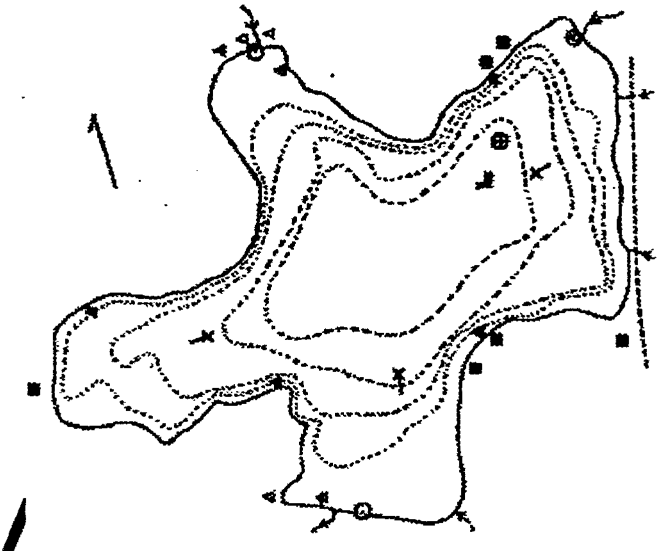
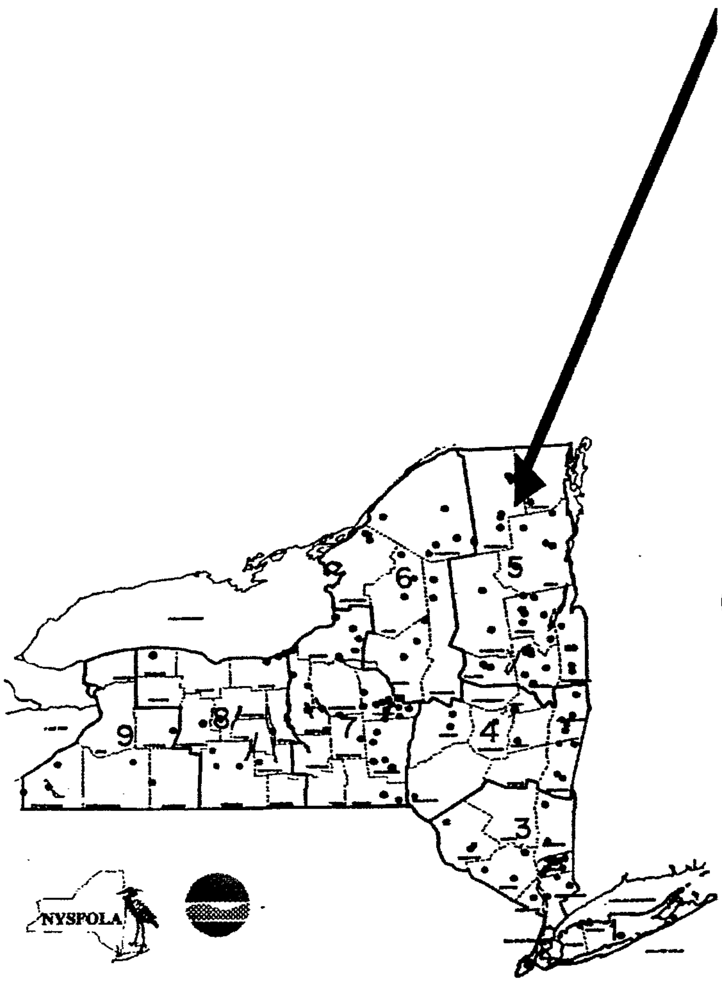
LAKE COLBY





CSLAP ANNUAL REPORT 1999

NYSPOLA

1999 INTERPRETIVE SUMMARY

NEW YORK
CITIZENS STATEWIDE
LAKE ASSESSMENT PROGRAM
(CSLAP)

LAKE COLBY

Scott A. Kishbaugh
Betsy R. Hohenstein

NYS Department of Environmental Conservation
Division of Water, Lake Services Section

April 2000

BACKGROUND AND ACKNOWLEDGMENT

The Citizens Statewide Lake Assessment Program (CSLAP) is a volunteer lake monitoring program conducted by the NYS Department of Environmental Conservation and the NYS Federation of Lake Associations. Founded in 1986 with 25 pilot lakes, the program now involves more than 150 lakes, ponds, and reservoirs and 1000 volunteers from eastern Long Island to the Northern Adirondacks to the western-most lake in New York, including several Finger Lakes, Lake Ontario, and lakes with state parks. In this program, lay volunteers trained by the NYSDEC collect water samples, observations, and perception data every other week in a fifteen-week interval between May and October. Water samples are analyzed by the NYS Department of Health. Analytical results are interpreted by the NYSDEC and utilized for a variety of purposes by the State of New York, local governments, researchers, and, most importantly, participating lake associations. This report summarizes the 1999 sampling results for **Lake Colby.**

Lake Colby is a 185 acre, class A(T) lake found in the Town of Harrietstown in Franklin County, in the northcentral Adirondack region of New York State. 1999 is the first year that Lake Colby has been sampled as part of CSLAP. The following volunteers have participated in CSLAP, and deserve most of the credit for the success of this program at **Lake Colby**: **Debbie Neill, Roger Neill, and Mike Gaukin.**

In addition, the authors wish to acknowledge the following individuals, without whom this project and report would never have been completed:

From the Department of Environmental Conservation, N.G. Kaul, Sal Pagano, Dan Barolo, Italo Carcich, and Phil DeGaetano, for supporting CSLAP for the past fourteen years; Jay Bloomfield and James Sutherland, for their work in developing and implementing the program; the technical staff from the Lake Services Section, for continued technical review of program design; and the support staff from the Bureau of Watershed Management, for assistance in copying and distributing this report.

From the Federation of Lake Associations, Anne Saltman, John Miller, Nancy Mueller, Dr. John Colgan and the Board of Directors, for their continued strong support of CSLAP.

The New York State Department of Health, particularly Jean White, provided laboratory materials and all analytical services, reviewed the raw data, and implemented the quality assurance/quality control program.

Finally, but most importantly, the authors would like to thank the more than 1000 volunteers who have made CSLAP a model for lay monitoring programs throughout the country and the recipient of a national environmental achievement award. Their time and effort have served to greatly expand the efforts of the state and the public to protect and enhance the magnificent water resources of New York State.

Expected Ranges in Trophic Indicators

The relationship between phosphorus, chlorophyll *a*, and Secchi disk transparency has been explored by many researchers, in hopes of assessing the trophic status (the degree of eutrophication) of lakes. **Table 2** shows ranges for phosphorus, chlorophyll a, and Secchi disk transparency (summer averages) that are representative for each of the major trophic classifications, along with a summary of the "typical" or average conditions for Lake Colby:

Table 2. Trophic Status Indicators

Parameter	Eutrophic	Mesotrophic	Oligotrophic	Lake Colby
Phosphorus (mg/l)	> 0.020	0.010 - 0.020	< 0.010	**0.009**
Chlorophyll a (μg/l)	> 8	2- 8	< 2	**2.3**
Secchi Disk Clarity (m)	2	2- 5	> 5	**5.5**

These classifications are valid for clear-water lakes only (waters with less than 30 platinum color units). Some humic or "tea color" lakes, for example, naturally have dissolved organic material with greater than 30 color units. This will cause the water transparency to be unexpectedly poor relative to low phosphorus and chlorophyll *a* levels. **The CSLAP data suggest that Lake Colby is a clearwater lake (color levels less than 30 ptu), and thus these trophic evaluations can be applied to this lake.** Water transparency can also be surprisingly lower than expected in shallow lakes, due to influences from the bottom. Even shallow lakes with high water clarity, low nutrient concentrations, and little algal growth may also have significant weed growth due to shallow water conditions. While such a lake may be considered unproductive by most standards, that same lake may experience severe aesthetic problems and recreational impairment related to weeds, not trophic state. **Water depth does not limit the measurable clarity in Lake Colby; as such, these trophic criteria can be applied to this lake.** Generally, however, the trophic relationships described above can be used as an accurate "first" gauge of productivity and overall water quality. It should be noted that trophic characterizations and categories place signposts in what is a productivity continuum- for example, lakes do not experience dramatically different conditions in the small range separating upper oligotrophy and slight mesotrophy. In other words, there are no obvious or significant differences between a lake with a water clarity of 5.1 meters and a second lake with a clarity of 4.9 meters. As such, these vaguely arbitrary boundaries dividing trophic states should not be assigned greater significance than warranted by the modest advantages afforded any "labeling" scheme.

By the total phosphorus and Secchi disk transparency trophic standards described above, Lake Colby would be considered to be an oligotrophic lake, while chlorophyll *a* readings are more indicative of a mesotrophic lake. As such, the most appropriate trophic classification is probably mesoligotrophic (moderately unproductive).

Aquatic Vegetation

Aquatic vegetation" usually refers to the larger rooted plants called **macrophytes** (although large loosely rooted algae such as Chara or Nitella are common mistaken for macrophytes). However, the greatest portion of aquatic vegetation consists of the microscopic algae referred to as phytoplankton, and the other algal types listed in **Table 3**.

Table 3. Types of Algae

Phytoplankton	Free-floating algae
Periphyton	Algae attached to surfaces
Charaphytes	Larger branched alga

Aquatic plants should be recognized for their contributions to lake beauty as well as providing food and shelter for other life in the lake. Emergent and floating plants such as water lilies floating on the lake surface may provide aesthetic appeal with their colorful flowers; sedges and cattails help to prevent shoreline erosion, and both may provide food and cover for birds. Submergent plants like pondweeds and leafy waterweed harbor beneficial aquatic insects, provide nurseries for amphibians and fish, and provide food for birds and other animals. Macrophytes can be found throughout the *littoral zone*, the near-shore areas in which sufficient light reaches the lake bottom to promote photosynthesis. Plant growth in any particular part of the lake is a function of available light, nutrition and space, bottom substrate, wave action, and other factors, and may only be marginally be influenced by overlying water quality. As such, extensive weed growth can occur even in otherwise "clean" lakes, particularly since many of these lakes possess characteristics (high transmission of sunlight to the lake bottom, reduced competition for nutrients) that can contribute to extensive or explosive weed growth.

Of particular concern to many lakefront residents and recreational users are the exotic, or non-native macrophytes that can frequently dominate a native aquatic plant community and crowd out more beneficial plant species. These plants may be introduced to a lake by waterfowl, but in many cases they are introduced by fragments or seedlings that enter from inflowing streams or remain on watercraft transported from already-infested lakes. Once introduced, these species have tenacious survival skills, frequently crowding out, dominating and eventually aggressively overtaking the indigenous (native) plant communities, interfering with recreational activities such as fishing, swimming or water-skiing. Some plants can reduce water flow in lakes and canals. **Eurasian watermilfoil** *(Myriophyllum spicatum)* is the most common non-native species found in New York State Other non-native species found in NYS lakes are **Curly-leaf pondweed** *(Potamogeton crispus)*, **Eurasian water chestnut** *(Trapa natans)*, and **Fanwort** *(Cabomba caroliniana)*. These plant species need to be properly identified for lake associations to effectively manage their lake. If these plants are not present, the lake should be protected from the introduction of these invasive plants.

Whether the role of the lake manager is to better understand the lake ecosystem or better manage the aquatic plant community, knowledge of the macrophyte species distribution is paramount to the management process. There are many procedures available for assessing and monitoring aquatic vegetation. The CSLAP Sampling Protocol contains procedures for a "semi-quantitative" plant monitoring program. Volunteers collect plant specimen and provide field information and qualitative abundance estimates for an assessment of the macrophyte communities within critical areas of the lake. While these techniques are no substitute for professional plant surveys, they can help provide better information for lake managers. Lake associations planning to devote significant time and expenditures toward a plant management program are advised to pursue more extensive plant surveying activities.

Aquatic plant surveys conducted through CSLAP at Lake Colby identified *Myriophyllum spicatum* (Eurasian water milfoil) and *Potamogeton perfoliatus* (redhead pondweed) at Neill's dock in early July. Limited plant surveys conducted through the Adirondack Lake Survey of the lake identified the following plant genera:

Species	CommonName	Subm/Emer?	Exotic?	Date	Location	%Cover	Abund.
Chara spp.	muskgrass	submergent	no	10/31/84	not reported	not reported	not reported
Potamogeton spp.	unidentified pondweed	submergent	Probably not	10/31/84	not reported	not reported	not reported
Elodea spp.	waterweed	submergent	no	10/31/84	not reported	not reported	not reported
Nuphar spp.	yellow water lily	floating	no	10/31/84	not reported	not reported	not reported
Nymphaea spp.	whiter water lily	floating	no	10/31/84	not reported	not reported	not reported
Brasenia spp.	water shield	floating	no	10/31/84	not reported	not reported	not reported
Utricularia spp.	bladderwort	submergent	no	10/31/84	not reported	not reported	not reported

The Other Kind of Aquatic Vegetation

As noted above, the microscopic algae referred to as phytoplankton make up the bulk of aquatic vegetation found in lakes. For this reason, and since phytoplankton are the primary producers of food (through photosynthesis) in lakes, they are the most important component of the complex food web that governs ecological interactions in lakes.

In a lake, phytoplankton communities are usually very diverse, and are comprised of hundreds of species having various and individually unique requirements for nutrients, temperature and light. In many lakes, including those of New York, diatom populations are greatest in the spring, due to a competitive advantage in cooler water and relatively high levels of silica. In most lakes, however, diatom densities rarely reach nuisance portions in the spring. By the summer, green algae take advantage of warmer temperatures and greater amounts of nutrients (particularly nitrogen) in the warm water and often increase in density. These alga often grow in higher densities than do diatoms or most other algal species, although they are often not the types of algae most frequently implicated in noxious algae blooms. Later in the summer and in the early fall, blue green algae (taxonomically better defined as bacteria), which possess the ability to utilize atmospheric nitrogen to provide this required nutrient, increase in response to higher phosphorus concentrations, often after lakes approach and complete destratification (turn over) in the fall. These alga are most often associated with taste and odor problems, bloom conditions, and the "spilled paint" slick that prompts the most complaints about algae. However, each lake possesses a unique brew of algal communities, often varying seasonally and from year to year, and with differing types, ranging from the aforementioned diatoms, green, and blue-green algae, to golden-brown algae to dinoflagellates and many others, dominating each lake community.

So how can this be evaluated through CSLAP? Phytoplankton communities have not been regularly identified and monitored through CSLAP, in part due to the cost and difficulty in analyzing samples, and in part due to the difficulty in using these highly unstable and dynamic water quality indicators to assess short- or long-term variability in lake conditions. CSLAP does assess algal biomass through the chlorophyll *a* measurement. While algal differentiation is important, many CSLAP lake associations are primarily interested in "how much?", not "what kind?", and this is assessed through the chlorophyll *a* measurement. However, in 1992, nearly all CSLAP lakes were sampled once for phytoplankton identification, and since then some lakes have been sampled on one or more occasions. For these lakes, a summary of the most abundant phytoplankton species is included below. Algal species frequently associated with taste and odor problems are specifically notated in this table, although it should be mentioned that these samples, like all other water samples collected through CSLAP, come from near the center of the lake, a location not usually near water intakes or swimming beaches. Since algal communities can also be spatially quite variable, even a preponderance of taste and odor-causing species in the water samples might not necessarily translate to potable water intake or aesthetic impairments, although the threat of such an impairment might be duly noted in the "Considerations" section below.

Phytoplankton surveys have not yet been conducted through CSLAP at Lake Colby.

III. UNDERSTANDING YOUR LAKE DATA

CSLAP is intended to help lake associations understand their lake's conditions and foster sound lake protection and pollution prevention decisions supported by a strong water quality and lake perception database. This individual lake summary for 1999 contains two forms of information. These raw data and graphs present a snapshot or glimpse of water quality conditions at each lake. They are based on (at most) eight sampling events during the summer. As lakes are sampled through CSLAP for a number of years, the database for each lake will expand, and assessments of lake conditions and water quality data become more accurate. For this reason, lakes participating in CSLAP for only one year will not have information about annual trends.

Background Information About Lake Colby

To adequately evaluate the water quality conditions in a lake, some sense of the setting of the lake can be critical. The following background information about Lake Colby may be useful in better understanding the water quality conditions in, and their significance to, the lake and its use:

Table 4- Background Information for Lake Colby

CSLAP NUMBER	157
Lake Name	L Colby
First CSLAP Year	1999
Sampled in 1999?	yes
Latitude	442002
Longitude	740914
Elevation (m)	474
Area (ha)	110.1
Volume Code	2
Volume Code Name	Lake Champlain
Pond Number	106
Qualifier	none
Water Quality Classification	A(T)
County	Franklin
Town	Harrietstown
Watershed Area (ha)	920.3
Retention Time (years	1.40
Mean Depth (m)	7.2
Runoff (m/yr)	0.64
Watershed Number	10
Watershed Name	Lake Champlain
NOAA Section	3
Closest NOAA Station	Raybrook
Closest USGS Gaging Station-Number	4270000
Closest USGS Gaging Station-Name	Salmon River at Chasm Falls
CSLAP Lakes in Watershed	Augur L, Bartlett P, Glen L, Hadlock L, L Clear, L Colby, L Kiwassa, L Placid, L Sunnyside, Lincoln P, Mirror L, Silver L-C

Raw Data for Lake Colby

Two **"data sets"** are provided in **Table 5** and **Appendix A.** The data presented in **Table 5** show the entire CSLAP sampling history of Lake Colby, including the minimum, maximum, average, and number of samples for each sampling year and parameter. These data may be useful for comparing a certain data point for the current sampling year with historical information. This table also includes data from other sources for which sufficient quality assurance/quality control documentation is available for assessing the validity of the results. **Appendix A** contains the "raw" data collected during all sampling seasons and years in which the lake was sampled as part of CSLAP (historical raw data, collected prior to CSLAP) are not included in this database.

Graphs

The second form of data analysis for Lake Colby is presented in the form of **graphs**. These graphs are based on the raw data sets to represent a snapshot of water quality conditions at Lake Colby. The more sampling that has been done on a particular lake, the more information that can be presented on the graph, and the more information that is available to identify annual trends for this lake. Therefore, it is important to consider the number of sampling years of information in addition to where the data points fall on a graph while trying to draw conclusions about annual trends, although the size of the dataset does figure into the statistical summary for each lake.

There are certain factors not accounted for in this report that lake managers should consider. These include:

- **Local weather conditions** (high or low temperatures, rainfall, droughts or hurricanes). Weather data summaries from the nearest NOAA station are provided below for 1999 and previous years to provide some context for understanding measured water quality conditions in the lake. However, for many lakes, the closest NOAA station, or the closest station with a consistent dataset, is too far away for assessing truly local conditions. The 1999 report does include, where appropriate, a more detailed discussion of the effect of weather conditions on the results at each program lake, particularly in reference to unusual weather events, such as Hurricane Floyd as described below. Weather often most directly affects lakes by changing the amount of runoff entering the lake- while stream gaging stations are maintained by the US Geological Survey on some tributaries entering CSLAP lakes, these data have not yet been sufficiently computerized to easily utilize in CSLAP lake analyses.

Table 5: CSLAP Data Summary for Lake Colby

Year	Min	Avg	Max	N	Parameter
1999	**4.2**	**5.5**	**7.4**	**7**	**CSLAP Zsd**
1984	3.7	4.4	5.0	2	ALSC Zsd

Year	Min	Avg	Max	N	Parameter
1999	**0.008**	**0.009**	**0.012**	**8**	**CSLAP Tot.P**
1984	0.020	0.026	0.032	2	ALSC Tot.P

Year	Min	Avg	Max	N	Parameter
1999	**0.01**	**0.01**	**0.01**	**8**	**CSLAP NO3**
1984	0.01	0.01	0.01	2	ALSC NO3

Year	Min	Avg	Max	N	Parameter
1999	**8**	**10**	**12**	**8**	**CSLAP TColor**
1984	15	18	20	2	ALSC TColor

Year	Min	Avg	Max	N	Parameter
1999	**6.51**	**7.21**	**7.96**	**8**	**CSLAP pH**
1984	7.4	7.70	7.99	2	ALSC pH

Year	Min	Avg	Max	N	Parameter
1999	**167**	**173**	**176**	**8**	**CSLAP Cond25**
1984	136	137	138	2	ALSC Cond25

Year	Min	Avg	Max	N	Parameter
1999	**1.14**	**2.28**	**4.77**	**7**	**CSLAP Chl.a**

Year	Min	Avg	Max	N	Parameter
1999	**1**	**1.6**	**2**	**8**	**QA**

Year	Min	Avg	Max	N	Parameter
1999	**2**	**2.9**	**3**	**8**	**QB**

Year	Min	Avg	Max	N	Parameter
1999	**1**	**1.9**	**3**	**8**	**QC**

DATA SOURCE KEY

CSLAP	New York Citizens Statewide Lake Assessment Program
LCI	the NYSDEC Lake Classification and Inventory Survey conducted during the 1980s and again beginning in 1996 on select sets of lakes, typically 1 to 4x per year
DEC	other water quality data collected by the NYSDEC Divisions of Water and Fish and Wildlife, typically 1 to 2x in any give year
ALSC	the NYSDEC (and other partners) Adirondack Lake Survey Corporation study of more than 1500 Adirondack and Catskill lakes during the mid 1980s, typically 1 to 2x
ELS	USEPA's Eastern Lakes Survey, conducted in the fall of 1982, 1x
EMAP	USEPA and US Dept. of Interior's Environmental Monitoring and Assessment Program conducted from 1990 to present, 1 to 2x in four year cycles

Additional data source codes are provided in the individual lake reports

CSLAP DATA KEY:

The following key defines column headings and parameter results for each sampling season:

Min	Minimum value
Avg	Geometric average (mean)
Max	Maximum value
N	Number of Samples
Zsd	Secchi disk transparency, meters
TAir	Temp of Air, °C
TH2O	Temp of Water Sample, °C
TotP	Total Phosphorus, in mg/l
Hypo	Samples collected for the hypolimnion (1-2 meters from the lake bottom)
NO3	Nitrate nitrogen as N, in mg/l (values of 0.01 refer to undetectable readings)
TColor	True color, as platinum color units
pH	(negative logarithm of hydrogen ion concentration), standard pH
Cond25	Specific conductance corrected to 25°C, in umho/cm
Chl.a	Chlorophyll a, in µg/l
QA	Survey question re: physical condition of lake: (1) crystal clear, (2) not quite crystal clear, (3) definite algae greenness, (4) high algae levels, and (5) severely high algae levels
QB	Survey question re: aquatic plant populations of lake: (1) none visible, (2) visible underwater, (3) visible at lake surface, (4) dense growth at lake surface,(5) dense growth completely covering the nearshore lake surface
QC	Survey question re: recreational suitability of lake: (1) couldn't be nicer, (2) very minor aesthetic problems but excellent for overall use, (3) slightly impaired, (4) substantially impaired, although lake can be used, (5) recreation impossible
QD	Survey question re: factors affecting answer QC: (1) poor water clarity; (2) excessive weeds; (3) too much algae/odor; (4) lake looks bad; (5) poor weather; (6) other

- **Sampling season and parameter limitations**. Because sampling is generally confined to May-October, this report does not look at CSLAP parameters during the winter and other seasons. Winter and spring conditions can impact the usability and water quality of a lake, but for logistic reasons cannot be monitored through CSLAP. Each lake is monitored on a schedule compatible with volunteers' availability, weather conditions, sampling safety, sampling budgets, and other factors, and this schedule often varies slightly from year to year, making annual comparisons somewhat problematic. **In an attempt to reconcile these slight annual sampling artifacts, the 1999 report attempts to standardize some comparisons by limiting the evaluation to common sampling periods (for example, reduced seasonal variability and CSLAP sampling schedules may allow for annual comparisons of data collected in July through August only).**

  In addition, there are other non-CSLAP sampling parameters (fecal coliform, dissolved oxygen, etc.) that may be responsible for chemical and biological processes and changes in physical measurements (such as water clarity) and the perceived conditions in the lake. Perhaps more importantly, many lakes experience marked intra-seasonal variabilities- the ultimate choice of sampling dates can significantly influence annual data summaries. For example, a lake with increasing productivity during the summer each year would demonstrate dramatically different "annual" averages for eutrophication parameters in years with relatively more early season sampling than in years with more late season sampling, although the overall conditions in these two years may be very similar. This clouds a purely statistical summary of the data, and requires a more detailed evaluation of the data specifics.

- **Other data**. While this report attempts to summarize all available historical data, some data may be available to some lake managers that are not summarized here. For example, this report does not generally include discussions of contemporary and historical non-CSLAP parameters, such as total nitrogen, alkalinity, and chloride, even though the monitoring programs summarized in this report may have collected this information. CSLAP staff continually searches for additional databases to include in individual lake analyses.

- **Statistical analyses**. True assessments of water quality trends and comparison to other lakes involve rigid statistical analyses. Such analyses are generally beyond the scope of this program, in part due to limitations on the time available to summarize data from nearly 100 lakes in the five months from data receipt to next sampling season. This may be due in part to the inevitable inter-lake inconsistencies in sampling dates from year to year, and in part to the limited scope of monitoring. Where appropriate, some statistical summaries, utilizing both parametric and non-parametric statistics, have been provided within the report and are documented in Appendix B of this report.

IV. A FIRST LOOK AT SAMPLING RESULTS FOR ALL CSLAP LAKES

Was 1999 Different Than Most Other Years?

The short answer to that question is certainly "yes", for every year the sampling results have been different from previous years, whether in comparison to a single year (such as 1998) or against the "average" from all previous CSLAP sampling seasons. And that is one of, if not the, primary reason for monitoring lakes over several years. To gain sufficient confidence of the accuracy of a "snapshot", you need multiple samples, in many cases collected over several years, and to evaluate trends, you need to collect multiple "snapshots". Much of this apparent water quality variability is due to the imprecision in trying to guess the position of a moving target, for water quality conditions vary on an almost continuing basis, although it is presumed (and mostly confirmed via monitoring data) that these variations are relatively small. Some of the variability associated with changes in comparing data indicators (such as averages, range of readings, etc.) are associated with both seasonal variability and sampling season variability. However, it is hoped that the latter influence is minimized by directly comparing data collected only over similar time frames (say July through August). And some of the changes are inevitably due to shifting biological cycles that are both complex and generally not measurable through CSLAP, and which may occur in timeframes larger than those measured through this program. However, some of the data differences may inevitably be linked to shifts in weather patterns (a change that can be at least partially assessed through evaluation of meteorological data) or an "actual" water quality trend (the finding of which would be the ultimate objective of this analysis). The following is an attempt to assess the potential impact of weather conditions, specifically precipitation, on broad water quality conditions in CSLAP lakes, and to utilize this information as a springboard to broader assessments about water quality trends in CSLAP lakes.

Figures 2-5 show the variability in precipitation levels and major eutrophication indicators during each of the 14 years in which CSLAP has been conducted; Figures 3-5 define "significant" change (either high or low) as exceeding the standard deviation of the 1986-99 average for each of the water quality indicators. The data in Figure 2 show that, on average, the primary growing season (May through August) in 1999 was quite a bit drier than in most previous sampling seasons, with 1993 the only other year with similarly dry conditions. While the winter of 1999 (Jan-Apr) was slightly wetter than normal, on balance it would be reasonable to call 1999 a dry year. Although more than 25% of the sampled CSLAP lakes demonstrated higher water clarity than usual in 1999, nearly 25% experienced lower water clarity. These results were largely borne out by the phosphorus and chlorophyll *a* data as well (Figures 4 and 5)- a slightly larger percentage of lakes showed a drop in phosphorus in 1999, although chlorophyll *a* readings neither increased nor decreased in a large number of lakes. Despite the likely connection between weather conditions and water quality, these results were largely replicated when looking at either lakes with short retention times (lakes "flush" in less than a year) or those with long retention times (flushing time greater than one year). This suggests that, in drier conditions, water quality conditions are less

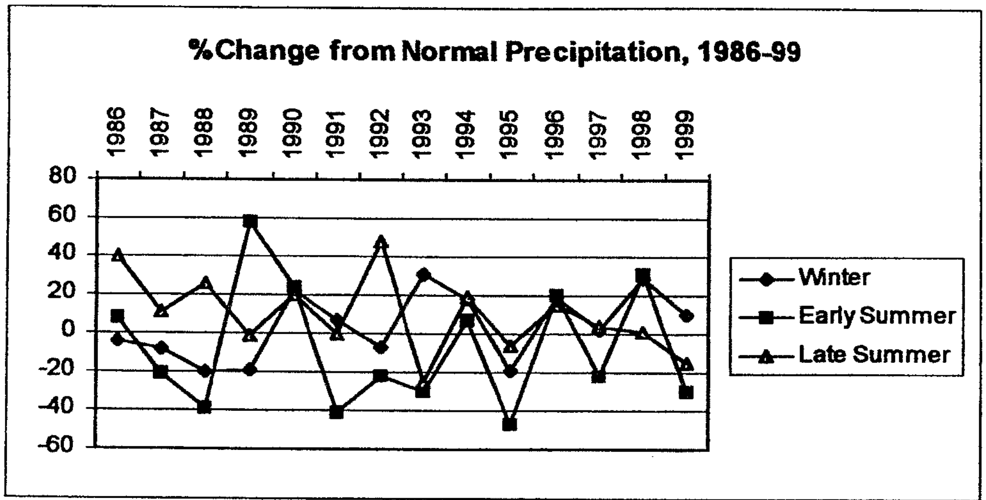


Figure 2. *Comparison of Change in Average NYS Precipitation From Normal Levels During The Winter (Jan-Apr), Early Summer (May-June), and Late Summer (July-August)*

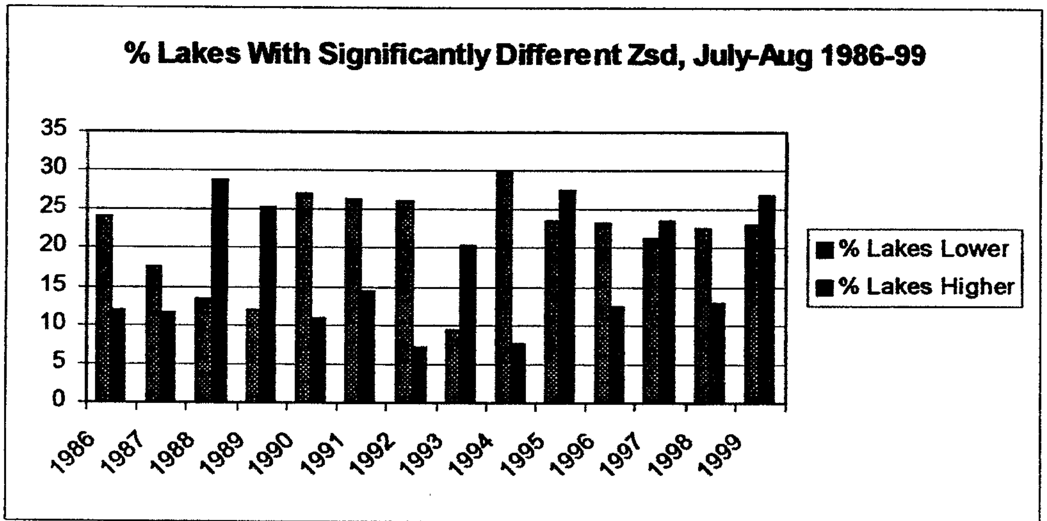


Figure 3. *Changes in Percentage of Lakes With Significant (>1SD) Deviation From 1986-98 Mean Secchi Disk Transparency*

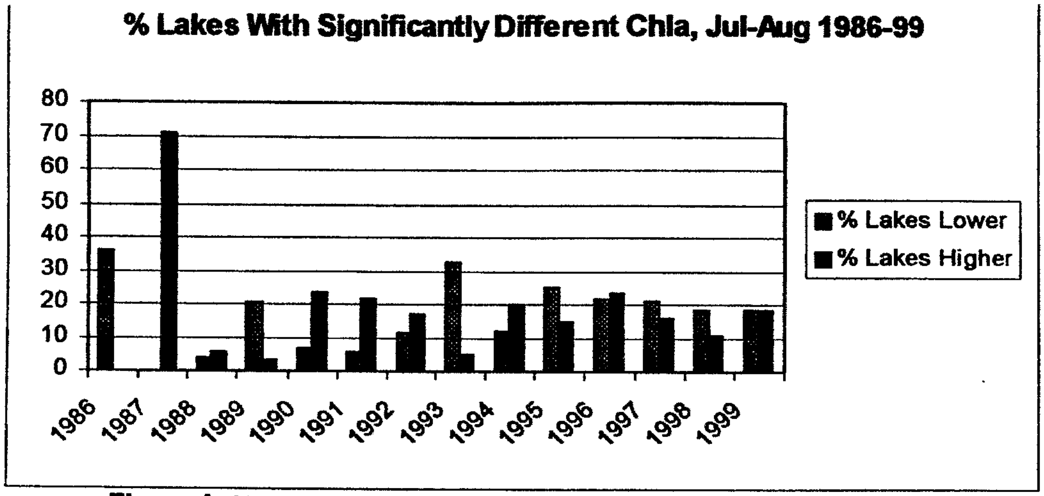


Figure 4. *Changes in Percentage of Lakes With Significant (>1SD) Deviation From 1986-98 Mean Chlorophyll a*

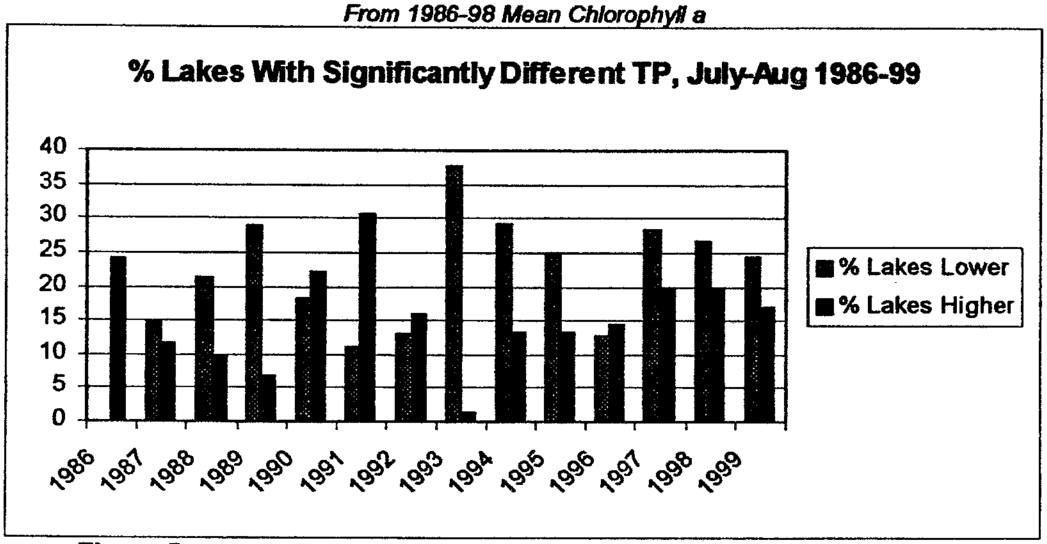


Figure 5. *Changes in Percentage of Lakes With Significant (>1SD) Deviation From 1986-98 Mean Total Phosphorus*

variable than under wetter conditions. However, as noted earlier, the 1999 weather conditions, at least prior to Hurricane Floyd, were most similar to those in 1993. In that year, water quality conditions were most variable (more than twice as many lakes showed an increase rather than a decrease in water clarity, and an extremely high percentage of lakes experienced decreases in phosphorus and chlorophyll *a* readings. This may be due to the greater contrast between winter and summer conditions in 1993 (wettest winter versus the driest summer since 1986) relative to 1999.

What Effect Did Hurricane Floyd Have on Water Quality in NYS Lakes?

From April through August of 1999, precipitation levels in NYS ranged from 5% to 50% below normal. That all changed over a two day period in mid-September, when the storms associated with Hurricane Floyd resulted in more rain falling during a single 24 hour period in Albany (=5.6 inches on September 16) than on any single day since at least 1874. The aptly-named Stormville NOAA station in Dutchess County recorded more than 11 inches of rain, and 33 stations in 16 counties reported more than 5 inches of rain during the storm. Like all large storms, Floyd didn't hit everywhere equally hard. In general, western NY and the northwestern Adirondacks were relatively high and dry, while southeastern NY was most heavily inundated.

There are probably many small ways that significant rain storms affect lakes that are not regularly assessed, such as shifts in spawning or breeding seasons, habitat disruption, changing micronutrient concentrations, and so on. Among the most common water quality indicators, three of the most susceptible are water clarity, phosphorus levels, and conductivity. Of more than fifty CSLAP lakes throughout New York State studied during and after the mid-September deluge, nearly 70% showed a drop in water clarity after the storm, and nearly 60% still had lower water clarity three to four weeks later. This was clearly related to an increase in nutrient concentrations, for more than 70% of the studied lakes also demonstrated an increase in phosphorus concentrations. There was also a decided difference between lakes with relative large watersheds (short retention time) and small watersheds (long retention time). More than 80% of lakes with long retention time (most of the lake input from direct rainfall rather than entering through runoff) showed a decrease in clarity and increase in phosphorus levels, while less than 60% of the short-retention time lakes showed these changes. While a mid-September increase in lake productivity is always as predictable as the drop in water temperature, it appears that the storms made these lakes somewhat more productive (above the productivity increase that comes with fall turnover).

Equally interesting is the noted drop in conductivity in many of the lakes studied during the storm- those in the western and northwestern parts of the state were relatively unchanged (about 55% showed a decrease in conductivity), but in the umbrella belt, nearly 80% showed a drop. Together these findings may suggest that this stormwater brought either runoff disproportionately high in phosphorus, or (more likely) caused an increase in lake turbidity that promoted the mixing of nutrient-enriched bottom (hypolimnetic) waters. This epilimnetic mixing may even triggering an early or at least temporary or partial turnover, or stirred near shore bottom sediments into the water. In either case, nutrient concentrations began to drop again in many of these lakes in the second round of samples after the storm.

Has Lake Water Quality Changed Significant in Recent Years?

A more detailed look at Figure 5 indicates that, with the exception of 1996 (perhaps coincidentally the consistently wettest sampling season in the last ten years), phosphorus concentrations have been lower than normal (running lake average) in at least 25% of CSLAP lakes every year since 1993. While this hasn't translated to an increase in water clarity over this period- in fact, water transparency has been both higher and lower than usual in at least 20% of the CSLAP lakes each year over this period- it does suggest that phosphorus concentrations may be decreasing in some CSLAP lakes. This trend toward lower productivity has surfaced despite somewhat variable sampling schedules, combinations of new and continuing lakes in the monitoring pool, and highly variable weather conditions. This suggests that at least some of the lower nutrient concentrations are the result of actual decreases in nutrient loading to lakes. This might be the realized effect of better septic and stormwater management, reduced lawn fertilization, reduced shoreline and tributary streambank erosion, and other locally initiated and driven lake and watershed management activities. In other words, part of the "improvement" in water quality conditions in many of the monitored NYS lakes may be the result of the efforts of lake associations, local government, county agencies, and dedicated individuals to reduce nutrient inputs and other "pollution" to lakes. This observation was first noted in the 1998 CSLAP report.

Which begs the question- not withstanding the apparent trend, at least in recent years, in Figure 8, has water quality in NYS lakes changed since CSLAP sampling began in 1986? An attempt to answer this question could be launched in several ways. As noted earlier, we cannot simply look at average Secchi disk transparency or chlorophyll *a* or phosphorus readings over this period, since the lakes sampled changed from one year to the next. The data presented in Figures 3 through 5, however, can be evaluated; the summary of the statistical analysis is presented in Appendix B1.

These analyses suggest that the percentage of CSLAP lakes that have exhibited phosphorus and chlorophyll *a* readings below the long-term average for the lake has increased since 1986 in a pattern that may be statistically significant. While Secchi disk transparency readings have likewise demonstrated a slight increase over the same period, the change in this indicator does not appear to be statistically as significant. Nonetheless, by analyzing changes in the percentages of lakes that have shown statistically viable increases or decreases in the primary eutrophication indicators, there appears to be some indication that, generally, the "typical" CSLAP lakes appears to have lower phosphorus and chlorophyll *a* readings since it began CSLAP sampling. It also may not be unreasonable to extrapolate this "finding" to other lakes in NYS, although there is not a sufficient database to determine if CSLAP lakes are truly representative of the "typical" NYS lake.

A second method that can be utilized to evaluate long-term trends is to look at the summary findings of individual CSLAP lakes and attempt to extrapolate consistent findings to the rest of the lakes. When similar parametric and non-parametric tools are utilized to evaluate long-term trends in NYS lakes, a few assumptions must be adopted:

1. Using the non-parametric tools, trend "significance" (defined as no more than appx. 3% "likelihood" that a trend is calculated when none exists) can only be achieved with at least four years of averaged water quality data. When looking at all summer data points (as opposed to data averaging), a minimum of forty data points is required to achieve some confidence in data significance. This corresponds to at least five years of CSLAP data. The "lesson" in these assumptions is that data trends assigned to data sets collected over fewer than five years assume only marginal significance.

2. As noted above, summer data only are utilized (as in the previous analyses) to minimize seasonal effects and different sampling schedules around the fringes (primarily May and September) of the sampling season. This reduces the number of data points used to compile averages or whole data sets, but is considered necessary to best evaluate the CSLAP datasets (and eliminates the more immediate problem of accounting for Hurricane Floyd in these calculations).

There are 106 CSLAP lakes that have been sampled for more than four years, and 68 CSLAP lakes that were sampled for at least five years. The following table summarizes the "trend" indicated from the parametric and non-parametric analyses- the latter consists of both methods indicated in note 1) above, while the former consists of the best-fit analysis of summer (July and August) averages for each of the eutrophication indicators. As alluded to earlier, Table 6 includes only those lakes with at least four years of water quality data.

Table 6

Indicator	# Lakes Showing Parametric Trend	# Lakes Showing Non-Parametric Trend	# Lakes Showing Either Parametric or Non-Parametric Trend	# Lakes Showing Both Parametric and Non-Parametric Trends
Secchi Disk:				
Increasing	15 (14%)	10 (9%)	16 (15%)	9 (8%)
Decreasing	2 (2%)	6 (6%)	7 (6%)	1 (1%)
No Trend	89 (84%)	90 (85%)	83 (78%)	96 (91%)
Chlorophyll a:				
Increasing	2 (2%)	2 (2%)	4 (4%)	2 (2%)
Decreasing	14 (13%)	9 (8%)	18 (17%)	4 (4%)
No Trend	90 (85%)	95 (90%)	84 (79%)	100 (94%)
Total Phosphorus				
Increasing	4 (4%)	5 (5%)	6 (6%)	2 (2%)
Decreasing	7 (6%)	12 (11%)	12 (11%)	6 (6%)
No Trend	95 (90%)	89 (84%)	88 (83%)	98 (92%)

These data suggest that while most NYS lakes have not demonstrated a significant change (again, this term is better defined in Appendix A), those lakes that have experienced some change show a trend toward less productive conditions. The lesser significance associated with the chlorophyll *a* readings is probably the result of higher sample-to-sample variability associated with this analysis. There does not appear to be any obvious shared characteristics among these lakes. Some are highly productive, others are quite unproductive, some have been actively managed, some have been sampled for only a few years or are small shallow lakes or are located in the western part of the state, while others are just the opposite. As noted above, there does not appear to be any clear pattern between weather and water quality changes. However, all of these lakes may be the long-term beneficiaries of the ban on phosphorus in detergents in the early 1970's, which with other local circumstances (perhaps locally more "favorable" weather, local management, etc.) has resulted in less productive conditions.

The "status" of each CSLAP lake on Table 6 will be discussed in the interpretive summary report provided for each lake.

How Do CSLAP Lakes Vary Regionally, By Size, or By Other Characteristics?

Evaluating the condition of a lake does not occur within a vacuum. Each lake is both affected by the setting and indigenous characteristics of the lake, but these characteristics are also critical in evaluating expectations of water quality conditions. For example, "desired" water clarity in a western Adirondack (where many lakes are naturally highly colored), Class C (best intended use = fishing) lake may be very different than in an eastern Adirondack, Class AA (best intended use = drinking water) lake.

The following tables report "typical" readings for each of the CSLAP sampling indicators for CSLAP lakes in 1999 in Table 7 and CSLAP and other sampled lakes (< 1999) in Table 8:

Table 7
CSLAP Results in 1999 By Water Quality Classification and Watershed

	Zsd	TP	NO3	Tcolor	pH	SpCond	Chla	QA	QB	QC	Tair	TH20
CSLAP	3.69	0.021	0.03	12	7.12	172	12.93	2.2	2.6	2.2	23.3	22.4
WQ Class												
AA	5.25	0.010	0.07	8	6.01	94	4.03	1.7	3.0	1.9	21.5	21.3
A	4.16	0.013	0.02	10	7.03	120	6.55	2.2	2.6	2.1	23.5	22.0
B	3.41	0.024	0.03	12	7.30	195	14.25	2.4	2.5	2.3	23.5	22.5
B(T)	4.55	0.017	0.01	10	7.37	169	9.96	2.1	2.6	2.2	22.7	21.6
C	3.22	0.027	0.04	17	7.28	175	23.09	2.1	2.3	1.9	23.5	23.1
Basin												
Lake Erie/Niagara River Basin	3.16	0.042	0.20	20	7.94	285	34.09	2.8	1.8	2.1	24.3	23.6
Allegheny River Basin	2.11	0.031	0.03	7	7.48	177	26.92	3.6	4.2	2.9	23.2	22.4
Lake Ontario Basin	1.94	0.019	0.01	8	7.57	126	7.16	2.5	2.8	2.5	28.0	25.7
Genesee River Basin	2.90	0.035	0.02	8	7.94	206	16.50	2.8	2.8	2.6	21.3	21.8
Chemung River Basin	3.51	0.047	0.01	8	7.62	137	9.40	2.0	2.3	3.0	25.3	22.6
Susquehanna River Basin	3.39	0.014	0.02	10	7.67	131	9.45	2.2	2.6	2.2	22.9	22.2
Seneca/Oneida/Oswego Rivers Basin	4.90	0.010	0.14	5	8.12	229	5.28	2.0	2.0	2.1	22.3	22.3
Black Rivers Basin	3.22	0.007	0.09	21	6.21	41	7.49	1.6	2.2	1.7	22.7	22.1
St. Lawrence Rivers Basin	4.39	0.013	0.01	11	6.68	91	6.72	1.9	2.4	1.8	22.0	21.4
Lake Champlain Basin	5.20	0.009	0.02	8	7.26	162	3.36	2.0	3.9	2.4	22.3	21.9
Upper Hudson River Basin	4.36	0.012	0.01	13	6.61	114	5.50	1.9	2.2	1.8	23.9	21.9
Mohawk River Basin	2.72	0.016	0.02	16	7.24	137	9.43	2.2	2.5	2.1	22.4	22.4
Lower Hudson River Basin	2.97	0.036	0.02	14	7.01	248	25.75	2.6	2.4	2.5	24.2	23.2
Delaware River Basin	3.56	0.022	0.01	9	6.77	94	12.05	2.3	2.4	2.0	22.5	22.5
Raritan River/Newark Bay Basin												
Housatonic River Basin												
Long Island Sound/Atlantic Ocean Basin	0.91	0.080	0.01	23	7.21	1188	38.65	2.9	2.6	2.4	26.4	24.6

Note- All CSLAP lakes that had once been classified as Class D lakes have been reclassified, usually as Class C lakes.

Table 8
Historical CSLAP and NYS Water Quality Data by Water Quality Classification and Watershed

Prior to 1999	Zsd	TP	NO3	Tcolor	pH	SpCond	Chla	QA	QB	QC
CSLAP	3.23	0.021	0.08	14	7.70	169	12.62	2.1	2.3	2.2
NYS	2.80	0.021		45	6.37	58	12.02			
WQ Class										
AA	4.21	0.013		21	7.05	56	5.30	1.7	1.7	1.6
A	3.84	0.014		22	6.96	67	6.49	1.9	2.1	1.9
B	3.15	0.030		18	7.46	181	15.12	2.1	2.5	2.3
C	2.90	0.016		43	6.34	41	10.63	2.0	2.2	2.2
D	2.82	0.017		40	6.12	41	8.03	2.5	3.0	2.6
Basin										
Lake Erie/Niagara River Basin	1.08	0.068		13	7.62	474	17.99			
Allegheny/Chemung Rivers Basin	1.94	0.038		12	7.60	136	18.06	2.3	2.2	2.4
Lake Ontario Basin	1.95	0.035		12	8.00	302	18.55	2.3	2.2	2.8
Genesee River Basin	3.19	0.022		9	7.84	209	34.23			
Susquehanna River Basin	3.16	0.017		9	7.76	156	9.42	2.1	2.5	2.4
Oswego River Basin	3.11	0.025		10	8.01	582	17.36	2.1	2.3	2.3
Oswegatchie/Black Rivers Basin	2.82	0.018		51	5.62	29	4.50	2.3	2.6	2.4
St. Lawrence River Basin	2.31	0.020		59	6.43	34	7.41	1.9	2.4	2.1
Lake Champlain Basin	2.80	0.025		41	6.78	49	8.50	1.7	2.0	1.6
Upper Hudson River Basin	3.10	0.016		33	6.87	47	9.83	1.9	2.3	1.9
Mohawk/Hudson Rivers Basin	3.37	0.024		27	6.52	104	9.71	2.0	2.2	2.0
Lower Hudson River Basin	2.70	0.035		18	7.26	178	17.41	2.3	2.7	2.4
Delaware River Basin	2.49	0.088		21	7.42	71	29.36	1.5	1.8	1.2
Housatonic River Basin	2.85	0.017		6	8.97	185	9.35			
Long Island Sound Basin	1.52	0.034		19	7.18	231	31.05	2.0	4.3	3.9
Raquette River Basin	2.78	0.017		57	6.27	30	4.60	1.4	2.5	1.7

Note: Some of the watersheds/basins listed in Table 8 do not exactly correspond to those listed in Table 3. The historical database file has been classified by the original NYS Biological Survey Volume Code designations, which correspond roughly to the more contemporary watershed designations. However, some discrepancies do exist. Where these exist, the differences are noted in the individual lake on Table 4. While nitrate has been analyzed in many monitoring programs evaluated in Table 8, it has not been used consistently enough to include here. The perception indicators QA, QB, and QC (see Table 5) have been included only in CSLAP monitoring, and thus the historical results in Table 8 represent only the data from that monitoring program.

Tables 7 and 8 show the differences in water quality from one part of the state to the next in 1999 (Table 7) and historically (Table 8). The latter consists primarily of data collected in the Adirondack Lake Survey, the Lake Classification and Inventory Survey, the Eastern Lakes Survey, the National Eutrophication Study, and historical CSLAP data. Only the Adirondack data set (Oswegatchie/Black, St. Lawrence, Lake Champlain, and Upper Hudson River basins) provides a reasonable cross section of lake water quality in any part of the state, since the percentage of unsampled lakes in the other basins is too high. However, the broad trends from Table 8 show that water quality conditions were generally less favorable for swimming and aesthetic quality as lake classification “dropped” from AA to B. Lakes with “lower” classifications were more influenced by water color (and perhaps pH) than were the clearer, higher classification lakes. Adirondack lakes were generally more colored but clearer than many other NYS lakes, while lakes in the western and southern parts of the state were generally less clear with higher nutrient concentrations and harder water. These same patterns generally applied in both the 1999 and historical data sets. In general, the typical CSLAP lake is clearer than the typical NYS lake (which by the

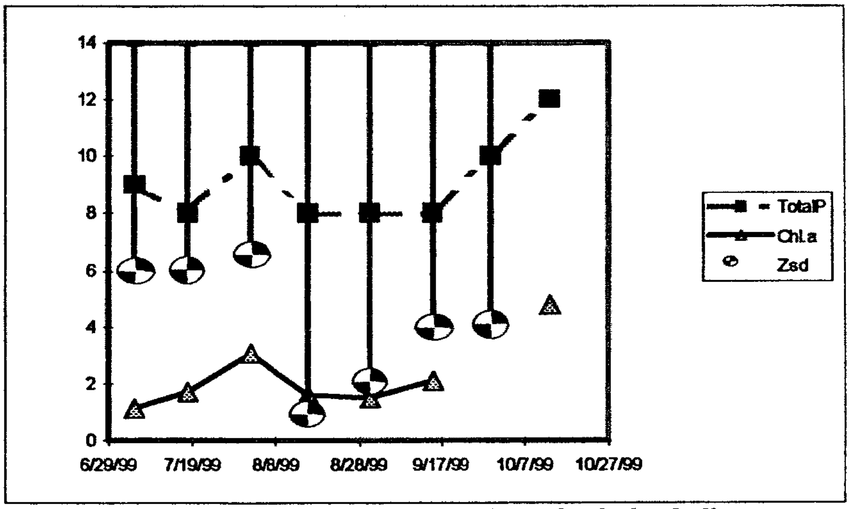


Figure 6. 1999 Eutrophication Data for Lake Colby
This graph illustrates the most recent condition of the lake.

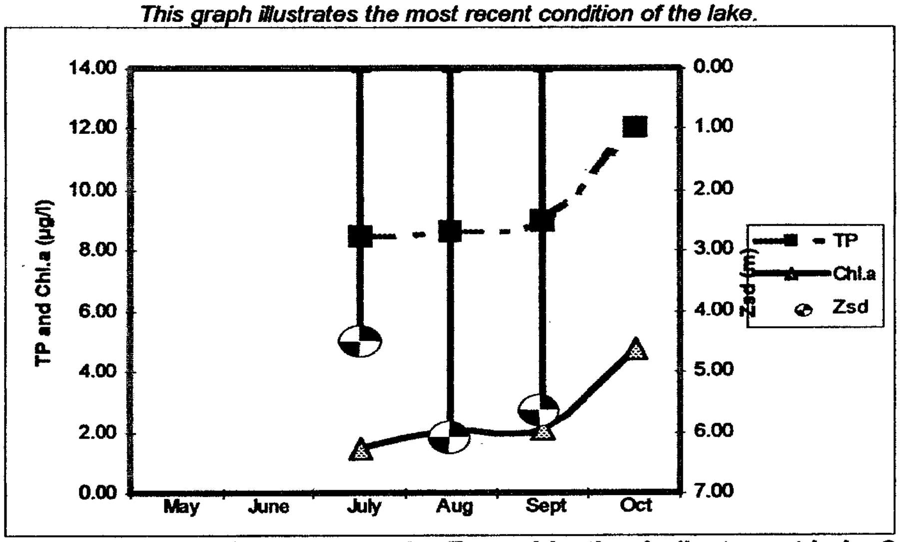


Figure 7. Typical Monthly Averages for Eutrophication Indicators at Lake Colby
This graph shows monthly averages compiled from all sampling seasons at the lake.

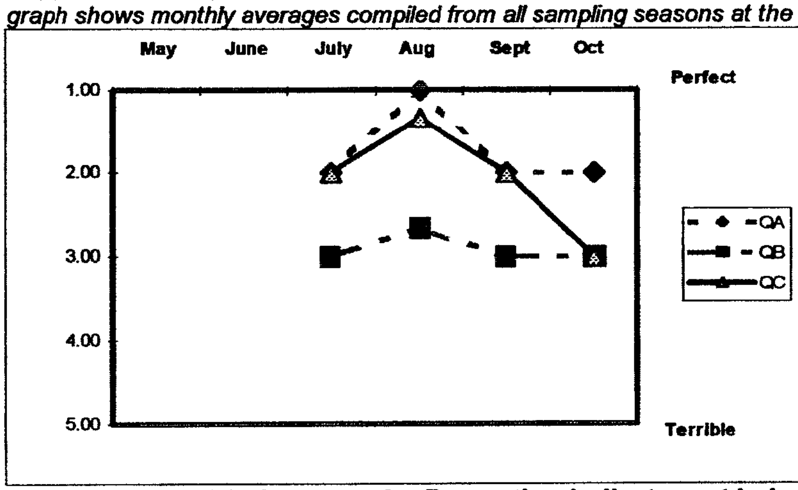


Figure 8. Typical Monthly Averages for Perception Indicators at Lake Colby
This graph shows monthly averages for QA (clarity), QB (weeds), and QC (recreation) for all years

These graphs provide evidence for the following conclusions about seasonal trends:

a) Each of the measured eutrophication parameters have demonstrated significant[1] change over the course of the sampling season: Water clarity increased through mid-summer, then decreased toward the end of the summer. Total phosphorus and chlorophyll *a* experienced mirror-image patterns- both decreased early, then increased through the end of the sampling season. However, the change in nutrients (total phosphorus) and algal densities (chlorophyll *a*) both demonstrated only "strong" statistical associations, while the change in water clarity was somewhat less statistically robust.
b) There **appears** to be a strong seasonal correlation[1] between nutrients and algae at Lake Colby, and it is likely that algae growth is often limited by phosphorus concentrations.
c) There does not appear to be a strong seasonal correlation[1] between algae and water clarity at Lake Colby, although it is likely that algae levels frequently control water clarity.
d) There does not appear to be a strong correlation[1] between seasonal changes in water color and clarity at Lake Colby, and it is likely that water color does not exert a significant influence on water transparency.

Not Yet Collected Through CSLAP

Figure 9. Typical Monthly Averages for Total Phosphorus at the Lake Surface and Hypolimnion

Discussion:
The 1999 CSLAP data suggest that each of the sampled eutrophication indicators demonstrate patterns that are "internally" consistent- that is, all interrelated. These data suggest that the seasonal change in water clarity (increasing at first, then decreasing) may have been the result of an inverse pattern for chlorophyll *a* (decreasing at first, then increasing), which in turn was somewhat related to a comparable seasonal change in total phosphorus concentrations. Although there does not appear to be a strong statistical correlation between water clarity and algae growth, it is likely that there is at least some connection among these indicators. That suggests that any lake management activities developed to maintain or improve water clarity will necessarily need to address algae control, which in turn will require some effort devoted to holding the line on or reducing nutrient loading to the lake.

Lake recreational perception (QC in Figure 8) appears to increase (improve) over the course of the summer, consistent with the perceived change in the "physical condition" of the lake (QA in Figure 8, related to perceived water clarity). This was also mostly consistent with the seasonal change in measured water transparency over the same period. This also broadly followed the same pattern as the change in weed densities (QB in Figure 8). However, the sampling volunteers' indicated that other (unnamed non-water quality) factors more strongly influence lake recreational perception than does water clarity or weed densities. Lake perception was most frequently evaluated as between "perfect" and "excellent".

It is anticipated that additional CSLAP will help to better assess seasonal water quality and lake perception conditions in Lake Colby.

[1] the definition of "significant" and "strong seasonal correlation", as defined here, are found in Appendix B

How has the lake changed since CSLAP began in 1999?

Annual Trends in Eutrophication Parameters and Recreational Assessment

Only One Year of Water Clarity Data

Figure 10
Mean Zsd (Water Clarity), 1999-

Only One Year of Chlorophyll *a* Data

Figure 11
Mean Chl.a, 1999-

Only One Year of Total Phosphorus Data

Figure 12
Mean TP, 1999-

Figures 10-12 compare the annual summer averages for each of the sampled eutrophication parameters, and provide information about the variability in each year's data and the best-fit lines for describing annual trends. Since Lake Colby was sampled for the first time in 1999, water quality trends cannot yet be evaluated.

Only One Year of Perception Data

Figure 13
Mean Perception (Clarity, Weeds, and Recreation), 1999-

Do There Appear To Be Any Significant Long-Term Trends at Lake Colby?

As noted earlier in this report, water quality trends can be evaluated by several statistical means. Figures 10 through 12 demonstrate the most common means- observing if "typical" (summer average or mean) readings for each year of CSLAP participation change significantly over time. This parametric method can be compared to non-parametric analyses, which ranks either all data points or some standard indicator of "central tendency" (such as seasonal or annual average). It may be reasonable to assume that if both methods demonstrate long-term trends in these water quality data, an actual water quality trend may be present. The data for Table 9 are presented in Appendix B-1.

Recreational perception of the lake is most frequently characterized between "perfect" and "excellent". While other factors (not identified by the sampling volunteers) most strongly influenced recreational perception, the highly favorable recreational assessments are consistent with the overall good (as can be assessed through CSLAP) and stable water quality conditions. This suggests that the favorable impressions of the lake are in fact largely controlled by the good water quality conditions in the lake.

The other measured water quality indicators (pH, conductivity, color, nitrate) suggest that Lake Colby possesses an adequate pH to support most aquatic organisms. The lake possesses water of intermediate hardness (neither hard nor soft), and likely has sufficient buffering capacity to prevent significant drops in pH. Nitrate concentrations were consistently undetectable. It is not yet known what role nitrogen plays in algae dynamics in Lake Colby, although these data suggest there is not a very strong connection between nitrogen and algal dynamics in the lake. The color readings are not high enough to influence water transparency- it is likely that the color of Lake Colby is a reflection of the soil and vegetation types in the lake watershed. These readings indicate low levels of dissolved organic matter, generally typical of other upper Adirondack lakes. Lake Colby exhibits water quality characteristics slightly different than (slightly harder water, slightly lower nitrate levels) but generally comparable to other nearby and comparably sized lakes (see below).

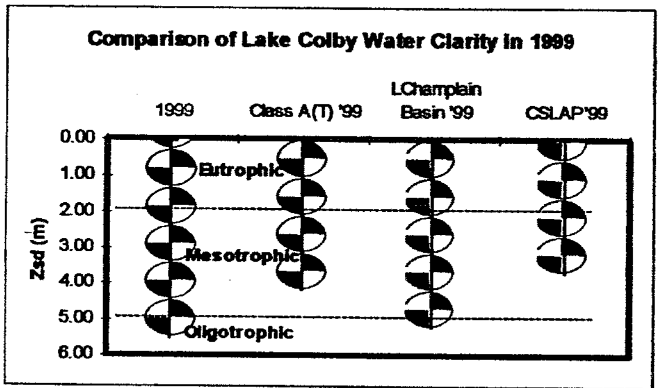


Figure 14. *Comparison of 1999 Secchi Disk Transparency to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other CSLAP Lakes in 1999*

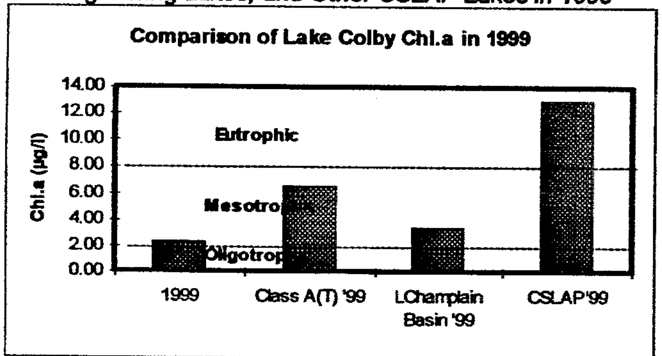


Figure 15. *Comparison of 1999 Chlorophyll a to Lakes with the Same Water Quality Classification, Neighboring Lakes, and Other CSLAP Lakes in 1999*

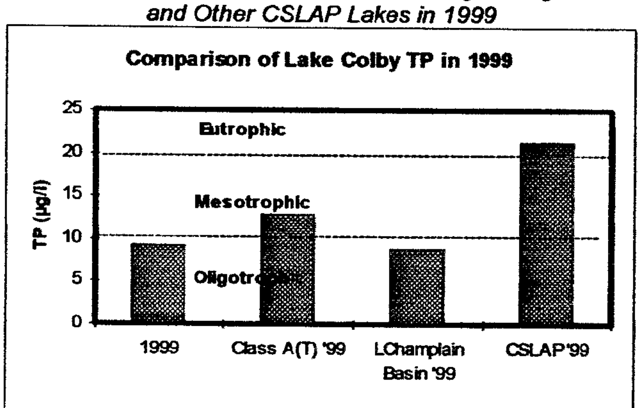


Figure 16. *Comparison of 1999 Total Phosphorus to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other CSLAP Lakes in 1999*

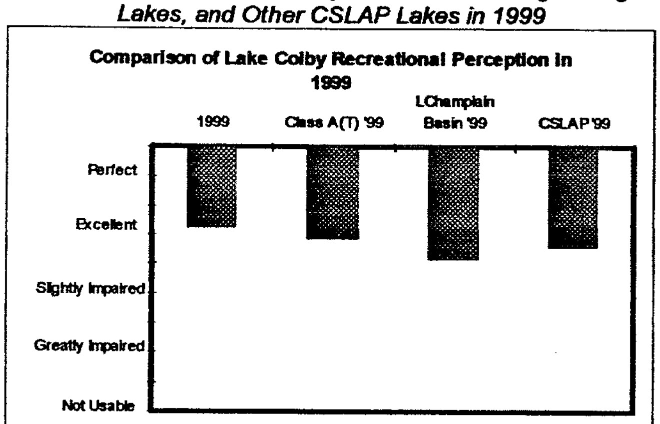


Figure 17. *Comparison of 1999 Recreational Perception*

How does Lake Colby compare to other lakes?

Annual Comparison of Eutrophication Parameters and Recreational Assessment For Lake Colby in 1999, Neighboring Lakes, Lakes with the Same Lake Classification, and Other NYS and CSLAP Lakes

The graphs to the left illustrate comparisons of each eutrophication parameter and recreational perception at Lake Colby-in 1999, other lakes in the same drainage basin, lakes with the same water quality classification (each classification is summarized in Appendix C), and all of New York State. Please keep in mind that differences in watershed types, activities, lake history and other factors may result in differing water quality conditions at your lake relative to other nearby lakes. In addition, the limited data base for some regions of the state preclude a comprehensive comparison to neighboring lakes.

Based on these graphs, the following conclusions can be made about Lake Colby in 1999:

a) Using water clarity as an indicator, Lake Colby is less productive than other Lake Champlain drainage basin lakes, other lakes with the same water quality classification (Class A(T)), and other CSLAP lakes.

b) Using chlorophyll *a* as an indicator, Lake Colby is less productive than other Lake Champlain basin lakes, other Class A(T) and other CSLAP lakes.

c) Using total phosphorus as an indicator, Lake Colby is about as productive as other Lake Champlain basin lakes, and less productive than other Class A(T) and CSLAP lakes.

d) Using QC on the field observations form as an indicator, Lake Colby is more suitable for recreation than other Class A(T), Lake Champlain drainage basin and other CSLAP lakes.

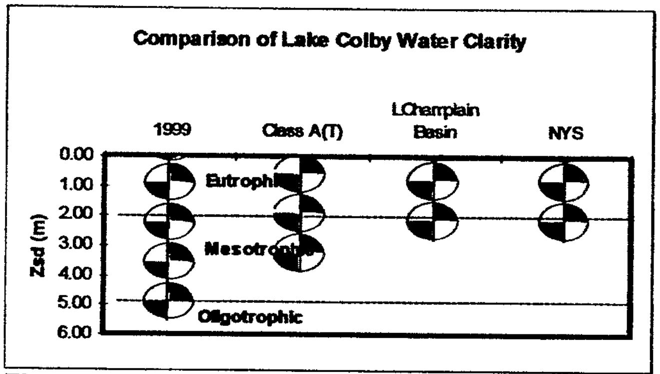


Figure 18. *Comparison of Average Secchi Disk Transparency to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other NYS Lakes*

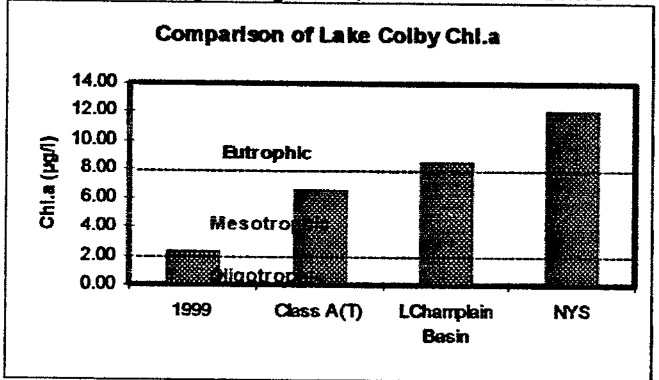


Figure 19. *Comparison of Average Chlorophyll a to Lakes with the Same Water Quality Classification, Neighboring Lakes, and Other NYS Lakes*

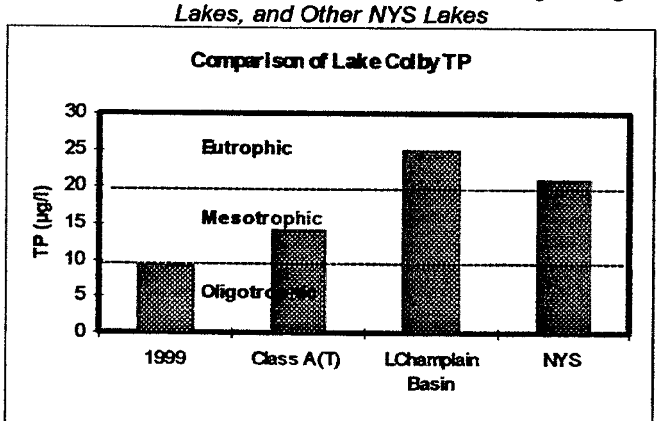


Figure 20. *Comparison of Average Total Phosphorus to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other NYS Lakes*

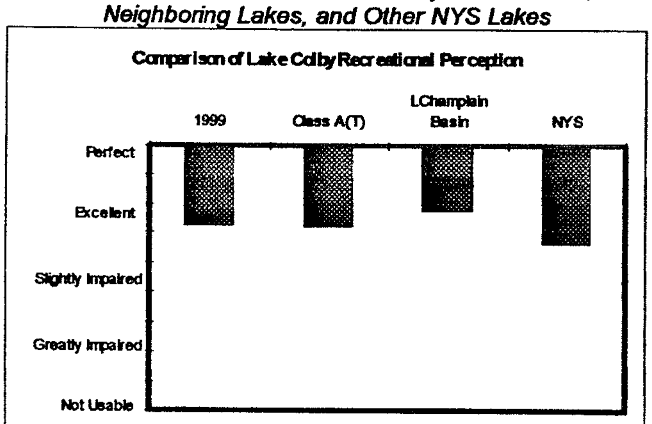


Figure 21. *Comparison of Average Recreational Perception*

For many lakes, 1999 was an unusual year. To minimize extrapolation of 1999 findings to conjectures about "typical" lake conditions, the same plots can be generated comparing historical (pre-1999) data sets. Based on these graphs, the following conclusions about Lake Colby overall can be postulated:

a) Using water clarity as an indicator, Lake Colby is less productive than other Lake Champlain drainage basin lakes, other lakes with the same water quality classification (Class A(T)), and other NYS lakes.

b) Using chlorophyll *a* as an indicator, Lake Colby is less productive than other Class A(T), Lake Champlain drainage basin, and other NYS lakes.

c) Using total phosphorus as an indicator, Lake Colby is less productive than other Class A(T), Lake Champlain basin, and other NYS lakes.

d) Using QC on the field observations form as an indicator, Lake Colby is slightly less suitable for recreation than other Lake Champlain basin lakes, and more suitable for recreation than other Class A(T) and NYS lakes.

Discussion:

As noted above, the highly favorable recreational assessment of Lake Colby is consistent with the good water quality conditions in the lake. The overall suitability of the lake is most frequently described as "excellent". Additional water quality and perception data will help to determine if these assessments are valid for and representative of Lake Colby.

Priority Waterbody List and Water Quality Standards Issues

The Priority Waterbody List (PWL) is presently an inventory of all waters in New York State known to have designated water uses with some degree of impairment of which are threatened by potential impairment. However, the PWL is slowly evolving into an inventory of all waterbodies for which sufficient information is available to assess the condition and/or usability of the waterbody. PWL waters are identified through a broad network of county and state agencies, with significant public outreach and input, and the list is maintained and compiled by the NYSDEC Division of Water. Monitoring data from a variety of sources, including CSLAP, have been utilized by state and agencies to evaluate lakes for inclusion on the PWL, and the process for incorporating lakes data is slowly becoming more standardized.

Specific numeric criteria have not yet been developed to characterize sampled lakes in the available use-based PWL categories (precluded, impaired, stressed, or threatened). Therefore, evaluations utilize the NYS phosphorus guidance value, water quality standards, criteria utilized by other states, and the trophic ranges described earlier to supplement the other more antidotal inputs to the listing. These are summarized in Appendix E.

None of the pertinent water quality standards listed in Figure 22 have been violated during CSLAP sampling sessions at Lake Colby. It is not suspected that any of the narrative water quality standards listed below have been violated at Lake Colby.

Lake Colby is not presently among the lakes listed on the PWL. Based on the limited 1999 CSLAP dataset, including water quality samples, volunteer perceptions, and physical measurements, it does not appear that any PWL listings are warranted.

Figure 22. Water Quality Standards Associated With Class B and Higher Lakes

Parameter	Acceptable Level	To Protect...
Secchi Disk Transparency	> 1.2 meters	Swimming
Total Phosphorus	< 0.020 mg/L and Narrative*	Swimming
Chlorophyll *a*	none	NA
Nitrate Nitrogen	< 10 mg/L and Narrative	Drinking Water
True Color	Narrative*	Swimming
pH	< 8.5 and > 6.5	Aquatic Life
Conductivity	None	NA

Narrative Standards – Color: None in amounts that will adversely affect the color or impair the waters for their best usages (for Class B waters, this is swimming)

Phosphorus and Nitrogen: None in amounts that will result in the growths of algae, weeds and slimes that will impair the waters for their best usages (Class B= swimming)

The 0.020 mg/l threshold for TP corresponds to a guidance value, not standard

The 10 mg/L Nitrate standard strictly applies to only Class A or higher waters, but is included here since some Class B lakes are informally used for potable water intake

IV. CONSIDERATIONS FOR LAKE MANAGEMENT

CSLAP is intended for a variety of uses, such as collecting needed information for comprehensive lake management, although it is not capable of collecting all the needed information. The Five Year Summary Report was envisioned to provide an extensive summary and interpretation of all the water quality, survey, perception, and background information available for each CSLAP lake. Those Reports contained a recommendation section, giving a summary of the most pressing lake problems identified by CSLAP and identifying the compendium of known strategies which are most likely to work at the lake, given some ecological, logistic, and economic considerations.

Staff limitations and the time intensive nature of such an in-depth analysis precludes additional work on these reports. However, the authors include here a ***broad summary of the major lake problems and "considerations" for lake management***. These include only those lake problems which may have been defined by CSLAP sampling, such as physical condition (algae and water clarity), aquatic plant coverage (type and extent of weed populations), and recreational suitability of the lake, as related to contact recreation. These broad categories may not encompass the most pressing issue at a particular time at any given CSLAP lake; for example, local concerns about filamentous algae or concerns about other parameters not analyzed in the CSLAP sampling. While there is some opportunity for CLSAP trained volunteers to report and assess some site specific conditions or concerns on the CSLAP Field Observations Form, such as algae blooms or shoreline vegetation, this section is limited to the confines of this program. The categories represent the most common, broadest issues within the lake management as reported through CSLAP.

If these summaries look like a compendium of Diet for a Small Lake, then (congratulations!) you have been doing your reading. Each summarized management strategy is more extensively outlined in Diet, and this joint NYSDEC-NYSFLA publication should be consulted for more details and for a broader context of in-lake or watershed management techniques. These "considerations" should not be construed as "recommendations", since there is insufficient information available through CSLAP to assess if or how a lake should be managed. Issues associated with local environmental sensitivity, permits, and broad community management objectives also cannot be addressed here. Rather, the following section should be considered as "tips" or a compilation of suggestions for a lake association to manage problems defined by CSLAP water quality data or articulated by perception data. In 1998, NYSDEC queried each of the CSLAP lake associations for information about management activities, historical and contemporary, on their lakes. When appropriate, this information, and other lake-specific or local "data" (such as the presence of a controllable outlet structure) is reported in ***bold*** in this "considerations" section.

Management Focus: **Water Clarity/Algae/Physical Condition/Recreational Condition**

Issue	Through	By?
Maintain water clarity	Maintaining or reducing algae levels	Maintaining or reducing nutrient Inputs to the lake

User perception and water quality data indicate that water clarity is sufficiently high to support recreational uses of the lake. This places the focus of water clarity management on maintaining present conditions. Although some increase in nutrient loading is inevitable, the lake association should devote efforts to minimize the input of nutrients to the lake, or change activities that otherwise influence water clarity. This may include the following:

Monitoring Continue ambient lake water quality monitoring such as CSLAP to better confirm water quality changes, especially related to eutrophication (clarity) indicators. **Lake Colby is scheduled to be sampled through CSLAP for another four years.**

Watershed Nutrient controls can take several forms, and may be a combination of all the below, depending on the source(s) of the nutrients. **It is not known how many of these activities are already conducted in the Lake Colby watershed.**

- Septic systems can be regularly pumped or upgraded to reduce the stress on the leach fields, which can be replaced (by replacing the soil or moving the discharge from the septic tank to a new field). Pumpout programs are usually quite inexpensive, particularly when lakefront residents negotiate a bulk rate discount with local pumping companies. Upgrading systems (tanks and leach fields) can be expensive, but may be necessary to handle increased loading to the system (through camp expansion or conversion to year-round residency). Replacing leach fields alone can be expensive and limited by local soil or slope conditions, but may be the only way to reduce actual nutrient loading from septic systems to the lake. It should be noted that upgrading or replacing the leach field may do little to change any bacterial loading to the lake, since bacteria are controlled primarily within the septic tank, not the leach field. While dye or other "hot spot" tests may be effective to pinpoint systems which may operate inefficiently, sometimes educational efforts which stress the importance of properly-functioning systems may be an effective catalyst for lake residents.
- Stormwater runoff control plans include street cleaning, artificial marshes, sedimentation basins, runoff conveyance systems, and other strategies aimed at minimizing or intercepting pollutant discharge from impervious surfaces such as surrounding pavement in the watershed. The NYSDEC has developed a guide called Reducing the Impacts of Stormwater Runoff to provide more detailed information about developing a stormwater management plan. This is a strategy that cannot generally be tackled by an individual homeowner, but rather requires the effort and cooperation of lake residents and municipal officials.
- Improved agriculture management practices which reduce nutrient export or retain particles lost from agricultural fields, related to fertilizer controls, soil erosion practices, and control of animal wastes. These practices are frequently employed in cooperation with county Soil and Water Conservation District offices, and are described in greater detail in the NYSDEC's Controlling Agricultural Nonpoint Source Water Pollution in New York State. Like stormwater controls, these require the cooperation of many watershed partners, including farmers. **It is unlikely that this is a significant issue in the Lake Colby watershed.**
- Streambank erosion can be caused by increased flow due to poorly managed urban areas, agricultural fields, construction sites, and deforested areas, or it may simply come from repetitive flow over disturbed streambanks. Control strategies may involve streambank stabilization, detention basins, revegetation, and water diversion.

Land use restrictions . Development and zoning tools such as floodplain management, placing clusters of development in less environmentally-sensitive areas of the watershed; deeded/ contractual access to the lake, and cutting restrictions can be used to reduce pollutant loading to lakes. This voluntary approach varies greatly from one community to the next and frequently involves balancing lake use protection with land use restrictions. State law gives great latitude to local government in developing land use plans.

Lawn fertilizers frequently contain phosphorus, even though nitrogen is more likely to be the limiting nutrient for grasses and other terrestrial plants. By using lawn fertilizers with little or no phosphorus, eliminating lawn fertilizers or using lake water as a "fertilizer" at shoreline properties, fewer nutrients may enter the lake. Planting a buffer strip (trees, bushes, shrubs) along the shoreline can reduce the nutrient load leaving a residential lawn.

Waterfowl introduce nutrients, plant fragments, and bacteria to the lake water through their feces. Feeding the waterfowl encourages congregation which in turn concentrates and increases this nutrient source, and will increase the likelihood that these fragments, particularly plants like Eurasian watermilfoil that easy fragment and reproduce through small fragments, can be introduced to a previously uncolonized lake.

No-wake zones can reduce shoreline erosion and local turbidity. Wave action, which can disturb flocculent bottom sediments and unconsolidated shoreline terrain is lessened. **It is not known if this represents a problem at Lake Colby, particularly since only hand public launches exist on the lake.**

Management Focus: **The Impact of Weeds on Recreational Condition**

Issue	Effect on Lake Use
Low to moderate weed growth	**No use impairments associated with weed growth**

Discussion:

Weed growth in this lake is not dense enough to have an impact on recreational or aesthetic quality of the lake. For many lake users this is the best situation, even though an ideal condition for swimmers, boaters and lakefront residents may not be ideal for a significant sports fishery. For lakes in this condition, lake management is largely a task of preservation, of keeping siltation from the watershed at a very low level, and of keeping nuisance plants under control or out of the lake. The DEC publication, Common Nuisance Aquatic Plants in New York State, contains information about nuisance plants. The following techniques have been useful at minimizing or preventing the introduction of nuisance plants to lakes, although by no means are they foolproof. *Longer term watershed protection of the lake from other sediment and nutrient loading which can encourage weed growth, is discussed above in* **Watershed Controls**, *since many of the same pollutants contribute to excessive weed and algae growth.*

-*Boat propellers* frequently get entangled by weeds and weed fragments. This is a very common mode of entry for these plants to a lake. Boats and propellers not completely cleaned before or after leaving one lake to another may introduce a viable non-native plant, as a fragment, to a lake. This is a particular problem for species such as many nuisance plants, that propagate through fragmentation, and which take only a small fragment to establish root.

-*Waterfowl* may introduce plant fragments to lakes, particularly nuisance weeds like *Eurasian watermilfoil* that easily fragment. Encouraging the congregation of waterfowl by feeding will increase the likelihood that these fragments can be introduced to a previously uncolonized lake.

-*Weed watcher* ("...look out for this plant..") signs have been successful in reducing the spread of nuisance aquatic plants. They are usually placed near high traffic areas, such as boat launch sites, marinas, and inlets and outlets.

-*Naturally occurring biological controls* - may include native species of *aquatic weevils and moths* which burrow into and ultimately destroy Eurasian watermilfoil. These organisms feed on Eurasian watermilfoil, and control nuisance plants in some Finger Lakes and throughout the Northeast. However, they also inhabit other lakes with varied or undocumented effectiveness for the long term. Because these organisms live in the canopy of weed beds and feed primarily on the top of the plants, harvesting may have severe negative impact on the population. Research is on-going about their natural occurrence, and their effectiveness both as a natural or deliberately- introduced control mechanism for Eurasian watermilfoil. **It is not known (by the report authors) if these herbivorous insects are indigenous to Lake Colby.**

If you have a small amount of nuisance plant growth you may want to consider the following:

-*Hand harvesting* is a very labor-intensive means for controlling weed populations. If only a very small number of nuisance plant stems exist, this may be the best means of control, removing the roots and stems of the entire plant, and disposing properly before they propagate into larger, uncontrollable beds that become the obnoxious neighbors of beneficial native plants.

-*Benthic barriers* are small opaque mats (usually constructed from plastic, burlap, or other materials) anchored down on top of plants to prevent sunlight from reaching the plants, thus eventually killing the plants. These are limited to only small areas, and the mats must be anchored and perforated to prevent gas bubbles from dislodging the mats.

Appendix A. CSLAP Data for Lake Colby
(refer to CSLAP Data Keys on previous page)

LNum	LName	Date	Zbot	Zsd	Zsamp	TotP	NO3	TColor	pH	Cond25	Chl.a	TAir	TH2O	QA	QB	QC	QD
157	L Colby	7/5/99	12.0	4.55	1.5	0.009	0.01	11	6.86	172	1.14	28	25	2	3	2	6
157	L Colby	7/18/99		4.53	1.5	0.008	0.01	11	6.85	167	1.74	30	21	2	3	2	6
157	L Colby	8/2/99		4.21	1.5	0.010	0.01	8	7.95	176	3.06	19	26	1	3	2	
157	L Colby	8/16/99		7.40	1.5	0.008	0.01	8	7.31	170	1.59	25	21	1	3	1	6
157	L Colby	8/31/99		6.77	1.5	0.008	0.01	12	7.96	175	1.52	30	21	1	2	1	6
157	L Colby	9/15/99		5.70	1.5	0.008	0.01	10	6.51	175	2.12	21	21	2	3	2	
157	L Colby	9/29/99		5.60	1.5	0.010	0.01	12	7.13	172		21	19	2	3	2	6
157	L Colby	10/13/99			1.5	0.012	0.01	11	7.09	173	4.77	20		2	3	3	56

CSLAP DATA KEY:
The following key defines column headings and parameter results for each sampling season:

L Name	Lake name
Date	Date of sampling
Zbot	depth of the bottom at the sampling site, meters
Zsd	average Secchi disk reading, meters
Zsp	depth of the sample, meters
TAir	Temp of Air, °C
TH2O	Temp of Water Sample, °C
TotP	Total Phosphorus, in mg/l
NO3	Nitrate nitrogen as N, in mg/l
TColor	True color, as platinum color units
pH	(negative logarithm of hydrogen ion concentration), standard pH
Cond25	specific conductance corrected to 25°C, in umho/cm
Chl.a	chlorophyll a, in µg/l
QA	survey question re: physical condition of lake: (1) crystal clear, (2) not quite crystal clear, (3) definite algae greenness, (4) high algae levels, and (5) severely high algae levels
QB	survey question re: aquatic plant populations of lake: (1) none visible, (2) visible underwater, (3) visible at lake surface, (4) dense growth at lake surface, (5) dense growth completely covering the nearshore lake surface
QC	survey question re: recreational suitability of lake: (1) couldn't be nicer, (2) very minor aesthetic problems but excellent for overall use, (3) slightly impaired, (4) substantially impaired, although lake can be used, (5) recreation impossible
QD	survey question re: factors affecting answer QC: (1) poor water clarity, (2) excessive weeds, (3) too much algae/odor, (4) lake looks bad, (5) poor weather, (6) other

Appendix B: Summary of Statistical Methods Used in this Report

A variety of statistical methods have been used to present, analyze, and interpret data collected through CSLAP. Some of these methods are commonly used procedures (and have been used previous in Annual Reports), while others have been modified for use on this dataset. The following is a summary of the methods used, or the terms used to summarize a method:

A brief word about including all data points. Occasionally, a sample result indicates that a laboratory, transport, processing, or collection error has occurred; for example, a pH reading of 2.2 (a not-so-weak acid) or a conductivity reading of 4 (distilled water). These results are not included in the dataset. All other data points are retained unless there is strong independent evidence that the result is erroneous.

A slightly less brief note about the statistical tools. Some of the statistical summaries used here assume a "normal" distribution of data. That means that the data collected constitute a subset of the data that describe the parameter (say total phosphorus readings) that, when graphed, are distributed in a bell-shaped (also called "normal" or "Gaussian") curve. In such a curve, the majority of the data points are concentrated near the average, and are less abundant near the extreme values. While an individual subset of data, such as the clarity readings for a particular year for a particular lake, may not be distributed normally (there may be too few points to plot a "normal" curve), they are a subset of a larger set of data (describing instantaneous lake water clarity, in this example) that may demonstrate a Gaussian distribution, though for many environmental indicators, such a normal distribution is less likely. While assuming normal distribution of data allows for the use of both more powerful statistical tools and more easily understood interpretation of these analyses, it may not always be a valid assumption. As such, for many of these statistical analyses presented in this report, both normal and asymmetric distributions are assumed. If no assumptions about the distribution of the data are made, then different and far less powerful, generally non-parametric, statistical tools need to be used.

The following terms are used in parametric (normal distribution of data) analyses in the report:

Mean- the statistical "average" of all samples in a particular dataset. Mean is determined by adding all of the data values within the dataset, and dividing by the number of samples in the dataset.

(**Mean pH**- since pH is not a direct analytical measure, but rather is a mathematical construct from a direct measure (it is the negative logarithm of the hydrogen ion concentration of the water), mean pH is determined by taking the negative logarithm of the mean hydrogen ion concentration)

(**Mean NO_3**- since nitrate is not detectable, an absolute reading for that sample is not obtainable. This becomes problematic when computing an average, or mean, for a set of samples that include undetectable values. For the purposes of calculating means, undetectable nitrate readings (reported as less than 0.02 mg/l) are assumed to be = 0.01 mg/l. Likewise, all other parameters reporting undetectable values are assumed to be 1/2 of the detection limit)

Standard Deviation is a measure of the variability of data points around the calculated mean. A large standard deviation indicates a wide variability in the data (and thus a lower assurance that the mean is representative of the dataset), while a small standard deviation indicates little variability in the data. The standard deviation presented here (the "brackets" on each data point in the **How the Lake Has Changed..** section) corresponds to a 95% confidence interval based on a *true population* standard deviation (σ), and assumes a normal distribution of data (therefore the number of degrees of freedom approaches infinity)).

Linear Regression is a statistical method for finding a straight line that best fits a set of two or more data points, in the form y = mx + b, with m the slope of the line, and b the value for y when the line crosses the x axis (when x = 0). **R^2**- R is a correlation coefficient used to measure linear association. R shows the strength of the relationship between the regressed parameters—the closer the value of R to 1 or -1, the stronger the linear association (R ranges from -1 to +1. When R = 1, the data fall exactly on a straight line with a positive slope, while at R = -1, the data fall exactly on a straight line with a negative slope. This value is squared (R^2) in most statistical analyses, in large part so R values < 0 can be compared to R values > 0). Some non-linear regressions are used only when strongly supported by the data- in these cases, the R^2 values represent the strength of the non-linear relationship, whether they be exponential, logarithmic, or multiple order polynomial equations.

The "significance" of the data reported in linear regressions, standard deviations, and other more rigorous statistical data analyses have been long debated among statisticians. For this report, we hope to provide some rudimentary statistical basis for evaluating the data collected at each lake, and to evaluate larger questions about each dataset, such as water quality trends ("has the lake changed"). In this report, "significant" is defined as the range of the best-fit line exceeding 95% confidence interval of each monthly average, and "strong correlation" is defined as a correlation coefficient (R^2) for the best fit line describing the parameters exceeding 0.5. R^2 readings between 0.3 and 0.5 suggest a "moderate" correlation, and this terminology is used in this report when appropriate.

This definition of "significant" may appear to be too, well, wordy, but the justification for it is as follows. If the amount that a measure such as water clarity changes over time, as determined by a best-fit line, is less than it changes in any given year, than it is likely that this change is not statistically valid. As an example, if a persons weight fluctuates by 6 pounds (say from 144 to 150) any given day, a reported weight loss of 2 pounds (from 149 to 147) should be considered within the normal range of variability. If you are that person, then you may think you lost weight, and may have according to the scale, but, at least statistically, you didn't. The justification for "strong correlation" is not as easy to explain, but may be more verifiable- it appears to be a definition consistent with that used to compare other datasets.

The following terms are used in non-parametric (assuming asymmetric or non-normal distribution of data) analyses in the report:

Kendall tau rank correlation coefficient τ : Kendall tau ranking orders paired observations by one of the variables (say arranging water clarity readings by date). Starting with the left-hand (say earliest date) pair, the number of times that the variable not ordered (in this case clarity readings) is exceeded by the same variable in subsequent pairs is computed as P, and the number of times in which the unordered variable is not exceeded is computed as Q. This computation is completed for each ordered pair, with N= total number of pairs, and the sum of the differences $S = \Sigma$ P-Q. The Kendall tau rank correlation coefficient τ is computed as

$$\tau = 2S/(N*(N-1))$$

Values for τ range from –1 (complete negative correlation) to +1 (complete positive correlation). As above, strong correlations (or simply "significance") may be associated with values for τ greater than 0.5 (or less than –0.5), and moderate correlations may be associated with values for τ between 0.3 and 0.5 (or between –0.3 and –0.5), but the "significance" of this correlation must be further computed. Standard charts for computing the probabilities for testing the significance of S are available in some detailed statistics text books, and for values of N greater than 10, a standard normal deviate D can be computed by calculating the quotient

$$D = S\sqrt{18} / \sqrt{[(N(N-1)(2N+5)]}$$

and attributing the following significance:

$D > 3.29$ = 0.05% significance (only 0.05% chance that a trend is assigned when none actually exists)
$2.58 < D < 3.29$ = 0.5% significance
$1.96 < D < 2.58$ = 2.5% significance
$D < 1.96$ = > 2.5% significance

For the purpose of this exercise, 2.5% significance or less is necessary to assign validity (or, using the vernacular above, "significance") to the trend determined by the Kendall tau correlation. It should be noted that this evaluation does not determine the magnitude of the trend, but only if a trend is likely to occur.

Appendix B1: Summary of Statistical Computations in This Report

IV- Was 1999 Significantly Different Than Most Other Years?

Parameter	Non-Parametric	Statistics:	Parametric	
Zsd	**Tau b**	**Significance**	**Slope**	**Correlation Coeff**
Low	0.1318681	>2.5%	0.4978906	0.3230873
Normal	-0.3846154	>2.5%	-2.1146643	-0.6879981
High	0.3186813	>2.5%	1.6167738	0.6328926
TP	**Tau b**	**Significance**	**Slope**	**Correlation Coeff**
Low	0.4945055	2.50%	1.4298186	0.7090606
Normal	-0.3846154	>2.5%	-1.3490067	-0.5544031
High	-0.010989	>2.5%	-0.0808119	-0.0358495
Chla	**Tau b**	**Significance**	**Slope**	**Correlation Coeff**
Low	0.4175824	2.50%	1.0379979	0.3685304
Normal	-0.2967033	>2.5%	-0.1740972	-0.0432283
High	0.1208791	>2.5%	-0.8639006	-0.1870692

Table 9: Trend Assessment for Lake Colby

Parameter	Non-Parametric	Statistics:	Parametric	
	Tau b	**Significance**	**Correlation Coeff**	**Slope/Max SD**
Zsd	NA	NA	NA	NA
TP	NA	NA	NA	NA
Chl.a	NA	NA	NA	NA

Appendix C. New York State Water Clarity Classifications

Class N: Enjoyment of water in its natural condition and where compatible, as source of water for drinking or culinary purposes, bathing, fishing and fish propagation, recreation and any other usages except for the discharge of sewage, industrial wastes or other wastes or any sewage or waste effluent not having filtration resulting from at least 200 feet of lateral travel through unconsolidated earth. These waters should contain no deleterious substances, hydrocarbons or substances that would contribute to eutrophication, nor shall they receive surface runoff containing any such substance.

Class $AA_{special}$: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival, and shall contain no floating solids, settleable solids, oils, sludge deposits, toxic wastes, deleterious substances, colored or other wastes or heated liquids attributable to sewage, industrial wastes or other wastes. There shall be no discharge or disposal of sewage, industrial wastes or other wastes into these waters. These waters shall contain no phosphorus and nitrogen in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.

Class $A_{special}$: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These international boundary waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class AA: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These waters, if subjected to approved disinfection treatment, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class A: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class B Suitable for primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival

Class C: Suitable for fishing, and fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Class D: Suitable for fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Class (T): Designated for trout survival, defined by the Environmental Conservation Law Article 11 (NYS, 1984b) as brook trout, brown trout, red throat trout, rainbow trout, and splake

Appendix D. Phytoplankton Information

Whether you fish, swim, or sit and watch the dragonflies over the water, you are aware that the lake is a large ecosystem which supports a variety of life. At the bottom of this system, or food web, are the primary producers, called algae, which are basic for life at the lake. The primary producers are so named because this remarkable life form can produce biomass from energy (the sun) and produce oxygen in a process called photosynthesis, the first step in the food chain for all the other living things. The free floating form of algae called phytoplankton, are consumed by tiny animals, zooplankton, and bacteria, which in turn are consumed by insects and small fish, and so on throughout the food web. While the absence of phytoplankton or algae may make for a clean swimming pool, the loss of phytoplankton has serious implications to a lake. The lowering of the pH of several Adirondack Lakes from acid rain attests to the importance of maintaining sufficient water chemistry characteristics necessary to support algae. In some of those lakes the pH is now too low for survival of most phytoplankton species, and thus for much aquatic life throughout the food web. Predation by zebra mussels of phytoplankton is another environmental factor which may drastically change the biological character of a lake. These non-native species may clear the water of algae but will also undermine and jeopardize the entire lake food web. A variety of phytoplankton is needed for a healthy lake.

The life of algae

Algae may be attached to substrates (periphyton) or free floating (plankton) in the water. In a lake, phytoplankton communities are usually very diverse, and are comprised of hundreds of species having various requirements for nutrients, temperature and light. For instance, the diatom group of algae need silica for their cell wall structure; green algae cell walls are composed of cellulose and some blue green algae have little to no need for nitrogen in the water, being able to "fix" it themselves, called nitrogen fixing. Consequently, these populations fluctuate as variables such as water temperature, nutrient availability and predation levels of zooplankton fluctuate. In most lakes, including those of New York, diatom (*Bacillariophyceae*) populations are greatest in the spring, and decline in number to proportionately less of the overall biomass as the summer progresses. This is often related to silica concentrations in the lake. At that time, the smaller populations of green algae (*Chlorophyta*) take advantage of warmer temperatures and greater amounts of nutrients, particularly nitrogen, in the warm water and become the more dominant species of the overall population. As noted earlier, blue green algae (*Cyanophyta*) possess the ability to convert atmospheric nitrogen to forms more readily available for growth, so many NYS lakes experience blue green algae increases when nitrogen levels fall and phosphorus levels increase. Phytoplankton are somewhat mobile and opportunistic life forms displaying great versatility among genus and species. They can move around by changing their density. Some species of algae can adjust their cell walls, giving them buoyancy, and moving up and down the water column to find what they need. Some, particularly the blue green algae, are able to use their gas vacuoles (tiny pockets in the cells) to move, thus avoiding predation or in response to changing environmental conditions, and some algae are flagellated, meaning they are equipped with tiny 'propellers' hairs on the outside of the cell wall to aid in finding the niche in the water column which has their nutrient and sunlight needs.

The diverse algal species need varying levels of temperature, light and nutrients to grow, but phytoplankton in most lakes of New York State are limited by the availability of phosphorus in the water. An overabundance of phosphorus may provide opportunity for what are called pollution-resistant species of algae (mostly the blue-green and green algae) to dominate the overall phytoplankton population, resulting in the familiar green or blue green color of the lake. However, excess phosphorous alone often is not enough to cause a proliferation of alga growth at a lake.

Availability of sunlight for photosynthesis (decreased in highly tea-colored lakes), water temperature, total alkalinity (higher pH) and availability of silicon or other specific nutrients are a few of the non-biological factors which influence various species habitation in the water column. Therefore, although phosphorus is the major limiting factor there are many other factors which trigger phytoplankton behavior which are independent of trophic state. A variety of phytoplankton will occur in all types of lakes, but population numbers or proportions will vary greatly.

Phytoplankton and their predators, zooplankton

Sunlight and nutrient availability affect the algae populations at any given time, as does the number of predators, particularly **zooplankton** (the microscopic animals found in all lakes) around to consume them. Both zooplankton and phytoplankton populations are very dynamic, moving in the water column. As with any ecosystem, the most ecologically viable balance will occur when these populations fluctuate together. However, blue-green algae are not significantly consumed by zooplankton, upsetting this balance. Other factors, whether natural, such as predation on zooplankton by planktivorous fish, or the result of human manipulation of lakes, such as copper sulfate treatments, can tip the zooplankton-phytoplankton equilibrium to, at least temporarily, favor one of the other.

When phytoplankton becomes a "problem"

Too much of a certain kind of algae presents important considerations in lake management. The first is that the proliferating algal growth or predominance of one type of algae may indicate an excess of phosphorus available in the water at that particular time. This may result in a loss of water transparency and ultimately lead to accelerated eutrophication of the lake. Second, the proliferating algal growth itself can be troublesome; it may be unsightly, encumber swimming uses, clog intake screens and be a source of taste and odor problems and threat to the living conditions for other aquatic species, from benthic animals to cold water fish., particularly if anaerobic decomposition (of fallen algae by bottom-dwelling bacteria) occurs.

Is there an easy way to tell if the algae is a problem?

There is no general way of distinguishing algae, according to genus or species as to its benefit and importance to the lake. A total of almost 500 genera and species of algae are important according to their occurrence in water. Generally speaking, the blue-green algae are most pollution resistant and will tend to dominate an ecosystem with enough nutrients. On the whole, green algae are less often associated with tastes and odors problems in water, in fact their growth may help to keep in check the blue-green algae and the diatoms.

Beyond this, however, there is no general rule for algae. It is not possible to predict exactly the succession of algae, based on the trophic state. Research does indicate that trophic factors have the greatest influence on the total biomass of blue-green and green algae. The biomass of other genera rely on factors such as total ion concentration for dinoflagellates and golden-brown algae, and lake morphometry (shape and depth of lakes) for diatoms. Within phytoplankton life forms there is also segregation in the trophic spectrum, meaning that closely related species may be far apart in the trophic spectrum. For instance, while most diatoms are typical of a healthy lake, a few species of diatoms are associated with eutrophication, some imparting taste and odor problems. (This is not unusual in the plant kingdom; for instance *Potamogeton pectinatus* is rare and endangered in some northeastern states, while the *Potamogeton crispus* can dominate a plant community and is considered a nuisance species). Therefore, some genera have different species which have evolved to adapt to varying trophic situations, and thus one genera is not specifically indicative of a certain trophic status of a body of water.

A word about toxic algae:

Currently, the concerns about poisonous or toxic algae, especially as related to humans, are focused on marine algae, specifically that found on the coasts and affecting shellfish. The health and environmental concerns addressed in the CSLAP program relate to those phytoplankton which in abundance and frequency would affect the amount and availability of oxygen in the water, or in their dominance be toxic to other phytoplankton, and the consequent changes to the aquatic organisms, the degree to which it can dominate and block the available sunlight in the water column, affecting transparency and inhibiting growth of other photosynthesizing life forms such as macrophytes in the lake. There are a few algae that promote taste and odor problems in lakes, but the extent of their influence is largely controlled by the use of these lakes (with drinking water supplies more affected than swimming lights).

What does this mean for management considerations for my lake

For most CSLAP lakes, the chlorophyll *a* analysis of phytoplankton sampled twice a month is adequate to estimate the total amount or biomass of algae in the lake. This directly relates the algal biomass to the seasonal cycle of productivity at the lake, assisting in assessments of trophic status when used in conjunction with transparency (Secchi disk readings), and nutrient (phosphorus) indicators.

While chlorophyll *a* may assess the amount of algae in a lake, and is important in assessing the overall productivity of a lake, this measure alone will not tell us about the variations in the population of this important aspect of lake life. A phytoplankton analysis can provide a profile of species they may be indicative of a pollution problem or pristine conditions. Such an analysis, in turn, begs information about the source of the excess nutrients, determining if the loading is more localized (say malfunctioning septic systems) or from changes in land uses and drainage related to agricultural or grazing uses. The source may be from historical nutrient loading, just beginning to cause the release of phosphorous from bottom sediments. Whether a "local" phenomena or localized from a larger phenomena, the identification of the resulting algal growths may help to assess early indicators of accelerated eutrophication.

During the 1992 sampling season, CSLAP conducted phytoplankton sampling at various participating lakes, for a general inventory of existing conditions. On occasion, CSLAP volunteers will collect samples for microscopic examination, in response to a noticeable or problem algal growth. If you have had a phytoplankton analysis through CSLAP which was the result of a problematic proliferating algal growth at the lake or during the 1992 sampling cycle, the microscopic examination results appear in summary in the text of the report and at the end of this appendix. The listing of contemporary assessments below also includes the current research results regarding the relationship of that particular type of phytoplankton species to pollution or eutrophication of the water. Keep in mind that for most waters, comparatively low concentrations of a variety of most genera of algae reflects favorably on the healthy biodiversity of the lake, rather than a liability. Repeated results however, may warrant longer term management activities for maintaining current water quality.

REFERENCES

Palmer, C.M., 1977. Algae and Water Pollution, EPA document 600/9-77-036, Office of Research and Development, US Environmental Protection Agency, Cincinnati, OH 45268. December 1977

G Dasi, M. J.; Miracle, M.R.; Camacho, A.; Soria, J. M.; and E. Vicente, 1998, Summer phytoplankton assemblages across trophic gradients in hard-water reservoirs, Hydrobiologia, 369/370. pp 27-42

Ejsmont-Karabin, J. and I. Spodniewska, 1990. Influence on phytoplankton biomass in lakes of different trophy by phosphorus in lake water and its regeneration by zooplankton. Hydrobiologia, 191. pp. 123-128

Rojo, C, 1998. Differential attributes of phytoplankton across the trophic gradient: A conceptual landscape with gaps. Hydrobiologia, 369/370, pp. 1-9

Fogg, G.E. and B. Thake, 1987, Algal Cultures and Phytoplankton Ecology, Wisconsin University Press

Laal, A. K.; Sarkar, S.K.; Sarkar,A. and M. Karthikeyan, 1994, Ecotendency of phytoplankton: An approach for categorizing algae as bio-indicators for monitoring water quality, Current Science, Vol 67, pp. 193-195

Trifonova, I.S., 1998, Phytoplankton composition and biomass structure in relation to trophic gradient in some temperate and subarctic lakes of north-western Russia and the Prebaltic, Hydrobiologia, 369/370.

Appendix E- PWL Criteria

Background-

The PWL identifies classes of use impairment(s), types and sources of pollutants, and resolvability. In general, CSLAP and other monitoring programs address only use impairments and type of pollutants, although some sources can be assessed within these programs. Among use impairments, all of these monitoring programs collect information to assess, at least in part, **bathing, aesthetics and boating** (apparently defined by the PWL as relating to navigability impacts associated with, among other things, excessive weed growth). These monitoring programs are less useful in assessing use impairments associated with water supplies (usually limited to filtration problems associated with turbidity, both algal and non-algal, but in the future these monitoring programs will also likely assess metals, THM-formation potential, taste and odor conditions, and other factors associated with water potability) and fish propagation and survival (usually limited to temperature/oxygen profiles, but occasionally addressing plankton populations). The primary types of pollutants measured are **nutrients**, although other pollutant types such as oxygen demand, priority organics, silt/sediment, and acid rain may be measured in some monitoring programs. *As such, the PWL criteria described below is, except where noted, limited to assessments of bathing, aesthetics, and boating impairments related to nutrients or other measured parameters. These assessments cannot be extended to evaluating the same use impairments associated with conditions not measured in these programs, or other use impairments not measured or evaluated via monitoring indicators.*

Some of the water quality monitoring data collected through these monitoring programs can be linked directly to the PWL designations. For example, bathing suitability can be directly influenced by water clarity, as dictated by the NYS Department of Health regulation requiring 4 feet of water transparency to establish an swimming beach and support safe swimming conditions (presumably to protect swimmers from "invisible" bottom debris). In other cases, although not codified by regulations, sampling parameters used to characterize lakes for trophic categorization that is an *a priori* factor influencing PWL designation. An example of this are the numeric "standards" for phosphorus, Secchi disk transparency, and chlorophyll *a* differentiating different trophic states. Finally, there are water quality monitoring information, for example lake perception surveys data, that have been demonstrated to be linked to assessments of use impairment, but the criteria providing these linkages are often debated and regionally variable. As such, they have not been universally adopted and may be more tenuous in a regulatory framework.

For the purposes of this evaluation, it is assumed that:

(1) nutrients are not, by default, implicated as the primary pollutant contributing to excessive weed growth. Although excessive silt and sediment load (which may also be contributory to excessive nutrient loading) is more likely to serve as the primary pollutant for excessive weed growth, this is also not assumed in this process. However, if the PWL listing does not identify any other primary pollutants, indicating that nuisance weed growth is the dominating impairment "process", then "silt/sediment" should be identified as the primary pollutant. In the presence of other pollutants, this assessment assumes it is appropriate to consider these pollutants as secondary when excessive weed growth impacts one of the primary lake uses described above, particularly if the existing aquatic plant communities consist primary of plants which draw their nutrition from the overlying water (e.g. coontail, bladderwort, chara, etc.) rather than the lake sediment (e.g. pondweeds, milfoil, emergents, etc.).

(2) Excessive nutrient concentrations in the hypolimnion (bottom waters) represent both potential impacts to bathing conditions and signify that bottom sediments are a source of lake nutrients. Excessive hypolimnetic nutrient concentrations are somewhat arbitrarily defined as more than 2x the concentrations found in the surface waters.

(3) Both excessive weed growth and excessive algae growth, as defined below, can contribute to an impairment of bathing conditions, unless explicitly stated. Bathing criteria apply only to Class B or higher waters.

(4) Only excessive weed growth (among the lake indicators measured in these monitoring programs), as defined below, can contribute to an impairment of boating conditions, unless explicitly stated.

(5) An impairment of aesthetic conditions must be explicitly identified through lake perception surveys, as explained below, to obtain this designation on the PWL

(6) Class B waters are assumed to be used for, among other things, public bathing, and therefore subject to regulations promulgated by the NYS Department of Health. This may not be completely accurate, since many Class B lakes do not presently entertain swimming, or do so via individual swimming, not sanctioned beaches, but it is a conservative assumption consistent with the intent of the classification. It is also assumed that water quality (or lake perception) conditions measured through these monitoring programs are found in areas in which these user activities (bathing, boating, aesthetic enjoyment) are practiced, even though (at least regarding the chemical monitoring data) actual sampling locations may not correspond directly to these recreational areas.

(7) pH readings in excess of 8.5 or below 6.5, and dissolved oxygen concentrations below 4.0 (5.0 in salmonid waters, as designated by the (T) or (TS) classification) represent critical conditions for **aquatic life**, a suggested PWL category to

address aquatic ecosystem concerns not adequately addressed via fish survival, consistent with the state water quality standards. Given the temporal and spatial imprecision associated with profile sampling, DO readings below 1 essentially indicate anoxia, and may represent hypoxic conditions throughout the hypolimnion in between sampling sessions. It should be noted that pH readings in CSLAP and (until 1998) the LCI are laboratory readings, and thus may lack the precision to strictly apply these criteria.

PWL Criteria

Using the aforementioned assumptions, and in the context described above, lakes monitored through CSLAP and other ambient monitoring programs can be assigned PWL designations using a number of criteria. As noted above, these can be divided into, for lack of a simpler distinction, water quality criteria and lake perception criteria. The Minnesota Pollution Control Agency has developed, using the nomenclature described above, water quality- based and lake perception-based criteria defining **fully supporting, fully-supporting-threatened, partially supporting-impaired, and non-supporting-impaired** conditions, using a database comparable (primarily volunteer monitoring and agency statewide lake ambient monitoring) to that available in NYS (Smeltzer and Heiskary, 1990). These impairment categories are consistent with USEPA designations and the present NYS PWL classifications. These criteria utilized a non-parametric analysis of water quality and lake perception data which determines thresholds at which water quality indicators signal likely use impairments (Heiskary and Walker, 1988). Such an analysis of NYS CSLAP data has been utilized to supplement the development of the state guidance value for phosphorus (Kishbaugh, 1992), and the same approach has been utilized by, among other states, Minnesota and Vermont to develop regional phosphorus standards. Other criteria utilized in the generation of PWL designations include the aforementioned NYSDOH swimming beach regulations and trophic state classifications, as well as ancillary perception data utilized to link use impairments to types of pollutants.

These criteria can be summarized as follows:

Precluded Conditions:

Bathing- Perception Data: QC= 4 or 5 for more than 25% of all observations and QC = 5 on at least one occasion *, **and** QA ≥ 3 and QD = 1 and/or 3 for more than 50% of all observations when QC = 4 or 5

Water Quality Data: average TP > 0.060 mg/L or average chlorophyll a > 30 µg/l or average Secchi disk transparency < 0.8 meters (with true color < 30 ptu and maximum depth > 2 meters).

Boating- Perception Data: if QC = 4 or 5 for more than 25% of all observations and QC = 5 on at least one occasion *, **and** QB ≥ 3 and QD = 2 for more than 50% of all observations when QC = 4 or 5.

Water Quality Data- none; in the absence of defining water quality data above, or if the QC criteria and QB criteria are met, but the QA criteria (see above) are not, this designation may also be applied to bathing conditions.

Aesthetics – not available as a criteria (there is no adequate guidance as to what an "aesthetically precluded lake" is)

Fish Survival/Aquatic Life- DO<1 for the surface and epilimnion or DO<1 for the entire hypolimnion for T or TS lake during all sessions

Impaired Conditions:

Bathing- Perception Data: if QC = 3, 4 or 5 for more than 75% of all observations and QC = 4 or 5 for more than 25% of all observations and QC < 5 on all occasions *, **and** QA ≥ 3 and QD = 1 and/or 3 for more than 50% of all observations when QC = 3, 4 or 5

Water Quality Data: average TP > 0.040 mg/L or average chlorophyll a > 15 µg/l or average Secchi disk transparency < 1.2 meters (with true color < 30 ptu and maximum depth > 2 meters)

Boating- Perception Data: if QC = 3, 4, or 5 for more than 75% of all observations and QC= 4 or 5 for more than 25% of all observations and QC < 5 all occasions *, **and** QB ≥ 3 and QD = 2 for more than 50% of all observations when QC = 3, 4 or 5.

Water Quality Data- none; in the absence of defining water quality data above, or if the QC criteria and QB criteria are met, but the QA criteria (see above) are not, this designation may also be applied to bathing conditions as well.

Aesthetics- Perception Data: if QC = 3, 4, or 5 for more than 75% of all observations and QC= 4 or 5 for more than 25% of all observations and QC < 5 all occasions *, **and** QD = 4 for more than 50% of all observations when QC = 3,4,5
Water Quality Data- no criteria available

Fish survival/Aquatic Life mean pH (defined as mean of all values, not negative logarithm of mean $[H^+]$) is above 8.5 or below 6.5 **or** DO < 1 at any time (in the epilimnion or hypolimnion) for any Class T or TS lakes.

Stressed Conditions:

Bathing- Perception Data: if QC = 3, 4 or 5 for more than 25% of all observations **and** QA ≥ 3 and QD = 1 and/or 3 for more than 50% of all observations when QC = 3, 4 or 5
Water Quality Data: average TP > 0.030 mg/L or average chlorophyll a > 12 µg/l or average Secchi disk transparency < 1.5 meters (with true color < 30 ptu and maximum depth > 2 meters)

Boating- Perception Data: if QC = 3, 4, or 5 for more than 25% of all observations **and** QB ≥ 3 and QD = 2 for more than 50% of all observations when QC = 3, 4 or 5.
Water Quality Data- none; in the absence of defining water quality data above, or if the QC criteria and QB criteria are met, but the QA criteria (see above) are not, this designation may also be applied to bathing conditions.

Aesthetics- Perception Data: if QC = 3, 4, or 5 for more than 25% of all observations **and** QD = 4 for more than 50% of all observations when QC = 3, 4 or 5.
Water Quality Data- no criteria available

Fish Survival/Aquatic Life- : pH is < 6.5 or > 8.5 for more than 25% of all measurements **or** DO<1 at all times in the hypolimnion for non T/TS lakes

Threatened Conditions

Bathing- Perception Data: if QC = 3, 4 or 5 for more than 12% of all observations (appx. 1x per summer) **and** QA ≥ 3 and QD = 1 and/or 3 for more than 25% of all observations and more than 50% of all observations when QC = 3, 4 or 5
Water Quality Data: average TP > 0.020 mg/L or average chlorophyll a > 8 µg/l or average Secchi disk transparency < 2 meters (with true color < 30 ptu and maximum depth > 2 meters) (these water quality criteria correspond approximately to the distinction between mesotrophic and eutrophic lakes) **or** hypolimnetic TP > 2x the surface readings for more than 50% of all sampling sessions.

Boating- Perception Data: if QC = 3, 4, or 5 for more than 25% of all observations **and** QB ≥ 3 and QD = 2 for more than 25% of all observations and more than 50% of all observations when QC = 3, 4 or 5 **and** there has been a confirmed identification of an exotic aquatic macrophyte species at the lake (Myriophyllum spicatum, Potamogeton crispus, Trapa natans, or Cabomba caroliniana).
Water Quality Data- none; in the absence of defining water quality data above, or if the QC criteria and QB criteria are met, but the QA criteria (see above) are not, this designation may also be applied to bathing conditions as well.

Aesthetics- Perception Data: if QC = 3, 4, or 5 for more than 12% of all observations **and** QD = 4 for more than 25% of all observations and more than 50% of all observations when QC = 3, 4 or 5.
Water Quality Data- no criteria available

Fish Survival/Aquatic Life- pH is < 6.5 or > 8.5 for more than 10% of all measurements **or** DO<4 at any time in the epilimnion or hypolimnion for non T/TS lakes **or** DO < 5 at any time in the epilimnion or hypolimnion for T/TS lakes.

[1] the definition of "significant" and "strong seasonal correlation", as defined here, are found in Appendix B