October 5, 1994 (see table 7 and figures 40-42). The following data summarize the 1994 conditions of Pemaquid Pond, and when applicable, historical data are incorporated into the interpretation. A more detailed discussion of the sampled parameters is included in the section of the report titled "Discussion of Lake Monitoring Measurements".

1) The Secchi Disk depth (a measure of water clarity) at Pemaquid Pond was representative of a moderately productive lake based on the criteria employed by the **Maine Department of Environmental Protection (DEP)**. The seasonal water transparency average of 4.0 meters (13.0 feet) is the lowest seasonal average recorded since participation in the **NH LLMP** was initiated in 1988.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) in the surface waters of Pemaquid Pond were moderate in 1994. The seasonal chlorophyll *a* concentration averaged 3.3 milligrams per cubic meter (3.3 mg $m^{-3}$ equivalent to 3.3 parts chlorophyll *a* per billion parts water) at Site 1 Basin which falls within the **Maine DEP** criteria for a moderately productive lake.

3) Phytoplankton (microscopic plant) samples collected in Pemaquid Pond during the 1994 sampling season were inconsistent with the chlorophyll *a* concentrations (i.e. as the chlorophyll *a* concentrations increased the number of algal "cells" showed no distinct pattern). Based on typical phytoplankton densities documented in **NH LLMP** lakes, Pemaquid Pond falls within the range typical of a borderline unproductive/moderately productive lake. Phytoplankton samples collected late in the season (September 15 and October 5) included increased densities of the blue-green bacteria (formerly referred to as blue-green algae), *anabaena,* 191 "cells" per milliliter and 373 "cells" per milliliter, on the former and latter sampling dates, respectively (see Appendix A). Increased densities of these forms are often associated with increases in lake productivity. However, blue-green algae such as *anabaena* generally "bloom" during the warm summer months and dye off as the temperatures decline. The increase in *anabaena* densities late in the season is likely the result of phytoplankton being flushed from highly productive Duckpuddle Pond into Pemaquid Pond. The lack of significant increases in chlorophyll *a* during the period of elevated *anabaena* densities in Pemaquid Pond suggests the *anabaena* population was "dying off" which would reduce the amount of chlorophyll *a* measured.

4) Dissolved lakewater color levels (a measure of naturally occurring "background" color) for Pemaquid Pond were moderate in 1994, 52.5 platinate

color units (ptu) and higher than the 1993 average of 44.2 ptu.

5) Total phosphorus samples (generally considered the limiting nutrient for plant growth in freshwater systems), collected in the surface waters of Pemaquid Pond were moderate early in the season (May 23), 9.0 parts per billion (ppb), and were high late in the sampling season (October 5), 18.2 ppb. An additional bottom water (hypolimnetic) total phosphorus sample collected on August 15 measured 16.7 ppb which is within the range of surface total phosphorus samples. The 1994 total phosphorus concentrations are within historical total phosphorus concentrations recorded by the **NH LLMP** and the **Maine DEP** and fall within the range characteristic of a moderately productive lake.

6) Temperature profiles collected by the lay monitor indicate the upper mixed layer of water extended to about 7.0 meters during the period of summer thermal stratification, typical of a northern temperate lake. Historical dissolved oxygen data, collected by the **Maine DEP** (1981, 1984, 1987, 1988 and 1991), indicate dissolved oxygen concentrations become reduced in the bottom (hypolimnetic) waters of Pemaquid Pond during thermal stratification. Low hypolimnetic dissolved oxygen concentrations are indicative of accumulating organic matter from both internal (i.e. decaying aquatic animal and vegetative matter) and external (i.e. leaf litter from watershed runoff) sources.

7) For all measurements considered and averaged for the season, Pemaquid Pond is classified as a moderately productive, mesotrophic, lake. However, the location of the Pemaquid Pond sampling likely biases the condition of more localized regions of Pemaquid Pond. We suggest reinitiating monitoring at the historical sampling station; Site 2 Basin. This could be achieved with no additional costs to sample processing yet would provide valuable information on the condition of the northern portion of the pond. Bi-weekly Secchi Disk readings should be included supplemented with "free" monthly chlorophyll *a* and dissolved color concentrations. Another sampling station near the inlet from Duckpuddle Pond would also be useful in discerning the impact of outwash from Duckpuddle Pond on Pemaquid Pond.

8) The primary purpose of the volunteer monitoring effort on Pemaquid Pond is to document long term changes in the pond's productivity and identify any land use practices within the watershed that are contributing to water quality degradation. However, "background" variability in seasonal precipitation and temperature patters can actually mask the effects of cultural eutrophication, or in some cases, augment the process, and in turn make trend (eutrophication) detection difficult. Variations in precipitation will often result in increased nutrient loading to a lake that in turn stimulates primary productivity (plant production), but can also result in increased flushing of the aquatic system that can mask the effects of internal nutrient loading (i.e. large precipitation events can reduce nutrient concentrations in highly productive lakes). Increasing temperatures will also effect the aquatic community, as most aquatic organisms will increase their activity (i.e. higher chlorophyll *a* concentrations or decreased Secchi Disk transparencies) during these periods, reflecting the thermal variations but not necessarily variations in available nu-

trients or other limiting resources that are commonly associated with poor land-use practices. As more data become available, the impact and interrelationship of these variables can be assessed for the study lake and the impact of land use changes can be evaluated.

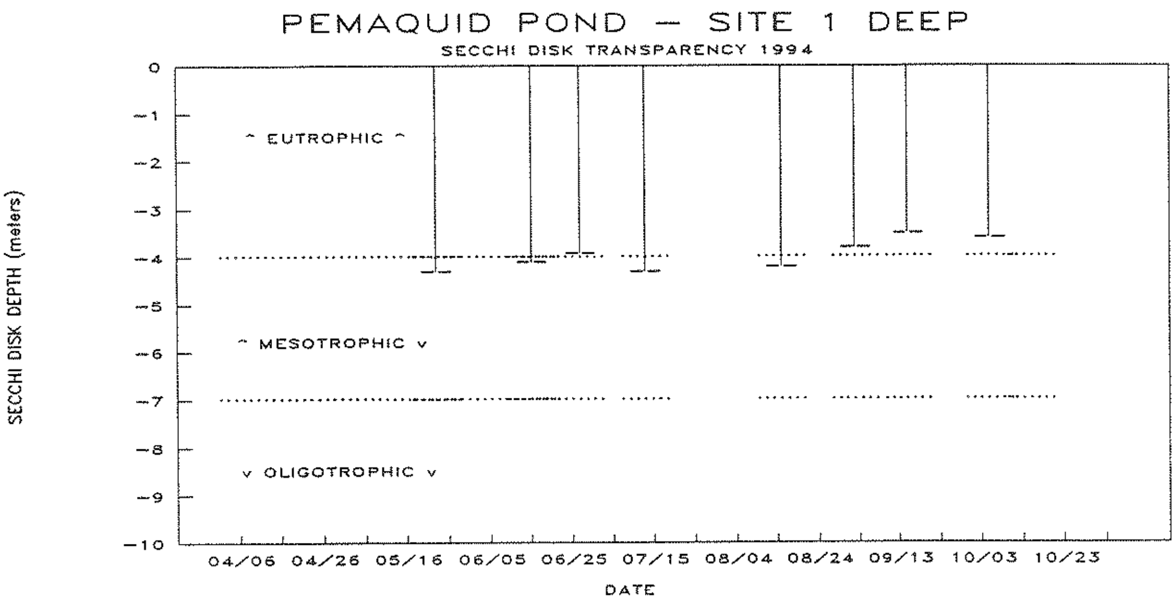
A second important component of trend assessment involves the frequent collection of water quality data. The most basic measurement, the Secchi Disk transparency, is commonly used as an indicator of algal productivity (measured as chlorophyll *a*), although it also reflects the impact of dissolved colored (organic) compounds as well as suspended sediments. Chlorophyll *a* levels undergo daily fluctuations which require frequent monitoring to document short term fluctuations in chlorophyll *a* concentrations. Likewise, the dissolved color and total phosphorus concentrations can vary, particularly early in the season during and following "peak" watershed runoff, as well as, following summer storm events. Only through frequent monitoring can these short term water quality perturbations be documented, which is important since they are often precursors to long term shifts in the trophic state (productivity). We therefore recommend continued monitoring on a frequent basis (bi-weekly or preferably weekly) during the summer months to more accurately identify both short term fluctuations (weekly and at times daily fluctuations) and long term trends in water quality measurements.

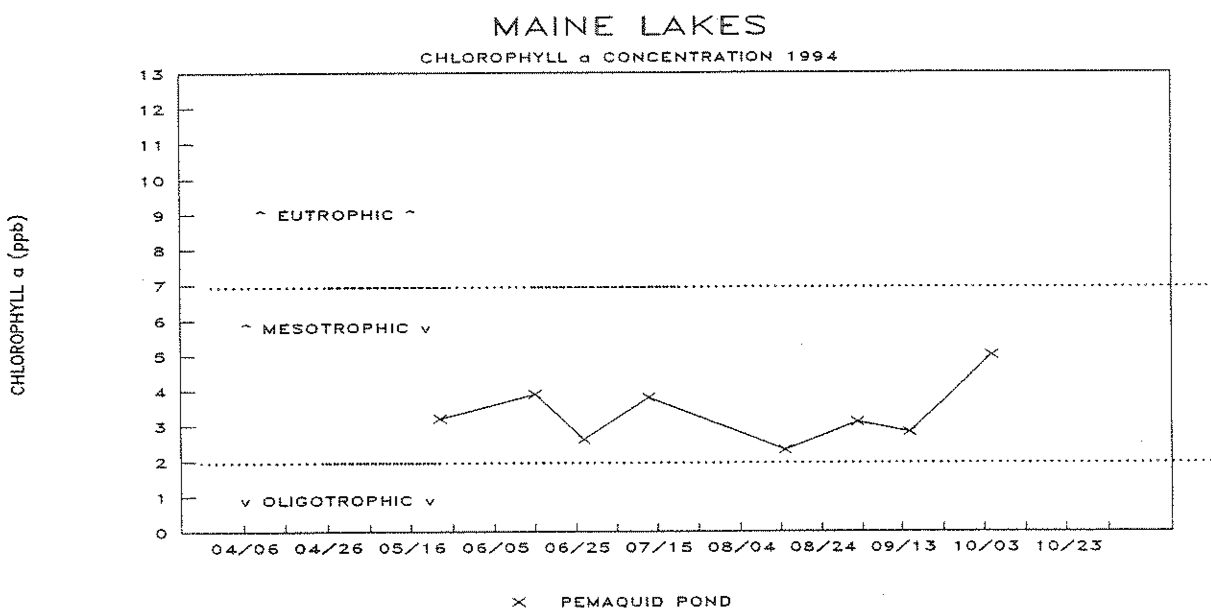
Water quality data collected from the Pemaquid Pond deep sampling station (representative of the average pond conditions) between 1988 and 1994 indicate a trend of increasing Secchi Disk transparency between 1988 and 1992 followed by a trend of decreasing water clarities the following two years with some of the lower Secchi Disk measurements on record documented in 1994 (see figure 43). Chlorophyll *a* concentrations are more variable and display no distinct water quality trend at this time (see figure 44). Future sampling of Pemaquid Pond will discern whether or not the decrease is a natural short term water quality perturbations part of the natural cycling of the lake (variations in productivity through the seasons), or weather the decline in Secchi Disk depth is a "warning sign" of the lakes response to improper land use practices within the watershed. If localized problems (i.e. improperly installed and failing septic systems, improper soil conservation procedures and practices, excessive fertilizer applications, etc.) are suspected, we recommend performing a shoreline survey of the lake or a watershed survey to located potential problem areas. We can than expand, or revise, the monitoring program to address more localized regions if the need exists.

Figure 40. Pemaquid Pond, 1994. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 1 Basin. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes while the double solid horizontal line denotes the maximum site depth. Secchi Disk measurements are reported to the nearest tenth (0.1) of a meter.

Figure 41. Pemaquid Pond, 1994. Seasonal trends for chlorophyll *a* concentrations of lay monitor Site 1 Basin. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are reported as parts per billion (ppb) of chlorophyll *a*.

Figure 42. Pemaquid Pond, 1994. Seasonal trends for dissolved color of lay monitor Site 1 Basin. The dotted horizontal line represents the dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).


PEMAQUID POND — SITE 1 DEEP
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


MAINE LAKES
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
× PEMAQUID POND

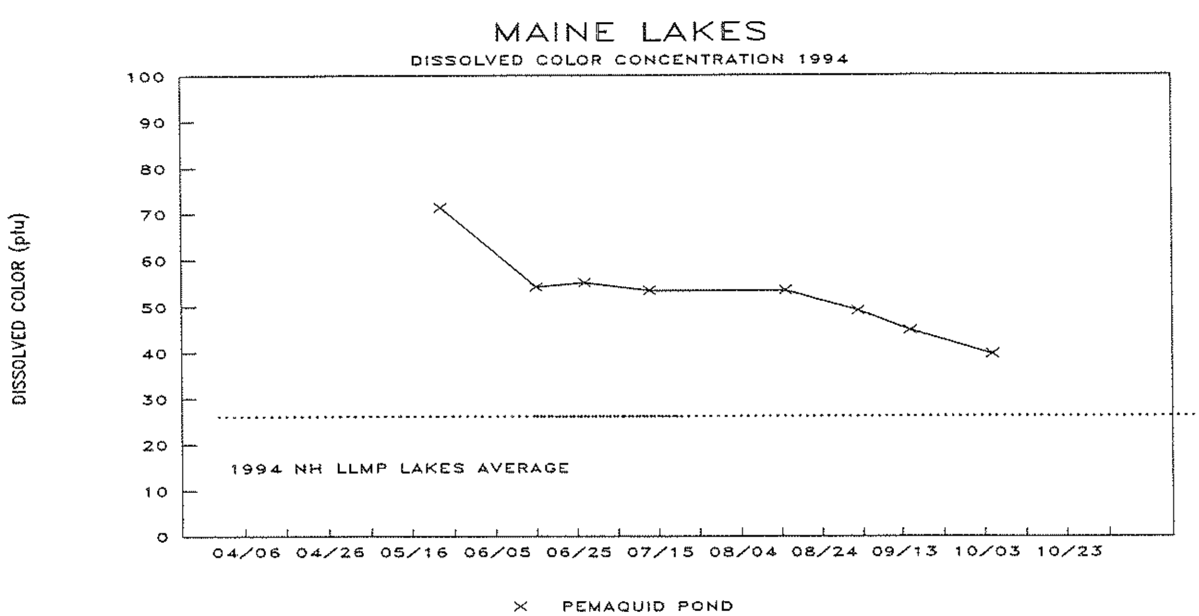
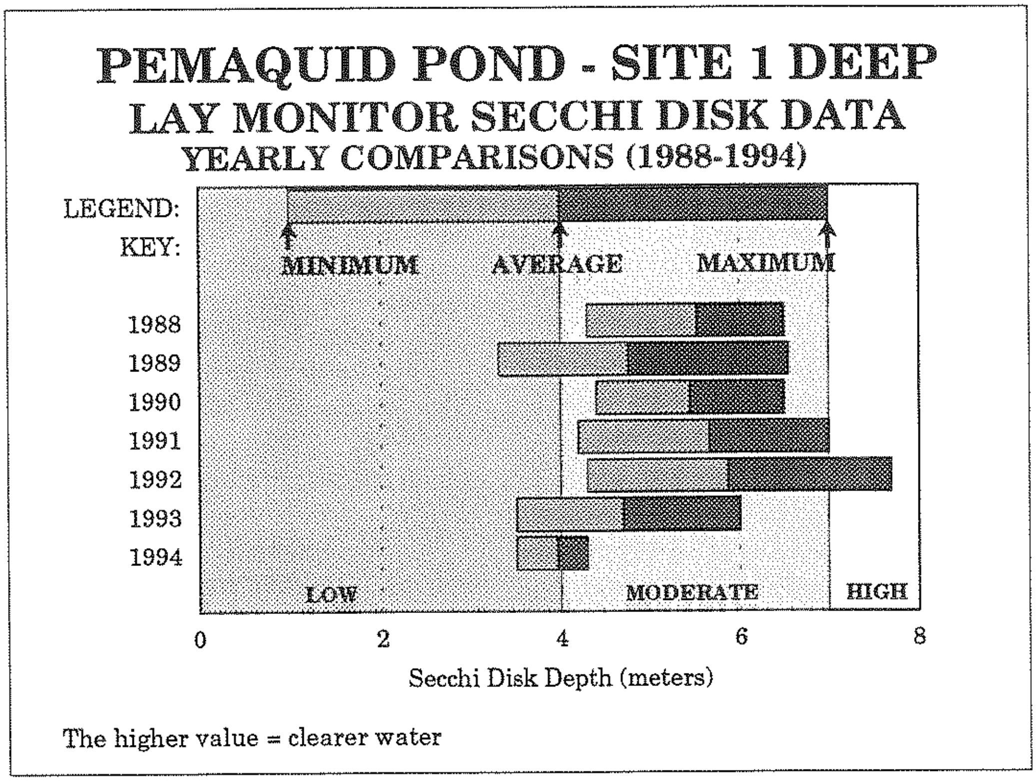
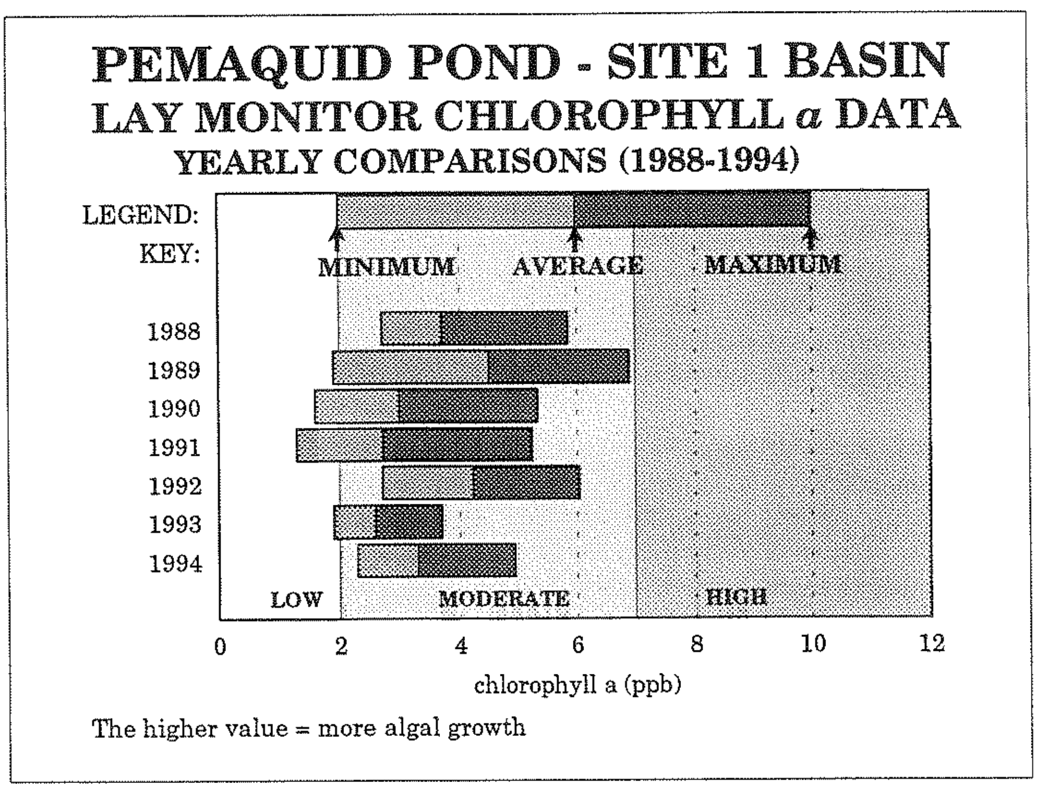

MAINE LAKES
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
100
90
80
70
60
50
40
30
20
10
0
1994 NH LLMP LAKES AVERAGE
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
× PEMAQUID POND

Figure 43. Comparison of the 1994 Pemaquid Pond lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP Secchi Disk standards for low, moderate and high water clarities. The higher the Secchi Disk value, the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 44. Comparison of the 1994 Pemaquid Pond lay monitor Chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the Maine DEP chlorophyll *a* standards for low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* value, the greener the water (more algal growth).



PEMAQUID POND - SITE 1 DEEP
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
Secchi Disk Depth (meters)
The higher value = clearer water

PEMAQUID POND - SITE 1 BASIN
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
chlorophyll a (ppb)
The higher value = more algal growth

# COMMENTS AND RECOMMENDATIONS

1) We recommend that each participating association, including the **Pemaquid Watershed Association**, continue to develop its data base on lake water quality through continuation of the long term monitoring program. The data base will provide information on the short and long-term cyclic variability that occurs in the lake and will eventually enable more reliable predictions of water quality trends.

2) We recommend continued tributary phosphorus sampling during the 1995 sampling season. Phosphorus samples collected early in 1995 will contrast the data from the previous two years which were characterized by heavy snowpack which resulted in considerable spring runoff.

If you are interested in detecting differences in nutrient loading due to land use differences in tributary watersheds, consider taking "simultaneous", composite samples during storm events, (the time when most phosphorus is mobilized). You can also supplement storm event samples with "low-flow" phosphorus samples using the same sampling sites and procedures. Sampling locations should be selected which will reflect different watershed characteristics and conditions as accurately as possible. Your objectives should be carefully thought out before undertaking this endeavor. If unsure of your current objectives, you might want to wait until you conduct your watershed survey and formulate a plan based on your findings.

All tributary total phosphorus samples should include streamflow measurements that will determine the phosphorus load in the respective tributaries at the time of sampling. Contact the **UNH FBG** for information on measuring streamflow.

3) We recommend continued in-lake total phosphorus sampling during the 1995 sampling season. Total phosphorus samples should be obtained from Duckpuddle Pond at a minimum monthly and preferably bi-weekly. These should include integrated samples (collected with the weighted garden hose) supplemented by point "grab" samples collected 1 meter off the lake-bottom whenever stratified conditions exist. You should consider taking triplicate integrated samples and replicate point samples at least monthly. This type of sampling will help eliminate "random" inaccuracies which can occur when only single samples are analyzed. Note: this recommendation was proposed by Roy Bouchard of the **Maine DEP**.

Additional total phosphorus sampling should be undertaken at the remaining ponds (Biscay, Boyd, McCurdy, Paradise and Pemaquid) as frequently as possible to more completely assess the condition of the ponds and determine the seasonal cycles they undergo.

4) We recommend the collection of Secchi Disk measurements on intermittent weeks, when chlorophyll *a* samples

are not taken, to better predict short term fluctuations which occur the Pemaquid Ponds. If new monitors are interested, we can set up a training session to familiarize the participants with the methodologies employed by the **NH LLMP**.

5) We recommend collecting bi-weekly dissolved oxygen profiles for the deeper ponds (Biscay, McCurdy and Pemaquid) to monitor the rate of oxygen depletion following the onset of thermal stratification. Continued collection of dissolved oxygen profiles in Duckpuddle Pond is also recommended. The data will provide a more complete assessment of the trophic state of these ponds and will add to the baseline data that have been generated. Knowledge of the dissolved oxygen concentrations is also useful when assessing the condition of the ponds' fisheries, as well as, to what degree internal nutrient cycling is contributing to the nutrient (phosphorus) pool.

6) We recommend continued algal (microscopic plant) sampling to detect seasonal differences in the phytoplanktonic community structure. Knowledge of the algal forms will provide additional insight into the trophic state of the Pemaquid ponds. Since the cost associated with this type of sampling are currently subsidized by the **NH LLMP**, this type of sampling is highly recommended.

7) Finally, we suggest collecting daily precipitation data from locations near the participating **PWA** ponds (rain gauges are available through the **NH LLMP** free of charge). The data generated through this endeavor will help resolve the influence of precipitation levels on seasonal fluctuations in the trophic parameters (i.e. Secchi Disk, chlorophyll *a* and total phosphorus).

Figure 45. Seasonal chlorophyll *a* trends in Biscay, Boyd, McCurdy, Paradise and Pemaquid Ponds. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes. Chlorophyll *a* concentrations are measured in parts per billion (ppb).

Figure 46.Seasonal dissolved color trends in Biscay, Boyd, McCurdy, Paradise and Pemaquid Ponds. The dotted horizontal line represents the 1994 dissolved color average for participating LLMP lakes. Dissolved color is expressed as platinum-cobalt units (ptu).

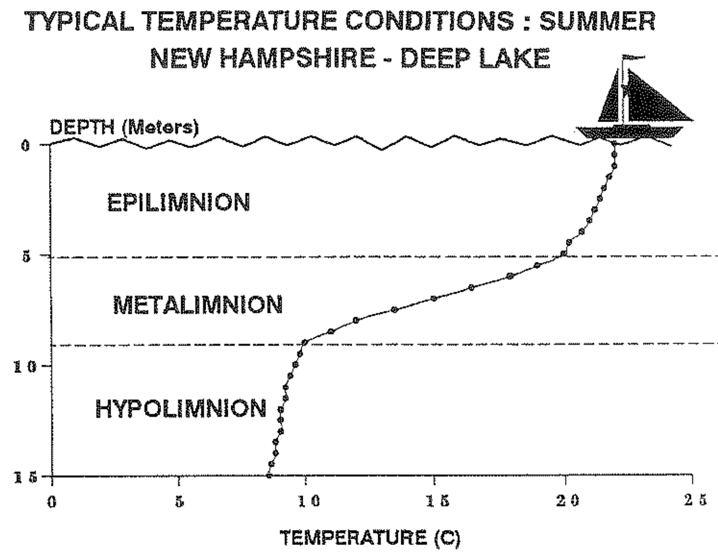
# DISCUSSION OF LAKE MONITORING MEASUREMENTS

The section below details the important concepts involved for the various testing procedures used in the **New Hampshire Lakes Lay Monitoring Program**. Where appropriate, summary statistics of 1994 results from all participating lakes are included. Certain tests or sampling performed at the time of the optional **Freshwater Biology Group** field trip are indicated by an asterisk (*).

## Thermal Stratification in the Deep Water Sites

Lakes in New Hampshire display distinct patterns of temperature stratification, that develop as the summer months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water (**hypolimnion**). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the **thermocline** or **metalimnion** (figure 47). Some shallow lakes may be continually mixed by wind action and will never stratify. Other lakes may only contain a developed epilimnion and metalimnion. The deeper ponds (Biscay, McCurdy and Pemaquid) became stratified into three distinct thermal layers, discussed above, while Duckpuddle and Boyd Ponds became only partially stratified, forming an epilimnetic and metalimnetic layer. No thermal stratification was documented in Paradise Pond as this pond is shallow and remains well circulated due to wind induced mixing.

Figure 47.




## Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of secchi disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and nonliving particles) to absorb and scatter it.

In the shallow areas of many lakes, the secchi disk will hit bottom before it is able to disappear from view (what is referred to as a "Bottom Out" condition). Thus, Secchi disk measurements are generally taken over the deepest sites of a lake. Based on the classification scheme employed by the **Maine DEP**, transparency values greater than 7 meters are generally an indication of clear, unproductive lakes, while values of 4 meters or less are generally an indication of productive lakes. Water clarity values between 4 and 7 meters are considered typical of a moderately productive lake. In 1994 the average transparency for lakes participating in the **NH LLMP** was 5.6 meters with a range of 0.3 to 10.7 meters.

Secchi Disk readings collected at Biscay, Boyd, McCurdy and Pemaquid Ponds remained within the range common to a moderately productive lake. The water clarity of Duckpuddle Pond, on the other hand, was typical of a productive lake and was characterized by decreasing Secchi Disk transparencies from July 4 until July 31 which corresponded to an algal bloom, followed by increasing water clarity readings as the algal (microscopic plant) population died off. Refer to table 8 for 1994 summary Secchi Disk data from the Pemaquid Ponds (note: data from Paradise Pond are not characterized trophicaly due to the shallowness of the pond).

**Table 8. 1994 Lay Monitor Secchi Disk Data comparison of the Pemaquid Ponds**

| LAKE | Trans-parency (m) Minimum | Trans-parency (m) Average | Trans-parency (m) Maximum | Trophic State |
|---|---|---|---|---|
| Biscay | 4.0 | 5.1 | 5.8 | Moderate |
| Boyd | 3.5 | 4.1 | 4.7 | Moderate |
| Duckpuddle | 0.3 | 1.4 | 2.4 | Poor |
| McCurdy | 5.2 | 6.4 | 7.2 | Moderate |
| Paradise | 3.1 | 3.8 | 4.1 | XXXXXXX |
| Pemaquid | 3.5 | 4.0 | 4.3 | Moderate |

## Chlorophyll *a*

The chlorophyll *a* concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. The Following classification scheme is based on the standard employed by the **Maine DEP**. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Characteristics include accumulated organic matter in the lake basin and lower dissolved oxygen in the bottom waters. Summer chlorophyll *a* concentrations average above 7 mg $m^{-3}$ (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll *a* concentrations are generally less than 2 mg $m^{-3}$. These lakes generally have cleaner bottoms and high dissolved oxygen levels throughout. **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll *a* generally between 2 mg $m^{-3}$ and 7 mg $m^{-3}$ (note: reports written between 1988 and 1992 employed a classification scheme devised by Forsberg and Rydig, 1980 while the 1993 and 1994 reports use a classification scheme devised by the **Maine DEP**). In 1994, the average chlorophyll *a* concentration for lakes participating in the **NH LLMP** was 3.3 mg $m^{-3}$ with a range of 0.4 to 58.1 mg $m^{-3}$. Refer to table 9 for 1994 summary chlorophyll *a* data from the Pemaquid Ponds.

**Table 9. 1994 Lay Monitor Chlorophyll *a* Data comparison of the Pemaquid Ponds.**

| Lake | Chl *a* (ppb) Minimum | Chl *a* (ppb) Average | Chl *a* (ppb) Maximum | Trophic State |
|---|---|---|---|---|
| Biscay | 1.5 | 2.7 | 3.6 | Moderate |
| Boyd | 2.1 | 3.1 | 4.6 | Moderate |
| Duckpuddle | 7.7 | 21.5 | 55.4 | Poor |
| McCurdy | 1.3 | 2.2 | 3.1 | Moderate |
| Paradise | 2.5 | 3.2 | 3.7 | Moderate |
| Pemaquid | 2.4 | 3.3 | 4.4 | Moderate |

Testing is sometimes done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentrations of a water sample collected in the thermocline is compared to the integrated epilimnetic sample. Greater chlorophyll levels of the point sample, in conjunction with microscopic examination of the samples (see Phytoplankton section below), confirm the presence of such a population of algae. These populations should be monitored as they may be an indication of increased nutrient loading into the lake.

## Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from **humic substances**, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters. Increases in dissolved watercolor can be an indication of increased development within the watershed as many land clearing activities (construction, deforestation, and the resulting increased run-off) add additional organic material to lakes. Natural fluctuations of dissolved color occur when storm events increase drainage from wetlands areas within the watershed. As suspended sediment is a difficult and expensive test to undertake, <u>both</u> dissolved color and chlorophyll information is important when interpreting the secchi disk transparency

Dissolved color is measured on a comparative scale that uses standard chloroplatinate dyes and is designated as a color unit or ptu. Lakes with color below 10 ptu are very clear, 10 to 20 ptu are slightly colored, 20 to 40 ptu are lightly tea colored, 40 to 80 ptu are tea colored and greater than 80 ptu indicates highly colored waters. Generally the majority of New Hampshire lakes have color between 20 to 30 ptu. In 1994 the average dissolved color for participating **NH LLMP** lakes was 25.7 ptu with a range of 2.6 to 371.1 ptu. Refer to table 10 for the 1994 Pemaquid Ponds dissolved color summary statistics.

**Table 10. 1994 Lay Monitor Dissolved Color Data comparison of the Pemaquid Ponds.**

| Lake | Color (ptu) Minimum | Color (ptu) Average | Color (ptu) Maximum |
|---|---|---|---|
| Biscay | 33.5 | 46.2 | 61.0 |
| Boyd | 36.1 | 55.1 | 91.9 |
| Duckpuddle | 63.6 | 86.8 | 122.8 |
| McCurdy | 18.9 | 25.5 | 33.5 |
| Paradise | 52.4 | 71.0 | 86.8 |
| Pemaquid | 39.5 | 52.5 | 71.3 |

## Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 15 parts per billion of phosphorus in a lake can cause an algal bloom.

Generally, in the more pristine lakes, phosphorus values are higher after spring melt when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants which in turn die and sink to the lake bottom causing phosphorus to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (Agriculture, Sediment Erosion, Septic Systems, etc) will show greater concentrations of nutrients as the summer progresses or after major storm events. Circulation of nutrients from the bottom waters of more productive lakes in late fall can result in algal blooms.

The **Maine DEP** classifies lakes containing 6 ppb total phosphorus or less as unproductive while those containing total phosphorus concentrations of 13 ppb and greater fall into the classification of a productive lake. Lakes between 6 ppb and 13 ppb are thus considered moderately productive. Table 11 characterizes the trophic state of the Pemaquid Ponds based on the 1994 in-lake total phosphorus data and the corresponding **Maine DEP** criteria.

## pH *

The pH is a way of expressing the acidic level of lake water, and is generally measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (ie: changes in 1 pH unit reflect a ten times difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction..

**Table 11. 1994 In-Lake Total Phosphorus Results and the Corresponding Maine DEP Trophic Classification**

| Lake | Date | Depth | Total Phos. (ppb) | Maine Water Quality Category |
|---|---|---|---|---|
| **Biscay** | 07-May | Surface | 7.7 | Moderate |
| | 29-Oct | Surface | 9.0 | Moderate |
| **Boyd** | 07-May | Surface | 9.4 | Moderate |
| | 16-Oct | Surface | 14.0 | High |
| **Duckpuddle** | 15-May | Surface | 19.1 | High |
| | 31-Jul | Surface | 37.0 | High |
| | 06-Aug | Surface | 31.9 | High |
| | 15-Aug | Surface | 23.5 | High |
| **McCurdy** | 07-May | Surface | 6.5 | Moderate |
| | 25-Sep | Surface | 7.0 | Moderate |
| **Paradise** | 07-May | Surface | 18.4 | High |
| | 23-Oct | Surface | 14.8 | High |
| **Pemaquid** | 15-May | Surface | 9.0 | Moderate |
| | 05-Oct | Surface | 18.2 | High |

## Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock and soils of lake watersheds.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada by Schindler, gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to

20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

The analysis of alkalinity employed by the **Freshwater Biology Group** includes use of a dilute titrant allowing an order of magnitude greater sensitivity and precision than the standard method. Two endpoints are recorded during each analysis. The first endpoint (gray color of dye; pH endpoint of 5.1 ) approximates low level alkalinity values, while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically, such as NH Fish and Game data, with the methyl-orange endpoint method.

The average alkalinity of lakes throughout New Hampshire is low, approximately 9 mg per liter (calcium carbonate alkalinity), while the average alkalinity of the lakes studied by the **Freshwater Biology Group** in the **NH LLMP** is approximately 6.3 mg per liter. When alkalinity falls below 2 mg per liter the pH of waters can greatly fluctuate. Alkalinity levels are most critical in the spring when acid loadings from snowmelt and run-off are high, and many aquatic species are in their early, and most susceptible, stages of their life cycle.

The classification scheme employed by the **Maine DEP** considers alkalinity concentrations of less than 4 ppm as low (more susceptible to acidification) while lakes with alkalinities greater than 10 ppm are considered highly alkaline (more resistant to acidification).

## Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Fertilizers and other pollutants can also increase the conductivity of the water. Conductivity is measured in micro**mhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans.

## Dissolved Oxygen and Free Carbon Dioxide *

Oxygen is an essential component for the survival of aquatic life. Submergent plants and algae take in free carbon dioxide and create oxygen through **photosynthesis** by day. **Respiration** by both animals and plants uses up oxygen continually and creates **carbon dioxide**. Dissolved oxygen profiles determine the extent of declining oxygen concentrations in the lower waters. High carbon dioxide values are indicative of low oxygen conditions and accumulating organic matter. For both gases, as the temperature of the water decreases, more gas can be dissolved in the water.

The typical pattern of clear, unproductive lakes is a slight decline in hypolimnetic oxygen as the summer progresses. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter (parts per million) in the cool deep waters. On the other hand, carp and catfish can survive very low oxygen conditions. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter.

Bacteria, fungi and other **decomposers** in the bottom waters break down organic matter originating from the watershed or generated by the lake. This process uses up oxygen and produces carbon dioxide. In lakes where organic matter accumulation is high, oxygen depletion can occur. In highly stratified eutrophic lakes the entire hypolimnion can remain unoxygenated or **anaerobic** until fall mixing occurs.

The oxygen peaks occurring at surface and mid-lake depths during the day are quite common in many lakes. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of photosynthesis, collecting in regions of high algal concentrations. If the peak occurs in the thermocline of the lake, metalimnetic algal populations (discussed above) may be present.

Bi-weekly dissolved oxygen profiles collected in Duckpuddle Pond indicate diminishing metalimnetic oxygen concentrations as the season progressed. Low dissolved oxygen concentrations were documented from July through August and likely resulted in the internal release of nutrients (nutrients released from the lake sediments). The buildup of nutrients in the bottom waters are often conducive to the formation of layering mid-lake algal populations, that can migrate into the surface waters when the conditions warrant (i.e. reduced light transmittance into the deeper waters). Elevated nutrients towards the lakebottom can also stimulate algal growth in the spring and fall when thermal stratification is disrupted and nutrients circulate through the water column.

## Underwater Light *

Underwater light available to photosynthetic organisms is measured with an **underwater photometer** which is much like the light meter of a camera (only waterproofed !). The **photic zone** of a lake is the volume of water capable of supporting photosynthesis. It is generally considered to be delineated by the water's surface and the level where light is reduced, by the absorption and scattering properties of the lake water, to one percent of the surface intensity. The one percent depth is sometimes termed the **compensation depth**. Knowledge of light penetration is important when considering lake productivity and in studies of submerged vegetation. Discontinuity (abrupt changes in the slope) of the profiles could be due to metalimnetic layering of algae or other particulates (discussed above). The underwater photometer allows the investigator to measure light at depths below the Secchi disk depth to supplement the transparency information.

## Indicator Bacteria *

Coliform bacteria in water indicate the possibility of fecal contamination. Although they are usually considered harmless to humans, they are much easier to test for than harmful pathogenic enteric bacteria (**Salmonella**, **Shigella** etc.) and viruses that may be present in fecal material. **Total coliform** includes all coliform bacteria which arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **Fecal streptococcus** (sometimes referred to as **enterococcus**) also can be monitored. The ratio of fecal coliform to fecal strep may be useful in suggesting the type of animal source responsible for the contamination. In 1991, the State of New Hampshire changed the indicator organism of preference to E. Coli which is a specific type of fecal coliform bacteria thought to be a better indicator of human contamination. The new state standard requires Class A bathing waters to be under 88 organisms per 100 milliliters of lakewater.

Ducks and geese are often a common cause of high concentrations of coliform at specific lake sites. While waterfowl are important components to the natural and aesthetic qualities of lakes that we all enjoy, it is poor management practice to encourage these birds by feeding them. The lake and surrounding area provides enough healthy and natural food for the birds and feeding them stale bread or crackers does nothing more than import additional nutrients into the lake and allows for increased plant growth. As birds also are a host to the parasite that causes "swimmers itch", waterfowl roosting areas offer a greater chance for infestation to occur. Thus while leaving offerings for our feathered friends is enticing, the results can prove to be detrimental to the lake system and to human health.

## Phytoplankton *

The planktonic community includes microbial organisms that represent diverse life forms, containing photosynthetic as well as non-photosynthetic types, and including bacteria, algae, crustaceans and insect larvae (the zooplankton are discussed below in a separate section). Because planktonic algae or "phytoplankton" tend to undergo rapid seasonal cycles on a time scale of days and weeks, the levels of populations found should be considered to be most representative of the time of collection and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

The composition and concentration of phytoplankton can be indicative of the trophic status of a lake. Seasonal patterns do occur and must be considered. For example **diatoms**, tend to be most abundant in April-June and October-November, in the surface or epilimnetic layers of New Hampshire lakes. As the summer progresses, the dominant types might shift to **green algae** or **golden algae**. By late season **Blue-green bacteria** generally dominate. In nutrient rich lakes, nuisance green algae and/or bluegreen bacteria might dominate continually. After fall mixing diatoms might again be found to bloom.

## Zooplankton *

There are three groups of zooplankton that are generally prevalent in lakes: the **protozoa**, **rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints usually make it necessary to sample only the larger zooplankton (macrozooplankton; larger than 80 or 150 microns; 1 million microns make up a meter). Thus, zooplankton analysis is generally restricted only to the larger crustaceans. Crustacean zooplankton are very sensitive to pollutants and are commonly used to indicate the presence of toxic substances in water. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods**.

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species may control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake.

As discussed above for phytoplankton, zooplankton undergo seasonal population cycles and the results discussed below are most representative of the collection dates and not necessarily of other times during the ice-free season, especially during the early spring and late fall.

# CURRENT CONCERN

## Sleuthing Fish Condition in New Hampshire Lakes

Anglers are an important component of New Hampshire's recreation and tourism industry. The state offers warm water fishing in over 400 lakes for species such as bass, crappie, and sometimes, pickerel. In addition, almost 200 lakes offer the chance to catch the much desired cold water species such as land-locked salmon and lake trout. As the demand to fish our lakes continues to increase, so does the concern about the health of our fishery; in light of the increased fishing and boating pressure on NH lakes, increased development throughout our watersheds, and the planned (ie: Rainbow Trout) and accidental (ie: water milfoil) introduction of non-native species, knowledge of native fish condition is critical.

Enter the **Freshwater Biology Group (FBG)**, the applied aquatic research unity of the University of New Hampshire that along with Cooperative Extension, oversees the **NH Lakes Lay Monitoring Program**. In a cooperative study with NH Fish and Game, Dr. Lin Wu, a post doctorate UNH research scientist, and **FBG** co-directors Dr. James Haney of the department of Zoology and Dr. Alan Baker of the department of Plant Biology, have been assessing growth and condition of several sport and non-sport fish in lakes and ponds throughout the state.

The study uses two techniques to investigate fish health: the first, scale analysis, provides age and yearly growth information. Like trees, fish scales have annual growth rings (annuli) that reflect their growth rates and condition. Utilizing a computerized measurement and analysis system, each fish scale sample provides the information to calculate the current age, as well as, to back-calculate yearly growth for each fish to its first year. As the average fish age measured was 5 to 8 years, depending on species, much historical information was gained. The second technique uses a condition index, a function of the length and weight of the fish to indicate the fish's health at the time of collection. Essentially, the more weight a fish has for a given length, the healthier it is. Both techniques allow for the return of fish unharmed after measurements are taken and a few scales are carefully scraped off.

Fish from over 50 NH lakes were obtained from NH Fish and Game, and **FBG** research teams using nets and traps. Samples were also taken at winter fishing derbies and provided by volunteer lay monitors who were outfitted with special fish measurement kits. In two years, scales and measurements were taken from over 6400 fish representing 29 different species.

For their initial analyses, the **FBG** investigators selected 33 lakes representative of the wide range of water quality conditions throughout the state and 11 target fish species. Results from the scale analysis indicate that a high percentage of the population of the different species studied reached maturity. This is good news since a high number of mature individuals indicates that reproduction of the population can generally be maintained. There is some indication of fishing pressure on the more popular sport species in that the less popular species, the yellow perch and white perch, had the highest percentage of older individuals.

Weight-length relationships for all of the fish species indicated that the fish populations are not crowded or stunted in any of the study lakes. The study also calculated a relative weight condition index that allows for comparisons to national and regional standards and the development of an in-state standard. In the majority of study lakes, smallmouth and largemouth bass populations, especially those in the Lakes Region and northern lakes, are in very good condition. On the other hand, lake trout, white perch and yellow perch populations in the majority of lakes had relative weights below the national mean.

Study results will provide managers and researchers with a baseline for further investigations into the changing health of the state's fishery resources, insight into the use of water quality data to predict fish growth, and information helpful to predict the effects of species introduction (stocking and non-native invasions). Efforts of the **FBG** researchers are currently focused on such a situation on Newfound Lake, Where Fish and Game is planning to introduce alewife to replace the declining smelt (a major food source for salmonoids) population in hopes of invigorating the trout and salmon fishery there. Lab experiments and field surveys will try to predict potential effects. Further field work will determine the effectiveness of the stocking.

For those Lakes which participated in the UNH Fish Condition Program, specific reports were distributed to the appropriate persons. Further information concerning results of this study can be obtained by contacting:

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**Spaulding Life Sciences/UNH**
**Durham NH 03824**
**(603) 862-2100**

**Dr. Alan Baker**
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**Nesmith Hall/UNH**
**Durham NH 03824**
**(603) 862-3845**

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**Epilimnetic Phytoplankton Community Assessment for Duckpuddle Pond - Site 1 Basin (1994)**

**The algal densities are reported as # of algal units per milliliter**

| | (Depth) | 0-5.0 | 0-5.5 | 0-3.0 | 0-2.0 | 0-2.0 | 0-2.5 | 0-3.5 | 0-4.0 | 0-4.0 | 0-2.5 | 0-6.0 | 0-6.0 | 0-5.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Date) | 15-May | 29-May | 12-Jun | 4-Jul | 17-Jul | 31-Jul | 6-Aug | 15-Aug | 21-Aug | 28-Aug | 11-Sep | 25-Sep | 24-Oct |
| **BLUEGREENS** | | | | | | | | | | | | | | |
| *Anabaena flos-aquae* | | | 6 | 42 | 36 | | | | | | | | | |
| *Anabaena planktonica* | | | 12 | 173 | 2024 | 5003 | 7904 | 1520 | 1564 | | 18 | 931 | 681 | 119 |
| *Aphanocapsa sp.* | | | | 3 | | | | | 42 | | | 60 | | |
| *Coelosphaerium sp.* | | | | | | | | | | | | | 12 | 6 |
| *Gomphosphaeria sp.* | | | | | | 6 | | | | | | | | |
| *Merismopedia sp.* | | | | | 12 | | 12 | | | | | | | |
| *Microcystis sp.* | | | | | 6 | 6 | | 6 | | | | | | |
| *Unidentifiable coccoid* | | | | | | | | | | | | | 24 | 6 |
| **GREENS** | | | | | | | | | | | | | | |
| *Ankistrodesmis sp.* | | | | 3 | 18 | | | 6 | | | 18 | 113 | 2227 | 2687 |
| *Chlamydomonas sp.* | | | | | | | | | | | | | 6 | |
| *Coelastrum sp.* | | | | | | | | | | | | 12 | | |
| *Crucigenia sp.* | | | | | 6 | | | | | | | | | |
| *Dictyosphaerium sp.* | | | | | 6 | | | | | | | | | |
| *Gloeocystis sp.* | | | | | 12 | | | | 6 | | | | | 6 |
| *Nephrocytium sp.* | | | | | | | | 6 | | | | | | |
| *Oocystis sp.* | | | | | | | | 6 | | | | | | |
| *Quadrigula sp.* | | | | | | | | | | | | | | 6 |
| *Scenedesmus sp.* | | | | 3 | | | | 6 | | | | | 12 | |
| *Sphaerocystis sp.* | | | | 3 | | 6 | | | | | | 6 | | |
| *Unidentifiable Coccoids* | | | | | 6 | | | | | | | | | |
| **DESMIDS** | | | | | | | | | | | | | | |
| *Cosmarium sp.* | | | | | | | | 6 | | | | | | |
| *Staurastrum sp.* | | | | 15 | 6 | | | | | | | | | |
| **EUGLENOIDS** | | | | | | | | | | | | | | |
| *Trachelomonas sp.* | | | | | | 30 | | | | | 9 | | 12 | |
| **DIATOMS** | | | | | | | | | | | | | | |
| *Asterionella sp.* | | | | 3 | | | | | | | | | | 12 |
| *Cyclotella sp.* | | | 6 | | 54 | | | | 12 | | 6 | 48 | | |
| *Fragelaria sp.* | | | | 3 | | | | | | | | | | |
| *Melosira sp.* | | | 12 | | | 6 | | 6 | | | | 18 | 12 | 12 |
| *Rhizoselinia sp.* | | | | 18 | | | | | | | | | 66 | 6 |
| *Synedra sp.* | | | | | | | | | | | | | 6 | |
| *Tabellaria sp.* | | | 90 | 548 | 101 | | | | | | | | | |
| **CRYPTOMONADS** | | | | | | | | | | | | | | |
| *Chroomonas sp.* | | | 173 | 212 | 251 | 24 | | | 30 | | 158 | 108 | 36 | 30 |
| *Cryptomonas sp.* | | | 30 | 75 | 96 | 96 | 322 | 233 | 430 | | 92 | 263 | 197 | 113 |
| **DINOFLAGELLATES** | | | | | | | | | | | | | | |
| *Ceratium hirundinella* | | | | | | | | | | | 3 | 36 | | |
| *Dinoflagellate cysts* | | | | 60 | 12 | 6 | 12 | | 12 | | | | | |
| *Peridinium sp.* | | | | | | | | | 12 | | | | | |
| **GOLDEN ALGAE** | | | | | | | | | | | | | | |
| *Chrysosphaerella sp. (cells)* | | | | | | | | | | | | | 167 | |
| *Chrysosphaerella sp. (colony)* | | | | | | | | | | | | | 30 | |
| *Dinobryon sp. (colony)* | | | | | 6 | | | | | | | | | |
| *Dinobryon sp. (loricas)* | | | 36 | 30 | 119 | | | | | | | | 18 | 42 |
| *Mallomonas sp.* | | | | | | | | | | | | | 6 | 12 |
| *Synura sp. (single cells)* | | | 1952 | 149 | 281 | | | 90 | 6 | | 3 | 90 | | 30 |
| *Synura sp. (colony)* | | | 6 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Unidentifiable flagellates** | | | 143 | 86 | 96 | 0 | 0 | 149 | 42 | | 48 | 149 | 90 | 406 |
| **Bluegreens** | | | 18 | 218 | 2078 | 5015 | 7916 | 1526 | 1606 | | 18 | 991 | 717 | 131 |
| **Greens** | | | 0 | 9 | 48 | 6 | 0 | 24 | 6 | | 18 | 131 | 2245 | 2699 |
| **Desmids** | | | 0 | 15 | 6 | 0 | 0 | 6 | 0 | | 0 | 0 | 0 | 0 |
| **Euglenoids** | | | 0 | 0 | 0 | 30 | 0 | 0 | 0 | | 9 | 0 | 12 | 0 |
| **Diatoms** | | | 108 | 572 | 155 | 6 | 0 | 6 | 12 | | 6 | 66 | 84 | 30 |
| **Cryptomonads** | | | 203 | 287 | 347 | 120 | 322 | 233 | 460 | | 250 | 371 | 233 | 143 |
| **Dinoflagellates** | | | 0 | 60 | 12 | 6 | 12 | 0 | 24 | | 3 | 36 | 0 | 0 |
| **Golden Algae** | | | 1994 | 179 | 406 | 0 | 0 | 90 | 6 | | 3 | 90 | 221 | 84 |
| **Total Algal Units** | | | 2466 | 1426 | 3148 | 5183 | 8250 | 2034 | 2156 | | 355 | 1834 | 3602 | 3493 |
| **Secchi Disk Depth** | | | 2.4 | | 1.5 | 0.6 | 0.3 | 1 | 1.6 | 1.5 | 1.3 | 1.5 | 1.8 | 2.1 |
| **Chlorophyll a Concentration** | | 5.2 | 8.8 | 7.6 | 11.3 | 28.3 | 53.3 | 23.8 | 13.9 | 10.4 | 6.2 | 12.7 | 7.2 | 10.3 |
| **Dissolved Color Concentration** | | 95.3 | 113.4 | 102.2 | 92.8 | 86.8 | 79.9 | 122.8 | 63.6 | 71.3 | 67 | 66.1 | 67.9 | 108.2 |

***anabaena filaments were classified into on of two species: planktonica, characterized by muscilaganous "wings" extending from the heterocysts, and flos-aque characterized by spiraling of the filament and spacing of the heterocysts and akinetes.***

***Note: some filaments deviated from these basic characteristics.***

| Epilimnetic Phytoplankton Community Assessment for Biscay Pond - Site 1 North (1994) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Depth) | 0-4.5 | 0-3.5 | 0-4.5 | 0-2.5 | 0-5.0 | 0-5.5 | 0-5.0 | 0-6.5 | 0-8.5 | 0-10.0 | 0-10.5 | 0-10.0 |
| | (Date) | 7-May | 30-May | 5-Jun | 18-Jun | 2-Jul | 16-Jul | 31-Jul | 13-Aug | 27-Aug | 9-Sep | 25-Sep | 9-Oct |
| **BLUEGREENS** | | | | | | | | | | | | | |
| *Anabaena flos-aquae* | | | | | 9 | | | | 6 | 3 | | | |
| *Anabaena planktonica* | | | | | | | | 12 | | | 3 | 9 | 27 |
| *Aphanocapsa sp.* | | | | | | 6 | 6 | 21 | 18 | 6 | 12 | 15 | 6 |
| *Coelosphaerium sp.* | | | | | | | | 3 | | 3 | | | |
| *Dactylococoppsis sp.* | | | | 15 | 3 | 6 | | | | 15 | 21 | | |
| *Gloeocapsa sp.* | | | | | | | | 3 | | | | | |
| *Merismopedia sp.* | | | | | | | | 21 | 95 | 42 | 66 | 72 | 42 |
| *Microcystis sp.* | | | | | | | | 3 | | 9 | 3 | 3 | 3 |
| *Unidentifiable coccoid* | | | | | | | | 9 | | | 6 | | |
| **GREENS** | | | | | | | | | | | | | |
| *Ankistrodesmis sp.* | | | | | | | | | | | | | 3 |
| *Crucigenia sp.* | | | | | | | | | | | | | 3 |
| *Eudorina sp.* | | | | 12 | | | | | | | | | |
| *Gloeocystis sp.* | | | | | | | | | | | | | 6 |
| *Pandorina sp.* | | | | | | 12 | | | | | | | |
| *Pediastrum sp.* | | | | | | | | | | 6 | | 3 | |
| *Pleodorina sp.* | | | | 3 | | | | | | | | | |
| *Scenedesmus sp.* | | | | | | | 6 | | 3 | 6 | | | 3 |
| *Sphaerocystis sp.* | | | | | | | | | | 3 | | | |
| *Unident volvoc colony* | | | | | 45 | | | | | | | | |
| **DESMIDS** | | | | | | | | | | | | | |
| *Closterium sp.* | | | | 3 | | | | | | | | | |
| *Staurastrum sp.* | | | | | 3 | 6 | | | 3 | | | 3 | 3 |
| **EUGLENOIDS** | | | | | | | | | | | | | |
| *Trachelomonas sp.* | | | | 6 | | | | | | | | 3 | |
| **DIATOMS** | | | | | | | | | | | | | |
| *Asterionella sp.* | | | | 21 | 3 | 6 | 12 | 3 | | | | | 3 |
| *Cyclotella sp.* | | | | 3 | 24 | 18 | | | 15 | 21 | 15 | 39 | 30 |
| *Fragelaria sp.* | | | | | | | | 15 | | | | 3 | 3 |
| *Rhizoselinia sp.* | | | | | | 6 | | 3 | 9 | 9 | 15 | 45 | 86 |
| *Synedra sp.* | | | | | | 42 | | 3 | 3 | 3 | 3 | | |
| *Tabellaria sp.* | | | | 3 | 15 | | | 3 | 3 | 12 | | 24 | 27 |
| **CRYPTOMONADS** | | | | | | | | | | | | | |
| *Chroomonas sp.* | | | | 36 | 21 | 615 | 615 | 346 | 387 | 268 | 95 | 110 | 104 |
| *Cryptomonas sp.* | | | | 36 | 54 | 60 | 72 | 69 | 39 | 42 | 12 | 33 | 54 |
| **DINOFLAGELLATES** | | | | | | | | | | | | | |
| *Ceratium hirundinella* | | | | | | | | 6 | | | | | |
| *Dinoflagellate cysts* | | | | | | | | 3 | | 3 | | | 3 |
| *Peridinium sp.* | | | | | | | | | | 3 | | 3 | 3 |
| **GOLDEN ALGAE** | | | | | | | | | | | | | |
| *Chrysosphaerella sp. (cells)* | | | | | | 42 | | | | | 3 | | 3 |
| *Chrysosphaerella sp. (colony)* | | | | 3 | 9 | 48 | | 3 | | | | | |
| *Dicerus sp.* | | | | 3 | | 6 | 18 | 9 | | | | | 3 |
| *Dinobryon sp. (colony)* | | | | 21 | | 6 | 6 | 21 | 18 | 3 | 12 | 3 | 3 |
| *Dinobryon sp. (loricas)* | | | | 75 | 27 | 12 | 60 | 63 | | 12 | 191 | 63 | 3 |
| *Mallomonas sp.* | | | | | | | | | | | 6 | | |
| *Synura sp. (colony)* | | | | | | | 6 | | | | | | |
| *Synura sp. (single cells)* | | | | 18 | 42 | 245 | 251 | 51 | | 3 | | 27 | 6 |
| | | | | | | | | | | | | | |
| **Unidentifiable flagellates** | | | | 218 | 119 | 388 | 137 | 221 | 343 | 98 | 107 | 176 | 81 |
| **Bluegreens** | | | | 15 | 12 | 12 | 6 | 72 | 119 | 78 | 111 | 99 | 78 |
| **Greens** | | | | 15 | 45 | 12 | 6 | 0 | 3 | 15 | 0 | 3 | 15 |
| **Desmids** | | | | 3 | 3 | 6 | 0 | 0 | 3 | 0 | 0 | 3 | 3 |
| **Euglenoids** | | | | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| **Diatoms** | | | | 27 | 42 | 72 | 12 | 27 | 30 | 45 | 33 | 111 | 149 |
| **Cryptomonads** | | | | 72 | 75 | 675 | 687 | 415 | 426 | 310 | 107 | 143 | 158 |
| **Dinoflagellates** | | | | 0 | 0 | 0 | 0 | 9 | 0 | 6 | 0 | 3 | 6 |
| **Golden Algae** | | | | 120 | 78 | 359 | 341 | 147 | 18 | 18 | 212 | 93 | 18 |
| **Total Algal Units** | | | | 476 | 374 | 1524 | 1189 | 891 | 942 | 570 | 570 | 634 | 508 |
| **Secchi Disk Depth** | | 5.8 | 4.4 | | | 4 | 5.4 | 5 | | 5.6 | | | 5.2 |
| **Chlorophyll a Concentration** | | 2.8 | 3.2 | 4.3 | 2.7 | 10.8 | 5.5 | 3.6 | 3.1 | 2.7 | 3 | 3.1 | 3.5 |
| **Dissolved Color Concentration** | | 55.8 | 60.1 | 61 | 48.1 | 47.2 | 49.8 | 42.1 | 38.7 | 37.8 | 35.2 | 33.5 | 45.5 |

***anabaena filaments were classified into on of two species: planktonica, characterized by muscilaganous "wings" extending from the heterocysts, and flos-aque characterized by spiraling of the filament and spacing of the heterocysts and akinetes.***

***Note: some filaments deviated from these basic characteristics.***

**Epilimnetic Phytoplankton Community Assessment for McCurdy Pond - Site 1 Basin (1994)**

| (Depth) | 0-6.0 | 0-3.5 | 0-6.0 | 0-2.0 | 0-5.5 | 0-4.5 | 0-5.0 | 0-6.5 | 0-7.0 | 0-8.0 | 0-8.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (Date) | 7-May | 21-May | 4-Jun | 18-Jun | 1-Jul | 16-Jul | 30-Jul | 15-Aug | 28-Aug | 10-Sep | 25-Sep |
| **BLUEGREENS** | | | | | | | | | | | |
| *Anabaena flos-aquae* | | | | 3 | | | 3 | | | 3 | 6 |
| *Anabaena planktonica* | | | | | | | 3 | | | | |
| *Aphanocapsa sp.* | | | | | | 3 | 3 | | 12 | | 9 |
| *Cyanarcus sp* | | | | | | | | | 18 | | |
| *Dactylococoppsis sp.* | | | | | | | | | 12 | 9 | 3 |
| *Gloeocapsa sp.* | | | | 3 | 6 | 27 | 33 | 33 | 24 | 6 | 6 |
| *Merismopedia sp.* | | | | | 6 | 51 | 18 | 60 | 33 | 9 | 6 |
| *Rhabdoderma sp.* | | | | | | | | | | 3 | |
| *Unidentifiable coccoid* | | | | | 3 | 6 | 6 | 21 | | 6 | 6 |
| **GREENS** | | | | | | | | | | | |
| *Ankistrodesmis sp.* | | | 3 | 3 | 9 | 9 | 6 | 6 | | | |
| *Chlamydomonas sp.* | | | 3 | | | | | | | | |
| *Elakothrix sp.* | | | | | 6 | | 3 | | | | |
| *Eudonna sp.* | | | | | | | | | | 6 | 15 |
| *Gloeocystis sp.* | | | | | | | | 6 | | | |
| *Nephrocytium sp.* | | | | | | | 3 | | | | |
| *Oocystis sp.* | | | | | 3 | | | 3 | 3 | | 9 |
| *Scenedesmus sp.* | | | | | | 6 | | 3 | 6 | | |
| *Sphaerocystis sp.* | | | 12 | | 9 | | | | | 3 | |
| *Sphaerocystis sp.* | | | | | | 33 | | | | | |
| *Unident volvoc colony* | | | | | | 3 | | | | 9 | |
| *Volvox sp.* | | | 3 | | | | | | | | |
| **DESMIDS** | | | | | | | | | | | |
| *Cosmarium sp.* | | | | | | 3 | | | | | 3 |
| *Staurastrum sp.* | | | | | 3 | | 3 | 3 | 9 | 6 | 6 |
| **EUGLENOIDS** | | | | | | | | | | | |
| *Trachelomonas sp.* | | | | | 3 | | | | | | |
| **DIATOMS** | | | | | | | | | | | |
| *Asterionella sp.* | | | | 12 | 18 | 3 | | 3 | 24 | 3 | |
| *Cyclotella sp.* | | | | 6 | 30 | 18 | 3 | 3 | | 6 | |
| *Tabellaria sp.* | | | 3 | 3 | 12 | 12 | 6 | 42 | 45 | | |
| **CRYPTOMONADS** | | | | | | | | | | | |
| *Chroomonas sp.* | | | 30 | 119 | 179 | 75 | 36 | 12 | 57 | 48 | 36 |
| *Cryptomonas sp.* | | | 15 | 54 | 72 | 3 | 19 | 18 | 24 | 45 | 12 |
| **DINOFLAGELLATES** | | | | | | | | | | | |
| *Ceratium hirundinella* | | | | | | | 6 | | | | |
| *Dinoflagellate cysts* | | | 6 | | 3 | | | | 3 | 3 | 3 |
| *Peridinium sp.* | | | 3 | 3 | 6 | | 18 | 3 | | 3 | |
| **GOLDEN ALGAE** | | | | | | | | | | | |
| *Chrysosphaerella sp. (cells)]* | | | | | | | | | | | 6 |
| *Chrysosphaerella sp. (colony)* | | | | | | | | | | | 6 |
| *Dicerus sp.* | | | 3 | | | 3 | | | 6 | | 3 |
| *Dinobryon sp. (colony)* | | | | | 6 | 39 | | | 3 | 3 | 3 |
| *Dinobryon sp. (loricas)* | | | 6 | 15 | 27 | 9 | 51 | 3 | 33 | 78 | 24 |
| *Mallomonas sp.* | | | 6 | | | | | 3 | | | |
| *Synura sp. (single cells)* | | | 641 | | | | 3 | 3 | | | 9 |
| | | | | | | | | | | | |
| **Unidentifiable flagellates** | | | 113 | 191 | 101 | 328 | 24 | 81 | 89 | 113 | 81 |
| **Bluegreens** | | | 0 | 6 | 15 | 87 | 66 | 114 | 99 | 36 | 36 |
| **Greens** | | | 21 | 3 | 27 | 51 | 12 | 18 | 9 | 18 | 24 |
| **Desmids** | | | 0 | 0 | 3 | 3 | 3 | 3 | 9 | 6 | 9 |
| **Euglenoids** | | | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Diatoms** | | | 3 | 21 | 60 | 33 | 9 | 48 | 69 | 9 | 0 |
| **Cryptomonads** | | | 45 | 173 | 251 | 78 | 55 | 30 | 81 | 93 | 48 |
| **Dinoflagellates** | | | 9 | 3 | 9 | 0 | 24 | 3 | 3 | 6 | 3 |
| **Golden Algae** | | | 656 | 15 | 33 | 51 | 54 | 9 | 42 | 81 | 51 |
| **Total Algal Units** | | | 847 | 412 | 502 | 631 | 247 | 306 | 401 | 362 | 252 |
| **Secchi Disk Depth** | 5.2 | 7.2 | 6.5 | 5.6 | 6.6 | 6.3 | 6.5 | 6.2 | 6.2 | 6.9 | 6.8 |
| **Chlorophyll a Concentration** | 3.1 | 1.4 | 4.1 | 1.9 | 3.2 | 2.9 | 2.6 | 2.7 | 2.3 | 2.3 | 2.3 |
| **Dissolved Color Concentration** | 30.9 | 33.5 | 31.8 | 28.3 | 27.5 | 25.8 | 20.6 | 22.3 | 22.3 | 18.9 | 18.9 |

***anabaena filaments were classified into on of two species: planktonica, characterized by muscilaganous "wings" extending from the heterocysts, and flos-aque characterized by spiraling of the filament and spacing of the heterocysts and akinetes.***

***Note: some filaments deviated from these basic characteristics.***

**Epilimnetic Phytoplankton Community Assessment for Paradise Pond - Site 2 North (1994)**

| | (Depth) | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 | 0-3.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Date) | 7-May | 22-May | 5-Jun | 19-Jun | 4-Jul | 14-Jul | 31-Jul | 13-Aug | 28-Aug | 11-Sep | 25-Sep | 9-Oct | 23-Oct |
| **BLUEGREENS** | | | | | | | | | | | | | | |
| *Anabaena flos-aquae* | | | | | 9 | 18 | 6 | 21 | | 6 | 3 | 3 | | |
| *Aphanocapsa sp.* | | | | | 3 | 3 | 3 | | | 3 | | | | |
| *Dactylococoppsis sp.* | | | | | 12 | | 3 | | 6 | 3 | 12 | | 6 | |
| *Merismopedia sp.* | | | | | 21 | 3 | | | | 3 | 155 | 3 | 9 | |
| *Unidentifiable coccoid* | | | | | 18 | | | 6 | 3 | 12 | 66 | 143 | 75 | 9 |
| **GREENS** | | | | | | | | | | | | | | |
| *Ankistrodesmis sp.* | | | | | | 18 | | 27 | 6 | 27 | 24 | 6 | 6 | 3 |
| *Crucigenia sp.* | | | | | | 9 | 9 | 9 | | | | | | |
| *Dictyosphaerium sp.* | | | | | | | | 3 | | | | | | |
| *Gloeocystis sp.* | | | | | | 3 | | 3 | | | 3 | | | |
| *Oocystis sp.* | | | | | | | 6 | | | | | 3 | | |
| *Pediastrum sp.* | | | | | | 12 | | | | | 3 | | | |
| *Quadrigula sp.* | | | | | | 6 | | 3 | | | 9 | | | |
| *Scenedesmus sp.* | | | | | 6 | 18 | 9 | 24 | | | | 3 | | |
| *Sphaerocystis sp.* | | | | | | | | | | | 36 | | | |
| *Sphaerocystis sp.* | | | | | | | | | 3 | 3 | | | | |
| **DESMIDS** | | | | | | | | | | | | | | |
| *Cosmarium sp.* | | | | | | | | | | | | | | |
| *Staurastrum sp.* | | | | | 3 | 3 | | | | | | | | |
| **EUGLENOIDS** | | | | | | | | | | | | | | |
| *Trachelomonas sp.* | | | | | | | | 9 | | | 3 | | | |
| **DIATOMS** | | | | | | | | | | | | | | |
| *Asterionella sp.* | | | | | 9 | 9 | | | 3 | | | | 24 | 18 |
| *Cyclotella sp.* | | | | | 15 | 113 | 39 | 72 | 3 | 63 | 328 | 33 | 39 | 12 |
| *Rhizoselinia sp.* | | | | | | | | 6 | | | | | 12 | |
| *Tabellaria sp.* | | | | | | 12 | | | | | | | | |
| *Synedra sp.* | | | | | 3 | | | 3 | | 9 | | | | |
| **CRYPTOMONADS** | | | | | | | | | | | | | | |
| *Chroomonas sp.* | | | | | 66 | 9 | 3 | | 182 | 232 | 253 | 83 | 149 | 396 |
| *Cryptomonas sp.* | | | | | 51 | 167 | 81 | 36 | 54 | 24 | 21 | 9 | 21 | 27 |
| **DINOFLAGELLATES** | | | | | | | | | | | | | | |
| *Ceratium hirundinella* | | | | | | | | | | | 3 | | | |
| *Peridinium sp.* | | | | | 3 | | 3 | 3 | | | | | | |
| **GOLDEN ALGAE** | | | | | | | | | | | | | | |
| *Chrysosphaerella sp. (cells)]* | | | | | | | | | | | | 12 | 45 | |
| *Dicerus sp.* | | | | | | 27 | | 9 | 3 | 6 | 3 | 3 | 3 | |
| *Dinobryon sp. (colony)* | | | | | | | | | | 12 | 3 | | 3 | |
| *Dinobryon sp. (loricas)* | | | | | 12 | 12 | 21 | 6 | 6 | 24 | 6 | 6 | 3 | |
| *Mallomonas sp.* | | | | | | | | 6 | | | | 3 | 6 | 12 |
| | | | | | | | | | | | | | | |
| **Unidentifiable flagellates** | | | | | 170 | 15 | | 24 | 209 | 110 | 164 | 92 | 60 | 75 |
| **Bluegreens** | | | | | 63 | 24 | 12 | 27 | 9 | 27 | 236 | 149 | 90 | 9 |
| **Greens** | | | | | 6 | 66 | 24 | 69 | 9 | 30 | 75 | 12 | 6 | 3 |
| **Desmids** | | | | | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Euglenoids** | | | | | 0 | 0 | 0 | 9 | 0 | 0 | 3 | 0 | 0 | 0 |
| **Diatoms** | | | | | 27 | 134 | 39 | 81 | 6 | 72 | 328 | 33 | 75 | 30 |
| **Cryptomonads** | | | | | 117 | 176 | 84 | 36 | 236 | 256 | 274 | 92 | 170 | 423 |
| **Dinoflagellates** | | | | | 3 | 0 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 0 |
| **Golden Algae** | | | | | 12 | 39 | 21 | 21 | 9 | 42 | 12 | 24 | 60 | 12 |
| **Total Algal Units** | | | | | 401 | 457 | 183 | 270 | 478 | 537 | 1095 | 402 | 461 | 552 |
| **Secchi Disk Depth** | | 3.2 | 3.1 | 3.6 | 3.4 | 3.4 | | 3.6 | 3.5 | 3.6 | 3.6 | 3.7 | 3.7 | 3.8 |
| **Chlorophyll a Concentration** | | 12.3 | 4.9 | 3.8 | 6.3 | 7.5 | 4.3 | 4.9 | 2.3 | 2.6 | 2.1 | 2.4 | 3.3 | 1.8 |
| **Dissolved Color Concentration** | | 86.8 | 85.9 | 73 | 80.7 | 73 | 75.6 | 67 | 70.4 | 61.8 | 58.4 | 52.4 | 59.3 | 79 |
| | | | | | | **** | | **** | **** | **** | **** | **** | **** | **** |

****** denotes Secchi Disk measurements which rested on the pondbottom before disappearing from view**

***anabaena filaments were classified into on of two species: planktonica, characterized by muscilaganous "wings" extending from the heterocysts, and flos-aque characterized by spiraling of the filament and spacing of the heterocysts and akinetes.***

***Note: some filaments deviated from these basic characteristics.***

**Epilimnetic Phytoplankton Community Assessment for Pemaquid Pond - Site 1 Basin (1994)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (Depth) | 0-4.0 | 0-4.0 | 0-11.0 | 0-11.0 | 0-9.5 | 0-12.0 | 0-13.0 | 0-6.0 |
| | (Date) | 23-May | 15-Jun | 27-Jun | 13-Jul | 15-Aug | 2-Sep | 15-Sep | 5-Oct |
| **BLUEGREENS** | | | | | | | | | |
| *Anabaena flos-aquae* | | 3 | 18 | | 3 | | | 6 | 3 |
| *Anabaena planktonica* | | | | | 21 | 81 | 54 | 191 | 373 |
| *Aphanocapsa sp.* | | | | | | 6 | 3 | 9 | 3 |
| *Coelosphaerium sp.* | | | | | | | 3 | | 3 |
| *Gloeocapsa sp.* | | | | | | | 3 | | |
| *Merismopedia sp.* | | | | | 3 | 21 | 6 | 15 | 33 |
| *Microcystis sp.* | | | | | | | | 3 | |
| *Unidentifiable coccoid* | | 3 | | | 3 | 9 | | | |
| **GREENS** | | | | | | | | | |
| *Ankistrodesmis sp.* | | | | | | | 12 | | 24 |
| *Chlamydomonas sp.* | | | | 3 | | | | | |
| *Dactylcocopsis sp.* | | | | | | 3 | | | |
| *Elakothrix sp.* | | | | | | | 3 | 3 | |
| *Gloeocystis sp.* | | | | | | 3 | | 3 | |
| *Oocystis sp.* | | | | | | | 3 | | 3 |
| *Quadrigula sp.* | | | | | | | | 3 | |
| *Scenedesmus sp.* | | | | | | 3 | 3 | 6 | |
| *Unident volvoc colony* | | | 36 | | | | | | |
| *Unidentifiable Coccoids* | | 9 | 3 | | | | | | |
| **DESMIDS** | | | | | | | | | |
| *Arthrodesmus sp.* | | | | | | | | | 3 |
| *Spondylosium sp.* | | | | | | 3 | | | |
| *Staurastrum sp.* | | | 9 | | 6 | 6 | | | |
| **EUGLENOIDS** | | | | | | | | | |
| *Trachelomonas sp.* | | | | | | 3 | 9 | 9 | |
| **DIATOMS** | | | | | | | | | |
| *Asterionella sp.* | | 12 | 3 | | 15 | | | 15 | 6 |
| *Cyclotella sp.* | | 9 | 9 | 21 | 18 | 15 | 18 | 39 | 15 |
| *Fragelaria sp.* | | | | | | | | 6 | |
| *Navicula sp.* | | | 3 | | | | | | |
| *Rhizoselinia sp.* | | | 6 | | | 15 | 51 | 21 | 24 |
| *Synedra sp.* | | 6 | | | | 3 | 3 | 15 | 3 |
| *Tabellaria sp.* | | 3 | 9 | | 6 | 27 | 42 | 66 | 33 |
| **CRYPTOMONADS** | | | | | | | | | |
| *Chroomonas sp.* | | 12 | 27 | 3 | 9 | | 39 | 250 | 3 |
| *Cryptomonas sp.* | | 3 | 36 | 45 | 66 | 51 | 48 | 42 | 3 |
| **DINOFLAGELLATES** | | | | | | | | | |
| *Dinoflagellate cysts* | | 3 | | | | | | 6 | |
| *Peridinium sp.* | | | | | 15 | | | | |
| **GOLDEN ALGAE** | | | | | | | | | |
| *Chrysosphaerella sp. (cells)* | | | 15 | 6 | 89 | | 9 | 9 | |
| *Chrysosphaerella sp. (colony)* | | | | 12 | 9 | | | 3 | |
| *Dicerus sp.* | | | 6 | | 3 | | | | 3 |
| *Dinobryon sp. (colony)* | | | | 3 | | | | | 9 |
| *Dinobryon sp. (loricas)* | | 119 | 18 | 51 | 86 | 21 | 27 | 15 | 24 |
| *Synura sp. (colony)* | | | | 3 | 6 | | | | |
| *Synura sp. (single cells)* | | | 161 | 191 | 78 | 6 | | | |
| | | | | | | | | | |
| **Unidentifiable flagellates** | | 0 | 95 | 18 | 3 | 60 | 54 | 57 | 0 |
| **Bluegreens** | | 6 | 18 | 0 | 30 | 117 | 69 | 224 | 415 |
| **Greens** | | 9 | 39 | 3 | 0 | 9 | 21 | 15 | 27 |
| **Desmids** | | 0 | 9 | 0 | 6 | 9 | 0 | 0 | 3 |
| **Euglenoids** | | 0 | 0 | 0 | 0 | 3 | 9 | 9 | 0 |
| **Diatoms** | | 30 | 30 | 21 | 39 | 60 | 114 | 162 | 81 |
| **Cryptomonads** | | 15 | 63 | 48 | 75 | 51 | 87 | 292 | 6 |
| **Dinoflagellates** | | 3 | 0 | 0 | 15 | 0 | 0 | 6 | 0 |
| **Golden Algae** | | 119 | 200 | 266 | 271 | 27 | 36 | 27 | 36 |
| **Total Algal Units** | | 182 | 454 | 356 | 439 | 336 | 390 | 792 | 568 |
| **Secchi Disk Depth** | | 4.3 | 4.1 | 3.9 | 4.3 | 4.2 | 3.8 | 3.5 | 3.6 |
| **Chlorophyll a Concentration** | | 3.2 | 3.9 | 2.6 | 3.8 | 2.3 | 3.1 | 2.8 | 5 |
| **Dissolved Color Concentration** | | 71.3 | 54.1 | 55 | 53.3 | 53.3 | 49 | 44.7 | 39.5 |

***anabaena filaments were classified into on of two species: planktonica, characterized by muscilaganous "wings" extending from the heterocysts, and flos-aque characterized by spiraling of the filament and spacing of the heterocysts and akinetes.***

***Note: some filaments deviated from these basic characteristics.***

# APPENDIX B

## GLOSSARY OF LIMNOLOGICAL TERMS

**Aerobe**- Organisms requiring oxygen for life. All animals, most algae and some bacteria require oxygen for respiration.

**Algae**- See phytoplankton.

**Alkalinity**- Total concentration of bicarbonate and hydroxide ions (in most lakes).

**Anaerobe**- Organisms not requiring oxygen for life. Some algae and many bacteria are able to respire or ferment without using oxygen.

**Anoxic**- A system lacking oxygen, therefore incapable of supporting the most common kind of biological respiration, or of supporting oxygen-demanding chemical reactions. The deeper waters of a lake may become anoxic if there are many organisms depleting oxygen via respiration, and there is little or no replenishment of oxygen from photosynthesis or from the atmosphere.

**Benthic**- Referring to the bottom sediments.

**Bacterioplankton**- Bacteria adapted to the "open water" or "planktonic" zone of lakes, adapted for many specialized habitats and include groups that can use the sun's energy (phytoplankton), some that can use the energy locked in sulfur or iron, and others that gain energy by decomposing dead material.

**Bicarbonate**- The most important ion (chemical) involved in the buffering system of New Hampshire lakes.

**Buffering**- The capacity of lakewater to absorb acid with a minimal change in the pH. In New Hampshire the chemical responsible for buffering is the bicarbonate ion. (See pH.)

**Chloride**- One of the components of salts dissolved in lakewater. Generally the most abundant ion in New Hampshire lakewater, it may be used as an indicator of raw sewage or of road salt.

**Chlorophyll a**- The main green pigment in plants. The concentration of chlorophyll *a* in lakewater is often used as an indicator of algal abundance.

**Circulation**- The period during spring and fall when the combination of low water temperature and wind cause the water column to mix freely over its entire depth.

**Density**- The weight per volume of a substance. The more dense an object, the heavier it feels. Low-density liquids will float on higher-density liquids.

**Dimictic**- The thermal pattern of lakes where the lake circulates, or mixes, twice a year. Other patterns such as polymictic (many periods of circulation per year) are uncommon in New Hampshire. (See also meromictic and holomictic).

**Dystrophy**- The lake trophic state in which the lakewater is highly stained with humic acids (reddish brown or yellow stain) and has low productivity. Chlorophyll *a* concentration may be low or high.

**Epilimnion**- The uppermost layer of water during periods of thermal stratification. (See lake diagram).

**Eutrophy**- The lake trophic state in which algal production is high. Associated with eutrophy is low Secchi disk depth, high chlorophyll *a*, and high total phosphorus. From an esthetic viewpoint these lakes are "bad" because water clarity is low, aquatic plants are often found in abundance, and cold-water fish such as trout and salmon are usually not present. A good aspect of eutrophic lakes is their high productivity in terms of warm-water fish such as bass, pickerel, and perch.

**Free CO2**- Carbon dioxide that is not combined chemically with lake water or any other substances. It is produced by respiration, and is used by plants and bacteria for photosynthesis.

**Holomixis**- The condition where the entire lake is free to circulate during periods of overturn. (See meromixis.)

**Humic Acids**- Dissolved organic compounds released from decomposition of plant leaves and stems. Humic acids are red, brown, or yellow in color and are present in nearly all lakes in New Hampshire. Humic acids are consumed only by fungi, and thus are relatively resistant to biological decomposition.

**Hydrogen Ion**- The "acid" ion, present in small amounts even in distilled water, but contributed to rain-water by atmospheric processes, to ground-water by soils, and to lakewater by biological organisms and sediments. The active component of "acid rain". See also "pH" the symbolic value inversely and exponentially related to the hydrogen ion.

**Hypolimnion**- The deepest layer of lakewater during periods of thermal stratification. (See lake diagram)

**Lake**- Any "inland" body of relatively "standing" water. Includes many synonyms such as ponds, tarns, loches, billabongs, bogs, marshes, etc.

**Lake Morphology**- The shape and size of a lake and its basin.

**Littoral**- The area of a lake shallow enough for submerged aquatic plants to grow.

**Meromixis**- The condition where the entire lake fails to circulate to its deepest points; caused by a high concentration of salt in the deeper waters, and by peculiar landscapes (small deep lakes surrounded by hills and/or forests. (Contrast holomixis.)

**Mesotrophy**- The lake trophic state intermediate between oligotrophy and eutrophy. Algal production is moderate, and chlorophyll *a*, Secchi disk depth, and total phosphorus are also moderate. These lakes are esthetically "fair" but not as good as oligotrophic lakes.

**Metalimnion**- The "middle" layer of the lake during periods of summer thermal stratification. Usually defined as the region where the water temperature changes at least one degree per meter depth. Also called the thermocline.

**Mixis**- Periods of lakewater mixing or circulation.

**Mixotrophy**- The lake condition where the water is highly stained with humic acids, but algal production and chlorophyll *a* values are also high.

**Oligotrophy**- The lake trophic state where algal production is low, Secchi disk depth is deep, and chlorophyll *a* and total phosphorus are low. Esthetically these lakes are the "best" because they are clear and have a minimum of algae and aquatic plants. Deep oligotrophic lakes can usually support cold-water fish such as lake trout and land-locked salmon.

**Overturn**- See circulation or mixis

**pH**- A measure of the hydrogen ion concentration of a liquid. For every decrease of 1 pH unit, the hydrogen ion concentration increases 10 times. Symbolically, the pH value is the "negative logarithm" of the hydrogen ion concentration. For example, a pH of 5 represents a hydrogen ion concentration of $10^{-5}$ molar. [Please thank the chemists for this lovely symbolism -- and ask them to explain it in lay terms!] In any event, the higher the pH value, the lower the hydrogen ion concentration. The range is 0 to 14, with 7 being neutral 1 denoting high acid condition and 14 denoting very basic condition.

**Photosynthesis**- The process by which plants convert the inorganic substances carbon dioxide and water into organic glucose (sugar) and oxygen using sunlight as the energy source. Glucose is an energy source for growth, reproduction, and maintenance of almost all life forms.

**Phytoplankton**- Microscopic algae which are suspended in the "open water" zone of lakes and ponds. A major source of food for zooplankton. Common examples include: diatoms, euglenoids, dinoflagellates, and many others. Usually included are the blue-green bacteria.

**Parts per million**- Also known as "ppm". This is a method of expressing the amount of one substance (solute) dissolved in another (solvent). For example, a solution with 10 ppm of oxygen has 10 pounds of oxygen for every 999,990 pounds (500 tons) of water. Domestic sewage usually contains from 2 to 10 ppm phosphorus.

**Parts per billion**- Also known as "ppb". This is only 1/1000 of ppm, therefore much less concentrated. As little as 1 ppb of phosphorus will sustain growth of algae. As little as 10 ppb phosphorus will cause algal blooms! Think of the ratio as 1 milligram (1/28000 of an ounce) of phosphorus in 25 barrels of water (55 gallon drums)! Or, 1 gallon of septic waste diluted into 10,000 gallons of lakewater. It adds up fast!

**Plankton**- Community of microorganisms that live suspended in the water column, not attached to the bottom sediments or aquatic plants. See also "bacterioplankton" (bacteria), "phytoplankton" (algae) and "zooplankton" (microcrustaceans and rotifers).

**Saturated**- When a solute (such as water) has dissolved all of a substance that it can. For example, if you add table salt to water, a point is reached where any additional salt fails to dissolve. The water is then said to be saturated with table salt. In lakewater, gaseous oxygen can dissolve, but eventually the water becomes saturated with oxygen if exposed sufficiently long to the atmosphere or another source of oxygen.

**Specific Conductivity**- A measure of the amount of salt present in lakewater. As the salt concentration increases, so does the specific conductivity (electrical conductivity).

**Stratum**- A layer or "blanket". Can be used to refer to one of the major layers of lakewater such as the epilimnion, or to any layers of organisms or chemicals that may be present in a lake.

**Thermal Stratification**- The process by which layers are built up in the lake due to heating by the sun and partial mixing by wind.

**Thermocline**- Region of temperature change. (See metalimnion.)

**Total Phosphorus**- A measure of the concentration of phosphorus in lakewater. Includes both free forms (dissolved), and chemically combined form (as in living tissue, or in dead but suspended organisms).

**Trophic Status**- A classification system placing lakes into similar groups according to their amount of algal production. (See Oligotrophy, Mesotrophy, Eutrophy, Mixotrophy, and Dystrophy for definitions of the major categories)

**Z**- A symbol used by limnologists as an abbreviation for depth.

**Zooplankton**- Microscopic animals in the planktonic community. Some are called "water fleas", but most are known by their scientific names. Scientific names include: *Daphnia*, *Cyclops*, *Bosmina*, and *Kellicottia*.