I. INTRODUCTION: CSLAP DATA AND FINDLEY LAKE

Water quality monitoring serves a wide variety of purposes. It provides a window for observing and starting to understand the numerous and complex interactions of lakes. Monitoring can help to evaluate contemporary water quality conditions and project future water quality trends, and may serve as a bridge between lake conditions and use of the lake. However, even the most extensive and expensive monitoring program cannot completely assess the water quality of lakes, but by looking at some basic chemical, physical, and biological indicators, it is possible to gain a greater understanding of the general condition of lakes. Such information is critical for managing lakes, assessing short- and long-term water quality conditions and trends, and for comparing lakes sharing common geographic settings and lake uses.

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 175 lakes, ponds, and reservoirs and 1200 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 within 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. Generally, water samples are collected from the lake surface at the deepest part of the lake, using standard limnological equipment and sampling procedures. 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. **CSLAP was first conducted on Findley Lake in 1986.**

CSLAP collects some of the most important water quality indicators in lakes. Some of these indicators, particularly those related to **lake eutrophication** (literally lake nourishment), are collected to assess the aesthetic and ecological "health" of the lake, while others are used for generally characterizing lakes. Eutrophication indicators are most closely monitored because eutrophication represents the most common water quality problem in NYS lakes, and can be most closely linked to recreational and aesthetic uses of lakes. CSLAP also collects information about the perception of the lake, to link one of the objectives of water quality monitoring (to assess lake use impairment) to the data collected in these monitoring programs. Through vegetation and zebra mussel surveys, CSLAP also gathers information about exotic invasive organisms and macrophyte communities in each lake. These indicators collectively serve to provide a "snapshot" of conditions at each program lake, and, when collected over a longer period, serve to provide a contemporary assessment of each lake. Volunteer monitoring is critically important in stretching limiting monitoring resources, and many of these shorefront residents provide insights to the daily ebb and flow of lake activity and an understanding of important lake issues often lost in more traditional "professional" monitoring programs.

II. CSLAP SAMPLING PARAMETERS: WHAT AND WHY

CSLAP monitors several parameters related to the **trophic** (extent of eutrophication) state of a lake. Three parameters are the most important measures of eutrophication in most New York lakes: **total phosphorus, chlorophyll *a*** (measuring algal densities), and **Secchi disk transparency**. Because these parameters are closely linked to the growth of weeds and algae, they provide insight into "how the lake looks" and its suitability for recreation and aesthetics, as well as the more obvious connection to the basic functioning of the lake ecosystem. Additional CSLAP parameters are chosen to optimize the need to characterize lakes while balancing fiscal and logistic necessities (i.e. "the biggest bang for the buck…"). In addition, CSLAP also uses **Field Observation Forms** to gauge perceptions of lake water quality. Most water quality "problems" arise from impairment of accepted or desired lake uses, or the perception that such uses are somehow degraded. As such, any water quality monitoring program should attempt to understand the link between perception and measurable quality.

The parameters analyzed in CSLAP (**Table 1**) provide valuable information for characterizing lakes. By adhering to a consistent sampling protocol provided in the CSLAP Sampling Protocol, volunteers collect and use data to assess both seasonal and yearly fluctuations in these parameters, and to evaluate the overall water quality conditions in their lake. By comparing present data to historical water quality information, lake managers can pinpoint trends and determine if water quality is improving, degrading or is relatively stable. Such a determination answers a first critical question posed in the lake management process. For most CSLAP lakes, these parameters are monitored biweekly from May through October, with samples collected by a Kemmerer bottle from a depth of 1.5 meters (5 feet) in the deepest part of the lake. Deep water (hypolimnetic) phosphorus samples are occasionally collected from a depth 1-2 meters above the lake bottom in lakes that are thermally stratified.

Table 1. CSLAP Sampling Parameters

PARAMETER	SIGNIFICANCE
Water Temperature (°C)	Water temperature affects many lake activities, including the rate of biological growth and the amount of dissolved oxygen. It also affects the length of the recreational season
Secchi Disk Transparency (m)	Determined by measuring the depth at which a black and white disk disappears from sight, the Secchi disk transparency estimates the clarity of the water. In lakes with low color and rooted macrophyte ("weed") levels, it is related to algal productivity
Conductivity (µmho/cm)	Specific conductance measures the electrical current that passes through water, and is used to estimate the number of ions (charged particles). It is somewhat related to both the hardness and alkalinity (acid-buffering capacity) of the water, and may influence the degree to which nutrients remain in the water. Generally, lakes with conductivity less than 100 µmho/cm are considered softwater, while conductivity readings above 300 µmho/cm are found in hardwater lakes.
pH	pH is a measure of the (free) hydrogen ion concentration in solution. Most clearwater lakes must maintain a pH between 6 and 9 to support most types of plant and animal life. Low pH waters (<7) are acidic, while high pH waters (>7) are basic
Color (true) (platinum color units)	The color of dissolved materials in water usually consists of organic matter, such as decaying macrophytes or other vegetation. It is not necessarily indicative of water quality, but may significantly influence water transparency or algae growth. Color in excess of 30 ptu indicates sufficient quantities of dissolved organic matter to affect clarity by imparting a tannic color to the water.
Phosphorus (total, mg/l)	Phosphorus is one of the major nutrients needed for plant growth. It is often considered the "limiting" nutrient in NYS lakes, for biological productivity (algae growth, etc.) is often limited if phosphorus inputs are limited. Many lake management plans focus on phosphorus controls.
Nitrogen (nitrate, mg/l)	Nitrogen is another nutrient necessary for plant growth, and can act as a limiting nutrient in some lakes with certain types of algae, particularly in the spring and early summer. For much of the sampling season, many CSLAP lakes have very low or undetectable (<0.02 mg/l) levels.
Chlorophyll *a* (µg/l)	The measurement of chlorophyll *a*, the primary photosynthetic pigment found in green plants, provides an estimate of phytoplankton (algal) productivity, which may be strongly influenced by phosphorus. In most lake monitoring programs, this is a better indicator of planktonic (floating or suspended cellular) phytoplankton than of filamentous (thread-like fixed) phytoplankton or other algae
Lake Perception (integer rank)	Volunteer assessments of the physical condition (i.e. clarity of the water), weed coverage and density, and the recreational conditions of the lake are enumerated on a ranked scale from 1 (best) to 5 (worst),

Understanding Trophic States

All lakes and ponds undergo **eutrophication,** an aging process, which involves stages of succession in biological productivity and water quality (see **Figure 1**). **Limnologists** (scientists who study fresh water systems) divide these stages into **trophic** states. Each trophic state can represent a wide range of biological, physical, and chemical characteristics and any lake may "naturally" be categorized within any of these trophic states. In general, the increase in productivity and decrease in clarity corresponds with an enrichment of nutrients, plant and animal life. Lakes with low biological productivity and high clarity are considered **oligotrophic**. Highly productive lakes with low clarity are considered **eutrophic**. Lakes that are **mesotrophic** have intermediate or moderate productivity and clarity.

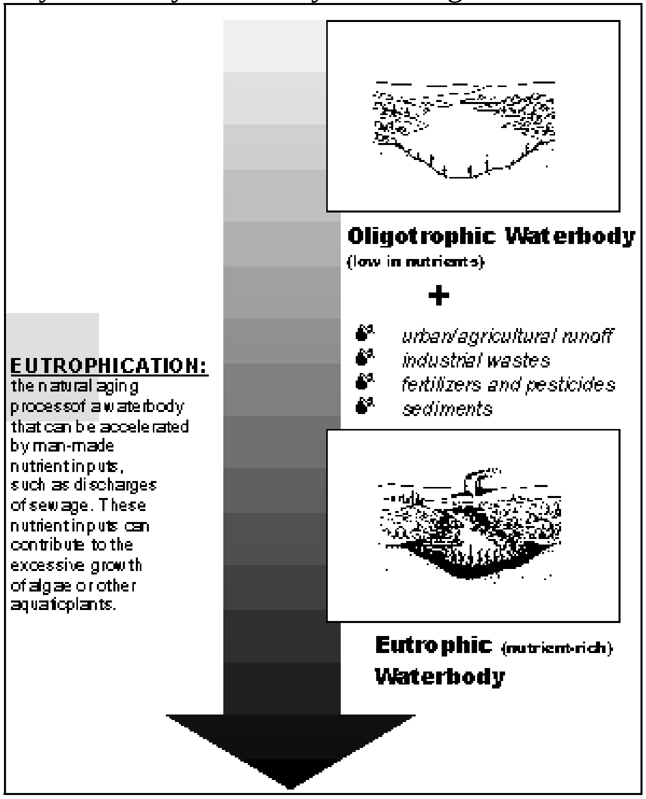

Figure 1. Trophic States

Eutrophication is a natural process, and is not necessarily indicative of man-made pollution. In fact, some lakes are thought to be "naturally" productive. It is important to understand that trophic classifications are not interchangeable with assessments of water quality. The condition of a lake may be viewed as degraded by one person but may be viewed by others as harmless or even beneficial. For example, a eutrophic lake may support an excellent warm-water fishery because it is nutrient rich, but a swimmer may describe that same lake as polluted. However, a lake's trophic state is still important because it provides lake managers with a reference point to view changes in a lake's water quality and begin to understand how these changes may cause **use impairments** (threaten the use of a lake for swimming, potable or irrigation water or fishing)**.** Changes in trophic status, particularly over a short period, may be ecologically stressful and represent progression toward water quality degradation.

When human activities accelerate lake eutrophication, it is referred to as **cultural eutrophication**. Cultural eutrophication, caused by shoreline erosion, agricultural and urban runoff, wastewater discharges or septic seepage, and other nonpoint source pollution sources are examples of activities that greatly accelerate the natural aging process of lakes, and significantly impair the water quality and value of a lake. These changes can cause succession changes in the plant and animal life within the lake, along the shoreline and in the surrounding watershed. They may ultimately extend aquatic plants and emergent vegetation throughout the lake, resulting in the transformation of the lake into a marsh, prairie, and forest. This process naturally occurs over many hundreds to thousands of years, but the extent of cultural eutrophication, and the corresponding pollution problems, can be signaled by significant changes in the trophic state over a short period of time (annual to generational scales).

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 Findley Lake:

Table 2. Trophic Status Indicators

Parameter	Eutrophic	Mesotrophic	Oligotrophic	Findley Lake
Phosphorus (mg/l)	> 0.020	0.010 - 0.020	< 0.010	**0.036**
Chlorophyll a (µg/l)	> 8	2- 8	< 2	**36.3**
Secchi Disk Clarity (m)	2	2- 5	> 5	**1.5**

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. **However, for the purposes of this evaluation, Findley Lake would be considered a clear water lake (color levels below 30 ptu), and thus it can be evaluated using these trophic indicators.** 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 appear limit the measurable clarity in Findley Lake; 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 all of the trophic standards described above, Findley Lake would be considered to be a eutrophic lake.

Aquatic Vegetation

Table 3. Types of Algae

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

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**.

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 Findley Lake have identified the following aquatic plants:

Species	CommonName	Exotic?	Type	Date	Location	%Cover	Abundance
Mspicatum	Eurasian watermilfoil	yes	submergent	8/25/90	site 1-Paradise Bay	4	scarce
M.verticillatum	whorled watermilfoil	no	submergent	8/25/90	site 1-Paradise Bay	6	scarce
M.verticillatum	whorled watermilfoil	no	submergent	8/25/90	site 2-Paradise Bay	4	scarce
M.verticillatum	whorled watermilfoil	no	submergent	8/25/90	site 3-Paradise Bay	1	scarce
N.flexilis	bushy pondweed	no	submergent	8/25/90	site 1-Paradise Bay	90	abundant
N.flexilis	bushy pondweed	no	submergent	8/25/90	site 2-Paradise Bay	96	abundant
N.flexilis	bushy pondweed	no	submergent	8/25/90	site 3-Paradise Bay	99	abundant

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.

The following phytoplankton species have been identified in Findley Lake:

Date: 7/18/92 **Algal Genera:** **Golden-Brown Algae (*Chrysophyta*)- 42%, Diatoms (*Bacillariophyta)*- 36%, Blue-Green Algae (*Cyanophyta*)- 18%**
Algae Species: ***Dinobryon divergens*-(Golden-brown algae) 42%, *Cyclotella planktonica* (diatoms)- 35%, *Gomphosphaeria aponina* (blue-green algae)- 12%**

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 Findley Lake

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 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 Findley Lake

CSLAP NUMBER	24
Lake Name	Findley L
First CSLAP Year	1986
Sampled in 1999?	yes
Latitude	420709
Longitude	794404
Elevation (m)	433
Area (ha)	124.3
Volume Code	12
Volume Code Name	Allegheny/Chemung Rivers
Pond Number	153
Qualifier	none
Water Quality Classification	B
County	Chautauqua
Town	Findley Lake
Watershed Area (ha)	1.24E+03
Retention Time (years	0.50
Mean Depth (m)	3.3
Runoff (m/yr)	0.661596774
Watershed Number	2
Watershed Name	Allegheny River
NOAA Section	9
Closest NOAA Station	Sherman
Closest USGS Gaging Station-Number	3014500
Closest USGS Gaging Station-Name	Chadakoun River at Falconer
CSLAP Lakes in Watershed	Chautauqua L-N, Cuba L, Findley L

Raw Data for Findley Lake

Two **"data sets"** are provided in **Table 5** and **Appendix A.** The data presented in **Table 5** show the entire CSLAP sampling history of Findley Lake, 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 Findley Lake 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 Findley Lake. 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 Findley Lake

Year	Min	Avg	Max	N	Parameter
1986-99	**0.33**	**1.53**	**5.13**	**128**	**CSLAP Zsd**
1999	0.50	0.79	1.19	8	CSLAP Zsd
1998	0.78	1.39	3.13	8	CSLAP Zsd
1997	1.28	2.30	5.13	8	CSLAP Zsd
1996	1.65	2.99	4.75	8	CSLAP Zsd
1995	0.33	0.90	2.00	6	CSLAP Zsd
1994	0.80	1.70	3.63	6	CSLAP Zsd
1993	0.75	1.22	1.50	6	CSLAP Zsd
1992	1.33	1.64	2.00	6	CSLAP Zsd
1991	0.33	0.68	1.00	6	CSLAP Zsd
1990	0.75	1.20	2.50	8	CSLAP Zsd
1989	1.00	2.12	3.25	13	CSLAP Zsd
1988	0.75	1.35	2.25	15	CSLAP Zsd
1987	0.50	1.14	3.00	15	CSLAP Zsd
1986	0.63	1.63	3.13	15	CSLAP Zsd
1985	1.00	2.12	4.00	5	LCI
1976	0.61	0.61	0.61	1	DEC
Year	Min	Avg	Max	N	Parameter
1986-99	**0.011**	**0.036**	**0.082**	**122**	**CSLAP Tot.P**
1999	0.031	0.056	0.081	8	CSLAP Tot.P
1998	0.025	0.046	0.067	2	CSLAP Tot.P
1998	0.211	0.564	0.960	4	CSLAP Hypo TP
1997	0.013	0.026	0.032	8	CSLAP Tot.P
1996	0.013	0.024	0.056	8	CSLAP Tot.P
1995	0.020	0.047	0.082	6	CSLAP Tot.P
1994	0.015	0.036	0.059	6	CSLAP Tot.P
1993	0.030	0.046	0.063	6	CSLAP Tot.P
1992	0.013	0.026	0.035	6	CSLAP Tot.P
1991	0.049	0.061	0.079	6	CSLAP Tot.P
1990	0.037	0.049	0.062	8	CSLAP Tot.P
1989	0.015	0.024	0.038	13	CSLAP Tot.P
1988	0.020	0.032	0.042	15	CSLAP Tot.P
1987	0.018	0.041	0.060	15	CSLAP Tot.P
1986	0.011	0.027	0.039	15	CSLAP Tot.P
1985	0.010	0.011	0.012	3	LCI
1976	0.022	0.022	0.022	1	DEC

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 µmho/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

Table 5 (cont)

Year	Min	Avg	Max	N	Parameter
1986-99	**0.01**	**0.03**	**0.17**	**86**	**CSLAP NO3**
1999	0.01	0.01	0.02	8	CSLAP NO3
1998	0.01	0.04	0.14	7	CSLAP NO3
1997	0.01	0.03	0.10	8	CSLAP NO3
1996	0.01	0.03	0.08	8	CSLAP NO3
1995	0.01	0.01	0.01	1	CSLAP NO3
1994	0.03	0.08	0.12	2	CSLAP NO3
1991	0.01	0.01	0.01	4	CSLAP NO3
1990	0.01	0.01	0.02	6	CSLAP NO3
1989	0.01	0.07	0.14	3	CSLAP NO3
1988	0.01	0.01	0.03	15	CSLAP NO3
1987	0.01	0.03	0.17	9	CSLAP NO3
1986	0.03	0.05	0.12	15	CSLAP NO3
1985	0.01	0.05	0.13	4	LCI
1976	0.02	0.02	0.02	1	DEC
Year	Min	Avg	Max	N	Parameter
1986-99	**2**	**9**	**20**	**124**	**CSLAP TColor**
1999	6	9	12	8	CSLAP TColor
1998	2	7	14	8	CSLAP TColor
1997	7	9	10	8	CSLAP TColor
1996	5	11	20	8	CSLAP TColor
1995	5	7	10	5	CSLAP TColor
1994	4	8	12	6	CSLAP TColor
1993	2	6	7	6	CSLAP TColor
1992	6	8	11	6	CSLAP TColor
1991	7	10	14	5	CSLAP TColor
1990	10	12	17	6	CSLAP TColor
1989	2	8	15	13	CSLAP TColor
1988	6	9	14	15	CSLAP TColor
1987	6	12	15	15	CSLAP TColor
1986	2	9	15	15	CSLAP TColor
1985	5	7	10	5	LCI
1991	35	36	37	7	CSLAP Cond25
1975	28	28	28	1	DEC

Table 5 (cont)

Year	Min	Avg	Max	N	Parameter
1986-99	**6.92**	**7.92**	**9.05**	**127**	**CSLAP pH**
1999	7.21	7.66	8.33	8	CSLAP pH
1998	7.51	8.38	9.05	8	CSLAP pH
1997	7.39	7.85	8.48	8	CSLAP pH
1996	7.84	8.02	8.43	8	CSLAP pH
1995	7.48	7.91	8.16	5	CSLAP pH
1994	7.70	8.01	8.60	6	CSLAP pH
1993	7.75	8.10	8.26	6	CSLAP pH
1992	7.81	8.12	8.34	6	CSLAP pH
1991	7.59	7.91	8.28	6	CSLAP pH
1990	7.24	7.74	8.23	8	CSLAP pH
1989	7.76	8.05	8.24	13	CSLAP pH
1988	7.71	8.02	8.32	15	CSLAP pH
1987	7.14	7.60	8.22	15	CSLAP pH
1986	6.92	7.85	8.98	15	CSLAP pH
1985	7.20	7.67	8.08	5	LCI
1976	7.27	7.27	7.27	1	DEC
Year	Min	Avg	Max	N	Parameter
1986-99	**173**	**210**	**237**	**126**	**CSLAP Cond25**
1999	196	209	227	8	CSLAP Cond25
1998	173	183	194	8	CSLAP Cond25
1997	186	199	207	8	CSLAP Cond25
1996	210	217	225	8	CSLAP Cond25
1995	230	233	237	5	CSLAP Cond25
1994	206	215	224	6	CSLAP Cond25
1993	202	211	216	6	CSLAP Cond25
1992	218	227	237	6	CSLAP Cond25
1991	215	220	224	6	CSLAP Cond25
1990	199	206	222	7	CSLAP Cond25
1989	198	207	214	13	CSLAP Cond25
1988	213	224	234	15	CSLAP Cond25
1987	198	208	221	15	CSLAP Cond25
1986	180	197	215	15	CSLAP Cond25
1985	140	170	200	5	LCI
1976	140	140	140	1	DEC

Table 5 (cont)

Year	Min	Avg	Max	N	Parameter
1986-99	**0.80**	**36.27**	**274.00**	**120**	**CSLAP Chl.a**
1999	19.20	46.73	69.00	8	CSLAP Chl.a
1998	6.32	34.67	57.10	8	CSLAP Chl.a
1997	2.60	15.96	27.80	8	CSLAP Chl.a
1996	3.50	10.53	20.50	8	CSLAP Chl.a
1995	9.86	66.34	172.00	6	CSLAP Chl.a
1994	3.73	26.31	50.30	6	CSLAP Chl.a
1993	15.50	30.75	49.30	6	CSLAP Chl.a
1992	9.18	15.11	28.50	6	CSLAP Chl.a
1991	30.90	98.25	149.00	6	CSLAP Chl.a
1990	9.40	42.39	62.70	7	CSLAP Chl.a
1989	2.16	10.53	19.60	13	CSLAP Chl.a
1988	1.78	23.81	52.50	14	CSLAP Chl.a
1987	17.00	93.94	274.00	11	CSLAP Chl.a
1986	0.80	20.69	53.30	13	CSLAP Chl.a
1985	4.80	10.62	22.70	5	LCI
1976	40.90	40.90	40.90	1	DEC
Year	Min	Avg	Max	N	Parameter
1992-99	**1.0**	**2.9**	**5.0**	**54**	**QA**
1999	3.0	3.4	4.0	8	QA
1998	2.0	3.4	5.0	8	QA
1997	1.0	2.5	3.0	8	QA
1996	1.0	2.1	3.0	7	QA
1995	2.0	3.0	4.0	6	QA
1994	2.0	2.8	4.0	6	QA
1993	2.0	2.8	3.0	6	QA
1992	2.0	2.6	3.0	5	QA
Year	Min	Avg	Max	N	Parameter
1992-99	**2.0**	**2.7**	**4.0**	**54**	**QB**
1999	2.0	2.9	3.0	8	QB
1998	3.0	3.8	4.0	8	QB
1997	2.0	2.9	3.0	8	QB
1996	2.0	2.6	4.0	7	QB
1995	2.0	2.3	3.0	6	QB
1994	2.0	2.2	3.0	6	QB
1993	2.0	2.7	4.0	6	QB
1992	2.0	2.2	3.0	5	QB
Year	Min	Avg	Max	N	Parameter
1992-99	**1.0**	**3.3**	**4.0**	**54**	**QC**
1999	3.0	3.5	4.0	8	QC
1998	4.0	4.0	4.0	8	QC
1997	3.0	3.4	4.0	8	QC
1996	1.0	2.9	4.0	7	QC
1995	2.0	3.0	4.0	6	QC
1994	2.0	3.2	4.0	6	QC
1993	2.0	3.3	4.0	6	QC
1992	2.0	2.6	3.0	5	QC

- **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 artefacts, 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

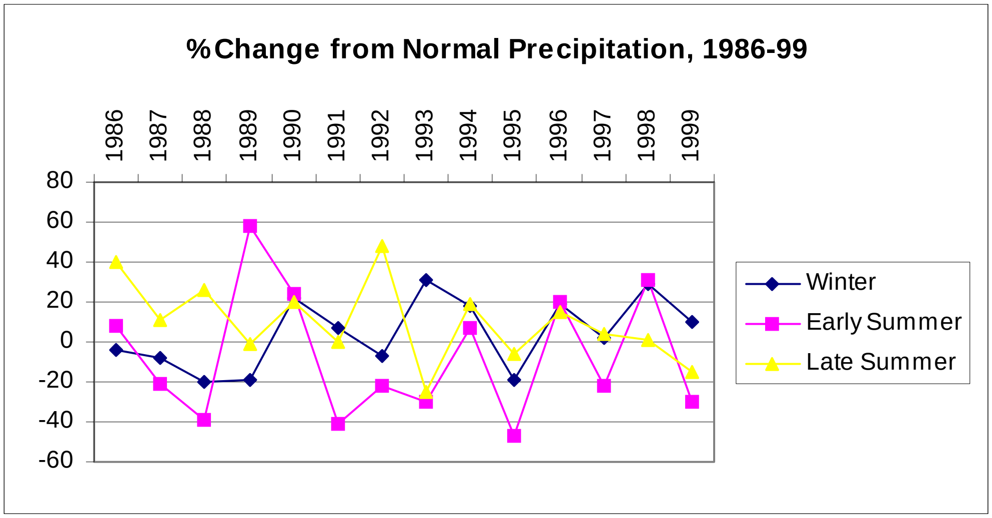

Figure 2. *Comparison of Change in Average NYS Precipitation From Normal Levels During The Winter (Jan-Apr), Early Summer (May-June), and Late Summer (July-August)*

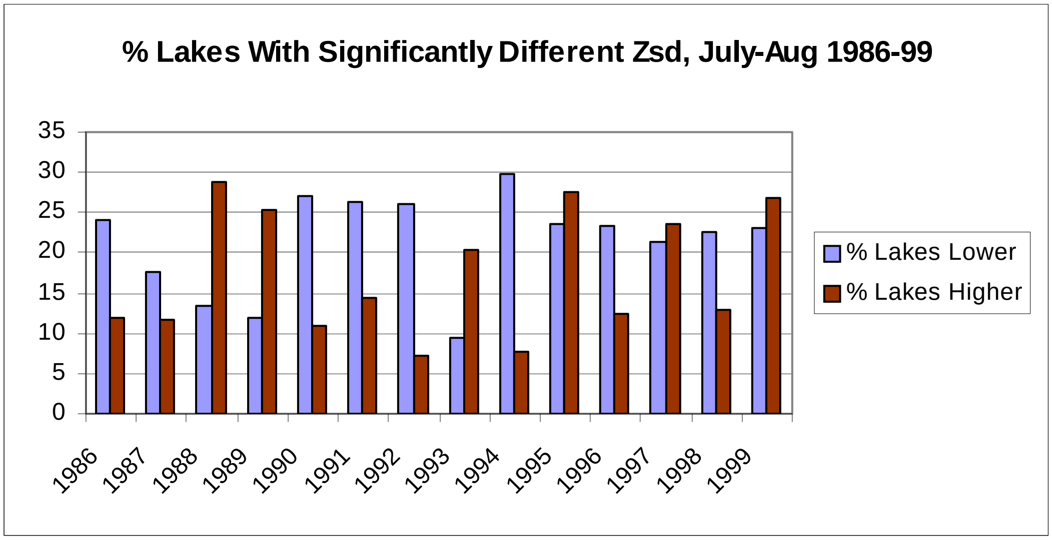

Figure 3. *Changes in Percentage of Lakes With Significant (>1SD) Deviation From 1986-98 Mean Secchi Disk Transparency*

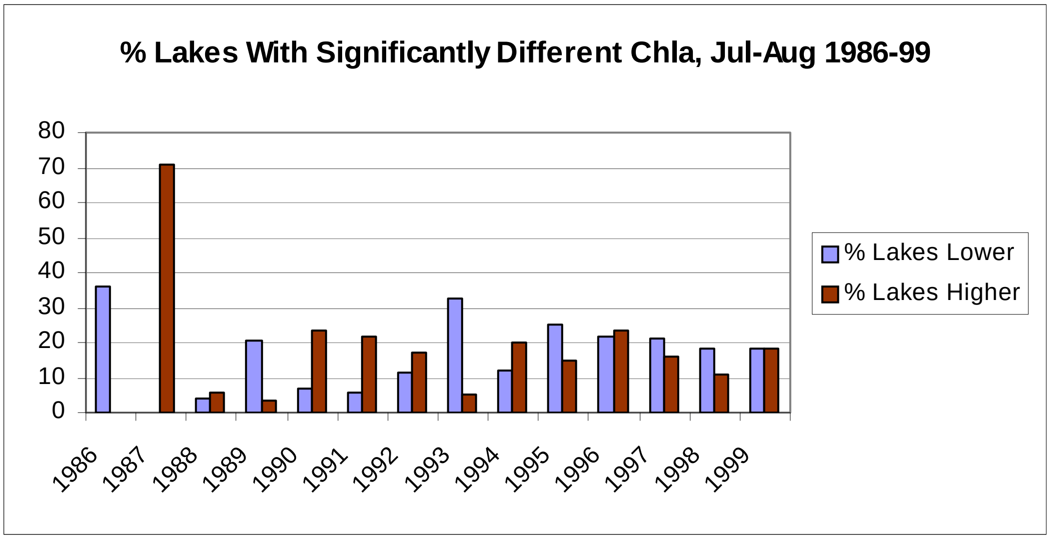

Figure 4. *Changes in Percentage of Lakes With Significant (>1SD) Deviation From 1986-98 Mean Chlorophyll a*

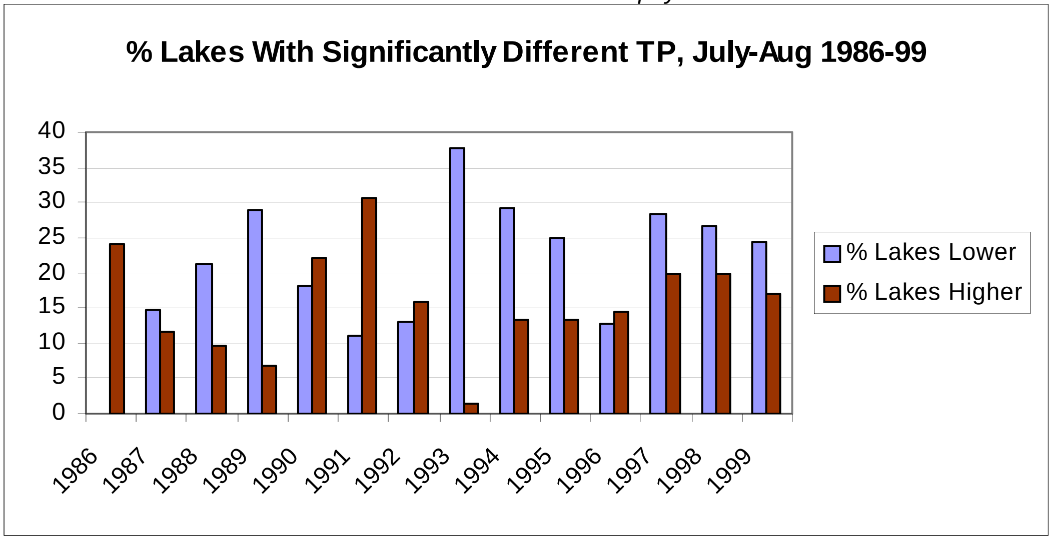

Figure 5. *Changes in Percentage of Lakes With Significant (>1SD) Deviation From 1986-98 Mean Total Phosphorus*

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

< 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 numbers is most likely an Adirondack lake), but this appears largely due to the higher levels of dissolved organic matter (i.e. color) in the typical NYS/Adirondack lake.

The connection between Findley Lake and other nearby lakes or other lakes possessing similar lake uses (i.e. similar water quality classification) will be discussed in more detail below.

Did That Pesky Lab Problem in 1998 Get Resolved?

As noted in the 1998 CSLAP reports, interpretation of the 1998 CSLAP dataset (by itself and via long-term data analysis) is somewhat marred by the potential inaccuracy of phosphorus data analyzed by a second laboratory due to a temporary inability to use the primary laboratory. In general, these data were not used in long term data analyses in 1998, and were used in only a very limited capacity in analyses of the 1998 dataset. Consistent with concerns about the use of a dataset fraught with uncertainty, these data have not been used in this report either. Fortunately, the primary laboratory was again available for use in 1999, and although concerns about overloading the laboratory reduced the amount of deepwater phosphorus monitoring conducted in 1999, the entire phosphorus dataset enjoyed the consistency and accuracy of the primary laboratory. Independent analyses also suggest that the accuracy of the 1999 phosphorus dataset has returned to the high level achieved during all CSLAP sampling sessions prior to 1998 (and the reduced number of 1998 samples, particularly those not collected between late June and early September).

IV. FINALLY….THE SAMPLING RESULTS FOR FINDLEY LAKE

Are There Any Seasonal Trends In The Water Quality Data For Findley Lake?

Seasonal Comparison of Eutrophication Parameters–1999

Figure 6 compares the measured eutrophication indicators for the current season at Findley Lake, while Figures 7 and 8 look at these indicators and at lake perception, respectively, in the historical CSLAP dataset. Figure 9 focuses on typical seasonal changes in hypolimnetic phosphorus samples.

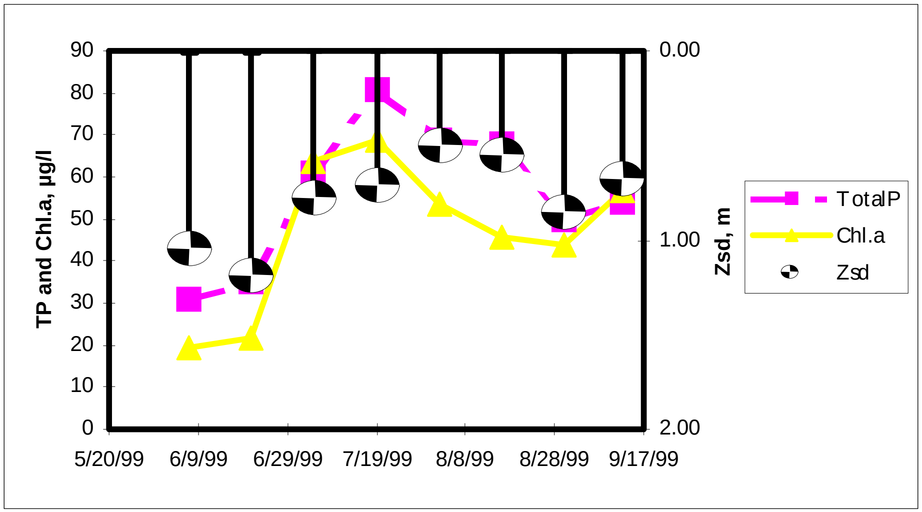

Figure 6. 1999 Eutrophication Data for Findley Lake
This graph illustrates the most recent condition of the lake.

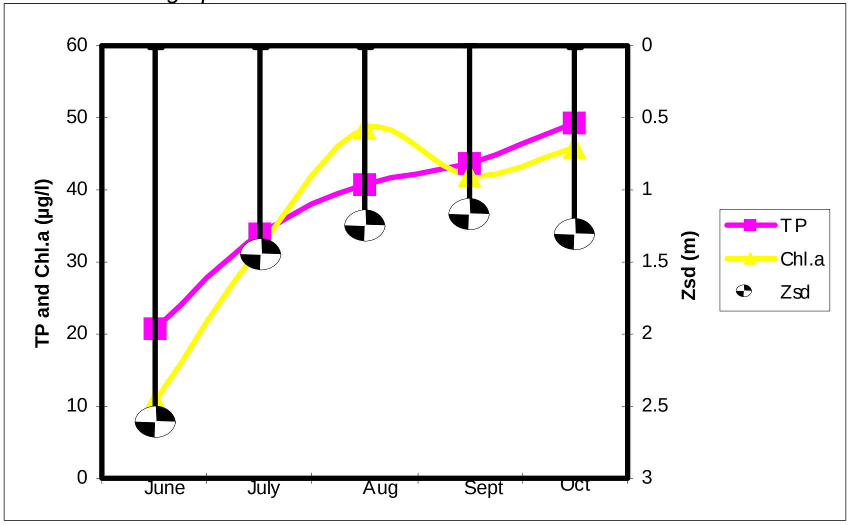

Figure 7. Typical Monthly Averages for Eutrophication Indicators at Findley Lake
This graph shows monthly averages compiled from all sampling seasons at the lake.

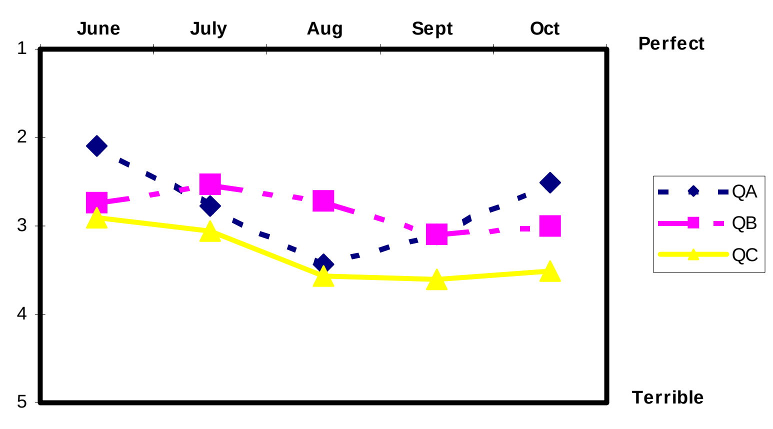

Figure 8. Typical Monthly Averages for Perception Indicators at Findley Lake
This graph shows monthly averages for QA (clarity), QB (weeds), and QC (recreation) for all years

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

a) None of the measured eutrophication parameters demonstrate significant[1] change over the course of the sampling season, although small seasonal changes in water clarity readings (decreasing slightly) and total phosphorus and chlorophyll *a* (slightly increasing) appear to be "internally" consistent.
b) There **appears** to be a strong seasonal correlation[1] between nutrients and algae at Findley Lake, and it is likely that algae growth is often limited by phosphorus concentrations.
c) There **appears** to be a strong seasonal correlation[1] between algae and water clarity at Findley Lake, and it is likely that algae levels frequently control water clarity.
d) There does not appear to be a strong correlation[1] between water color and clarity at Findley Lake, and it is likely that water color does not significantly influence water transparency.
e) Hypolimnetic phosphorus readings are substantially higher than those at the lake surface, particularly just before the lake destratifies ("turns over") in September.

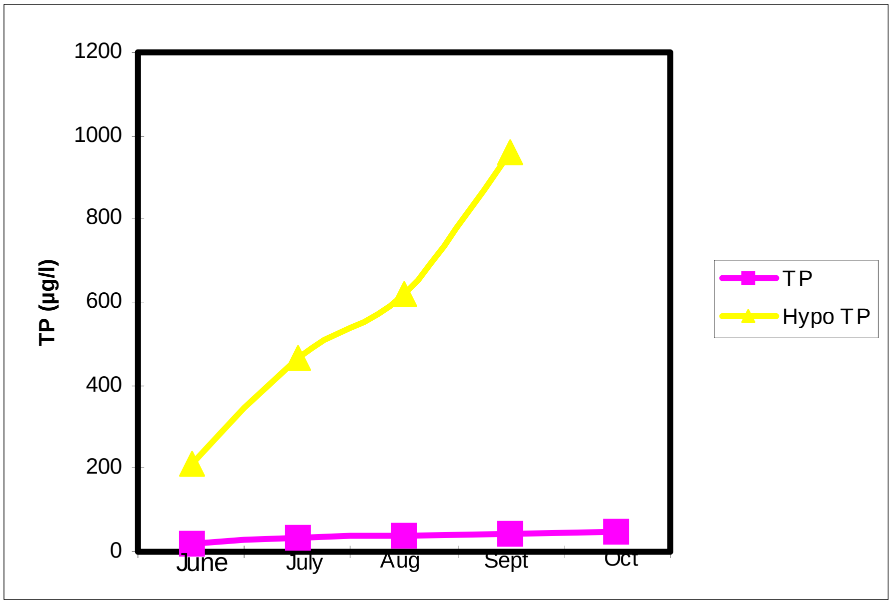

Figure 9. Typical Monthly Averages for Total Phosphorus at the Lake Surface and Hypolimnion

Discussion:
Although the increasing size of the dataset has somewhat dampened the seasonal tendencies noted in some previous CSLAP Annual Reports, there still appears to be a strong connection among the primary eutrophication indicators in Findley Lake. As phosphorus levels increase, algal densities increase, which causes a drop in water clarity. The seasonal tendencies toward increasing phosphorus concentrations at the lake surface are probably linked to the strong seasonal patterns toward increasing bottom (hypolimnetic) nutrient concentrations- increasing algae growth at the lake surface probably causes an rapid drop in hypolimnetic oxygen concentrations, which in turn trigger release of nutrients from bottom sediments, which migrate to the lake surface and renew the cycle. Lake perception (QC in Figure 8) drops over the same period, although this may be in response as much to increasing weed densities (QB in Figure 8) as to decreasing water clarity and less favorable perceptions of the "physical condition" of Findley Lake (QA in Figure 8). These patterns have been apparent during most CSLAP sampling seasons, including 1999.

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[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 1986?

Annual Trends in Eutrophication Parameters and Recreational Assessment

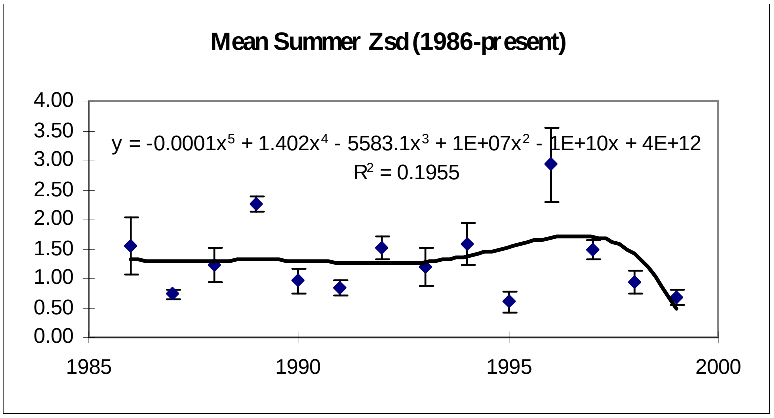

Figure 10
Mean Zsd (Water Clarity), 1986-1999

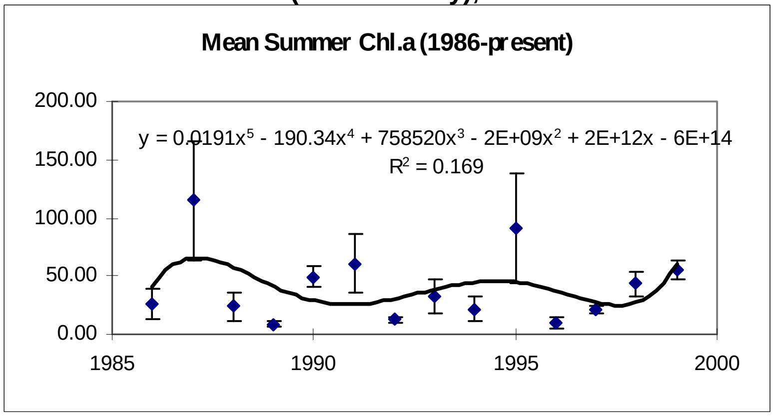

Figure 11
Mean Chl.a, 1986-1999

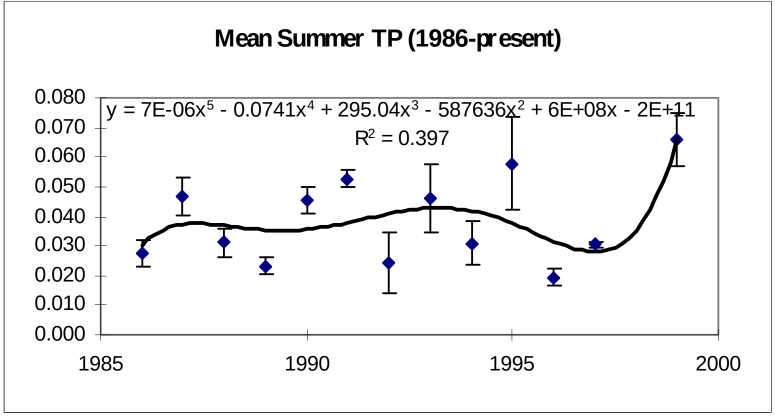

Figure 12
Mean TP, 1986-1999

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. Based on these three graphs, the following conclusions can be made:

a) None of the measured eutrophication parameters have demonstrated significant change since CSLAP sampling began on the lake, although all vary significantly from one year to the next.
b) Although there does not appear to be a strong annual Secchi disk transparency trend (see below), the peaks and valleys in Figure 10 are often (inversely) consistent with those in Figures 11 and 12.
c) The lack of a significant annual chlorophyll *a* pattern may mask a frequent connection between Figures 11 and 12, suggesting that chlorophyll *a* and phosphorus may still be strongly related.
d) The statistically insignificant annual phosphorus change (the multiorder equation in Figure 12 suggests only a moderate statistical association with time) appears to be somewhat related to changes in conductivity over the same period.

Discussion:
As noted above, none of the measured CSLAP eutrophication indicators have demonstrated a significant change since 1986, although all seem to be somewhat related. Phosphorus concentrations do appear to vary somewhat in response to changes in conductivity (increasing phosphorus readings often occurs in years when conductivity is highest), although the sample-to-sample connection between these indicators is not as strong. These data suggest that while the lake conditions vary, often significantly, from one year to the next, there is no indication that the lake is getting significantly better or worse. However, lake perception has degraded somewhat since 1992, and now is frequently assessed as "substantially impaired", in response to increasing weed densities. It is not yet clear if the decision to modify harvesting and introduce weevils into the lake will result in long-term reductions in weed densities.

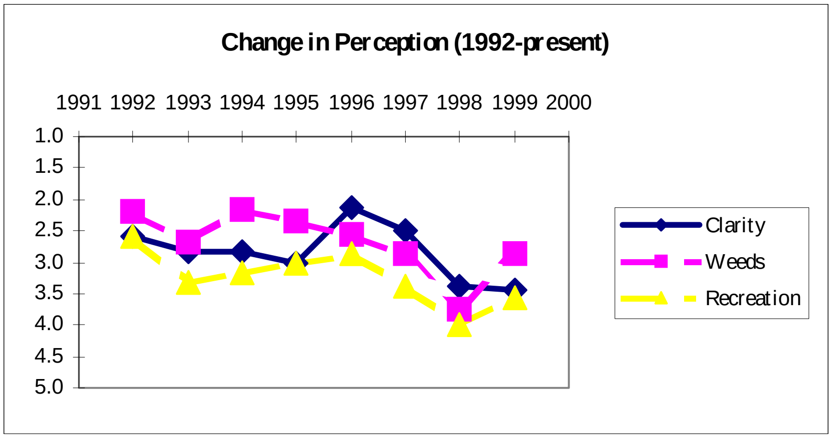

Figure 13
Mean Perception (Clarity, Weeds, and Recreation), 1992-1999

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

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.

Table 9- Trend Assessment for Findley Lake for the Primary Eutrophication Indicators

Indicator	Best Fit Line Correlation Rating (Figures 10-12)	Best Fit Line Slope Relative/Interannual Change Rating (Figures 10-12)	Non-Parametric Rank Correlation Coefficient Rating	Non-Parametric Rank Significance Rating
Secchi Disk:	no trend	no trend	no trend	no trend
Chlorophyll a:	no trend	no trend	no trend	no trend
Total Phosphorus	no trend	no trend	no trend	no trend

Note- Best Fit Line Correlation Rating indicates the Correlation of the Indicator versus Time, using the following code: $R^2 > 0.5$ = significant trend; $R^2 > 0.3$ = moderate trend; $R^2 < 0.3$ = no trend (see Appendix B)

Best Fit Line Slope/Interannual Change Rating indicates Rating of the Best Fit Slope Divided by the Interannual Change (2x Standard Deviation), using the following code—Ratio >1 = significant, Ratio >0.7 = moderate, Ratio < 0.7 = no trend (see Appendix B)

Non-Parametric Rank Correlation Coefficient Rating code: τ (="tau-b") > 0.5 = significant trend; $\tau > 0.3$ = moderate trend; $\tau < 0.3$ = no trend, using a combination (average) of the "raw" or averaged seasonal data (see Appendix B)

Non-Parametric Rank Significance Rating code: < 1% significance = significant trend; <3% significance = moderate trend, > 3% significance = no trend, using a combination (average) of the "raw" or averaged seasonal data (see Appendix B)

The summary in Table 9 suggests that none of the primary eutrophication indicators have demonstrated a consistent annual trend since CSLAP sampling began in 1986, consistent with the observations above.

What About 1999 at Findley Lake?

As reported above, some CSLAP lakes have shown a tendency toward decreasing lake productivity, as manifested in lower nutrient concentrations, decreasing chlorophyll *a* readings, and occasionally higher water clarity. For some lakes, this clearer water resulted in more significant weed growth (either more dense growth or in deeper parts of the lake), while for others the "flip side" of clear water never occurred. For some of these lakes, particularly those with a small watershed relative to the size of the lake, these findings could be linked to a cooler and slightly wetter than normal winter, a drier spring, and/or rainier summer. And for some lakes, the "improvement" was due to other factors, such as changing biological communities or active lake management. Yet for other lakes, these general statewide conditions were not replicated. The following section summaries the 1999 results for Findley Lake, and, where possible, postulates about the cause and/or source of data discrepancies from 1999 to previous CSLAP sampling seasons.

As noted above, the water quality conditions in Findley Lake appear to vary from year to year, and the variability can often be fairly significant. This even appears to be the case when evaluated over a common sampling period, such as July and August only (versus comparing years in which samples may have been collected more frequently after the lake has turned over). It is not clear why conditions vary so significantly from one year to the next. Clearly some of this is related to weather. In the 1990s, nearly every even year was wet and every odd year was dry at the Sherman NOAA meteorological station (1997 was an exception). In the dry years, such as 1999, lake productivity was higher (higher nutrient and algae levels, lower water clarity), while the opposite was generally true in the even years. However, this does not account for many of the year-to-year changes at the lake, and it is likely that the factors influencing water quality in Findley Lake often vary from year to year as well.

Recreational perception of the lake has degraded, largely in response to increasing weed densities. Lake perception does not appear to be as sensitive to year to year variability as water quality changes. This suggests either than water quality variability may be considered commonplace and even normal within moderately sized ranges (thus moderate changes in any of the eutrophication indicators does not result in changes in the perception of the lake), or non-water quality factors also strongly influence lake perception. Weed densities are certainly one of those factors, and the decrease in weed density or coverage in 1999 did appear to positively affect the volunteers' perception of the lake.

The other measured water quality indicators (pH, conductivity, color, nitrate) suggest that Findley Lake continues to possess an adequate pH to support most aquatic organisms, although readings occasionally exceed the upper NYS water quality standard (see below). The lake possesses hard water (though conductivity varies from year to year, though in broader cycles than explainable just by precipitation), and easily maintains an adequate buffering capacity to neutralize all present acidic inputs to the lake. Nitrate concentrations generally decrease over the summer, although peak readings are never particularly high. CSLAP data may not be adequate to assess the role nitrogen plays in algae dynamics in Findley Lake, although these data suggest that the strongest connection is between phosphorus and algal dynamics in the lake. The color readings were low enough to not influence water transparency. Readings for all of these parameters are in the high range (slightly harder water, more biologically productive conditions) for lakes in the area and in this size range.

How does Findley Lake compare to other lakes?

Annual Comparison of Eutrophication Parameters and Recreational Assessment For Findley Lake 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 Findley Lake-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 Findley Lake in 1999:

a) Using water clarity as an indicator, Findley Lake was more productive than other Allegheny River drainage basin lakes, other lakes with the same water quality classification (Class B), and other CSLAP lakes.

b) Using chlorophyll *a* as an indicator, Findley Lake was more productive than other Class B, Allegheny River basin, and other CSLAP lakes.

c) Using total phosphorus concentrations as an indicator, Findley Lake was more productive than other Class B, Allegheny River drainage basin and other CSLAP lakes.

d) Using QC on the field observations form as an indicator, Findley Lake was less suitable for recreation than other Class B, Allegheny River drainage basin lakes, and other CSLAP lakes.

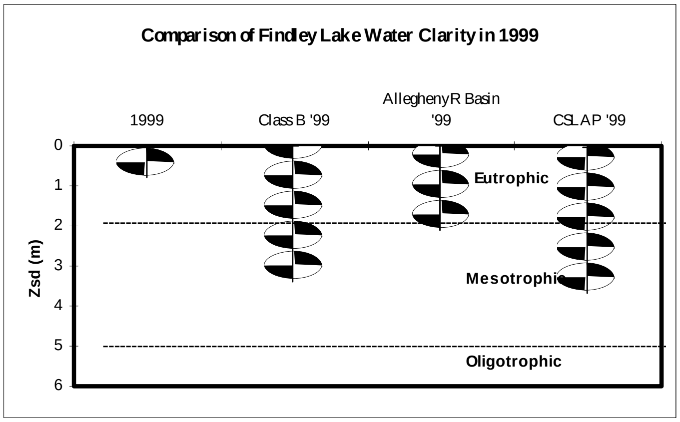

Figure 14. *Comparison of 1999 Secchi Disk Transparency to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other CSLAP Lakes in 1999*

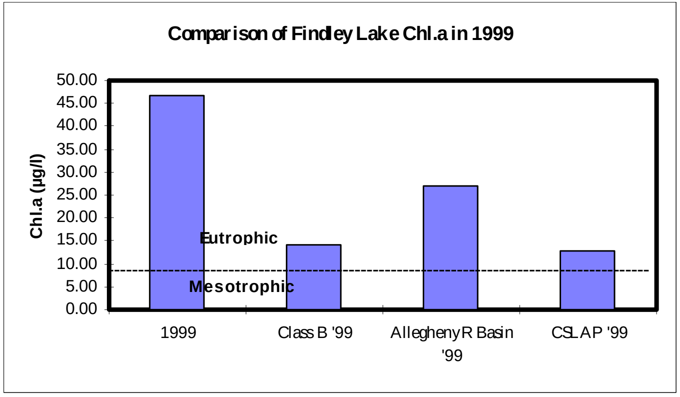

Figure 15. *Comparison of 1999 Chlorophyll a to Lakes with the Same Water Quality Classification, Neighboring Lakes, and Other CSLAP Lakes in 1999*

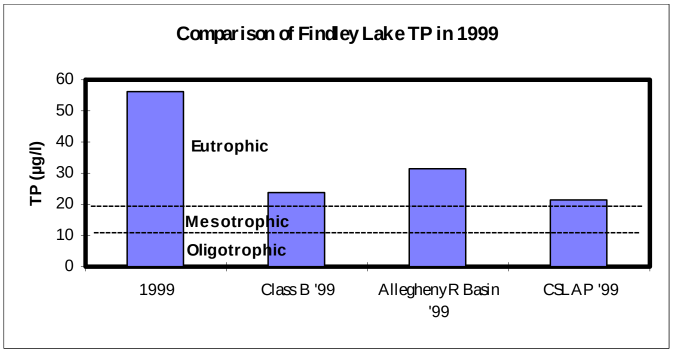

Figure 16. *Comparison of 1999 Total Phosphorus to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other CSLAP Lakes in 1999*

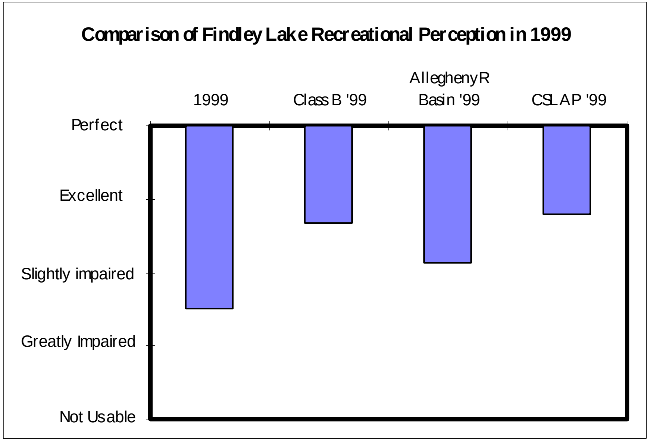

Figure 17. *Comparison of 1999 Recreational Perception*

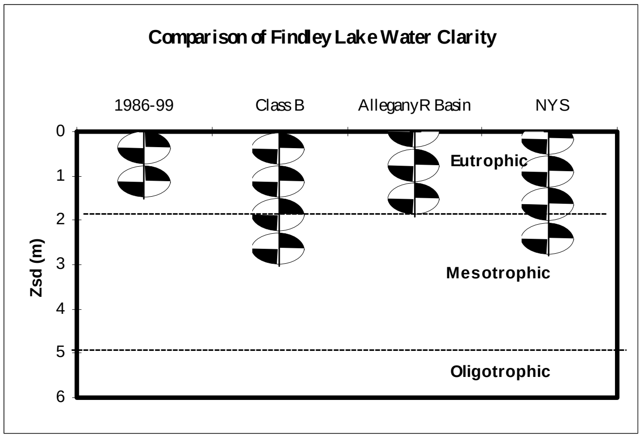

Figure 18. *Comparison of Average Secchi Disk Transparency to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other NYS Lakes*

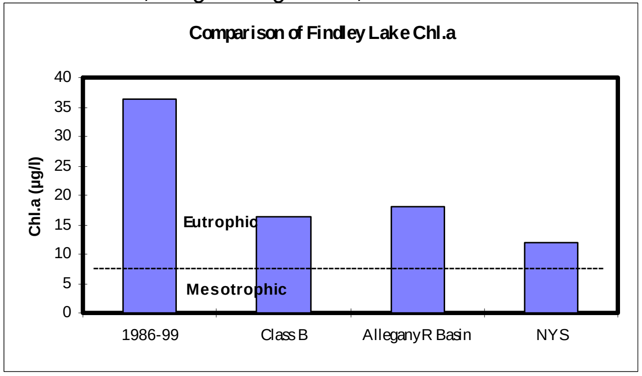

Figure 19. *Comparison of Average Chlorophyll a to Lakes with the Same Water Quality Classification, Neighboring Lakes, and Other NYS Lakes*

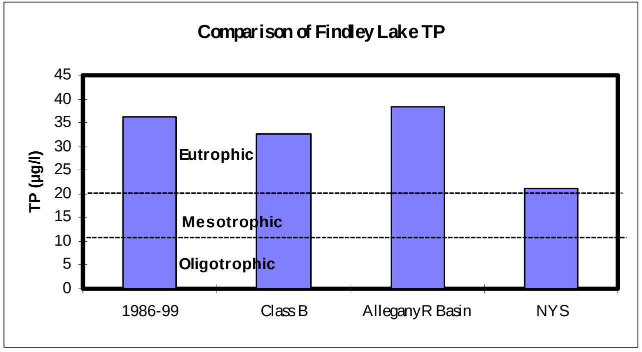

Figure 20. *Comparison of Average Total Phosphorus to Lakes With the Same Water Quality Classification, Neighboring Lakes, and Other NYS Lakes*

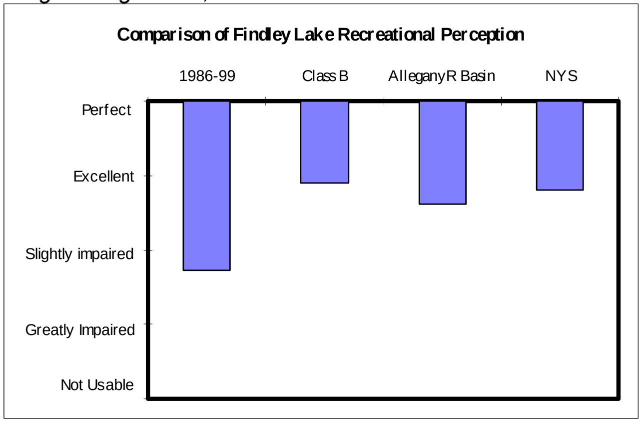

Figure 21. *Comparison of Average Recreational Perception*

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 Findley Lake overall can be postulated:

a) Using water clarity as an indicator, Findley Lake is more productive than other Allegheny River drainage basin lakes, other lakes with the same water quality classification (Class B), and other NYS lakes.
b) Using chlorophyll *a* as an indicator, Findley Lake is more productive than other Class B, Allegheny River basin, and other NYS lakes.
c) Using total phosphorus concentrations as an indicator, Findley Lake is about as productive as other Allegheny River drainage basin lakes, but more productive than other Class B and other NYS lakes.
d) Using QC on the field observations form as an indicator, Findley Lake is more suitable for recreation than other Class B, Allegheny River drainage basin lakes, and other NYS lakes.

Discussion:
The unfavorable recreational assessment of Findley Lake is consistent with the water quality conditions in the lake, and the high levels of weed growth in the lake. It is not yet known if reducing weed growth (an actively lake management objective in Findley Lake) will result in improved recreational assessments of Findley Lake.

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.

The upper pH water quality standard was exceeded in Findley Lake CSLAP samples during 5 of the 129 sampling sessions (4% of all sampling sessions)- this is common in highly productive lakes. While these exceedences have occurred more frequently in recent years, none occurred in 1999. The state phosphorus guidance value was exceeded during 110 of the 129 sampling sessions (85%). The minimum allowable water transparency for swimming beaches (=1.2 meters) was not achieved during 63 sampling sessions (53% of the time), although some of these "violations" occurred during times of the year when swimming was less likely. It is not known if the narrative water quality standards listed in Figure 22 have been violated at Findley Lake.

Findley Lake is presently among the lakes listed on the PWL, with *aesthetics*, *fishing*, and *fish survival* identified as *impaired* as a result of excessive nutrients and weeds. The CSLAP dataset is inadequate to evaluate fishing and many components associated with fish survival. However, this data set suggests that the present PWL listings for *aesthetics* and *fish survival* appear to be adequate, the latter due to the likely problem of low dissolved oxygen (in the hypolimnion, based on odors and the extremely high hypolimnetic phosphorus readings). In addition, this dataset suggests that *bathing* is *impaired* and *boating/recreation* is *stressed* as a result of excessive algae growth and nuisance weed growth, the latter (and perhaps the former) associated with excessive nutrient loading to and within the lake. However, since PWL listings often involve far more than CSLAP data, these "recommendations" should be evaluated within the context of all water quality data and other information necessary to evaluate potential PWL designations for the lake.

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	Swimming

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**

Problem	Probable cause	Probable source
Poor water clarity	Excessive algae	**Excessive phosphorus loading** from septics, watershed runoff (stormwater, construction sites, agriculture, ...)

Discussion:
The water sampling results indicate that recreational impairments in this lake are related to lower-than-desired water transparency. The CSLAP data suggest that water clarity in this lake appears to be related to excessive densities of planktonic algae. A management focus to improve water clarity involves reducing algae levels, which is linked (and confirmed through CSLAP) to reducing nutrient concentrations in the lake and within the watershed. These considerations do not constitute recommendations, since it is not known if the lake association is attempting to improve water clarity, but these considerations are a discussion of some management alternatives which may have varying levels of success addressing these problems.

POTENTIAL IN-LAKE CONTROLS

The strategies outlined below primarily address the cause, but not the ultimate source, of problems related to poor water clarity. As such, their effectiveness is necessarily short-term, but perhaps more immediately realized, relative to strategies that control the source of the problem. The problems may continue or worsen if the source of the problem, excessive nutrients, is not addressed, using strategies such as those described under **Watershed Controls** below. In-lake controls are listed in order of frequency of use in the "typical" NYS lake: *copper sulfate, precipitation/inactivation, hypolimnetic withdrawal, aeration, dilution/flushing, artificial circulation*, and *food web manipulation*.

- *Copper sulfate* is an algacide that is frequently used to control nuisance levels of planktonic algae (dots of algae throughout the water column) or filamentous algae (mats of algae on the lake surface, weeds, or rocks) throughout the lake. It is usually applied 1-3x per summer in granular or liquid form, usually by a licensed applicator. Many people feel that it is effective at reducing algae levels to below nuisance conditions, others feel it only "flattens the peak" of the worst blooms, and still others think it is merely a placebo, given the short – lived dominance of some phytoplankton species. There are concerns about the long-term affect of copper on the lake bottom, including the effects on bottom macroinvertebrate communities, and implications of increasing the concentrations of copper as a component of bottom sediments. Another concern is a possible deleterious affect of copper on the zooplankton (microscopic animals that feed on algae) community, which could, in some lakes, ultimately cause a “bounce-back” algae bloom that is worse than the original bloom. **It is not known to what extent copper products have been used for algae control at Findley Lake.**

- *Precipitation/Inactivation* involves adding a chemical binding agent, usually alum, to bind and precipitate phosphorus, removing it from the water column, and to seal bound phosphorus in the sediment, rendering it inactive for release to the overlying water (as often occurs in stratified lakes with low oxygen levels). It has a mixed rate of success in NYS, although when successful it usually provides long-term control of nutrient release from bottom sediments (it is only a short-term method for removing existing phosphorus from the water column). It is not recommended for lakes with low pH or buffering capacity (like most small NYS lakes at high elevation), for at low pH, aluminum can be toxic to fish. Since CSLAP does not conduct extensive deepwater monitoring, or any sediment release rate studies, the efficacy of this strategy, based on CSLAP data, is not known. **Findley Lake is sufficiently deep to consider using this method.**

- *Hypolimnetic withdrawal* takes deoxygenated, high nutrient water from the lake bottom and discharges the water downstream from the lake. This strategy is sort of a hybrid of aeration and dilution/flushing, and is usually limited to lakes in which control structure (such as a dam) exists where the release valve is located below the thermocline. It has been quite successful and usually inexpensive when applied properly, but must only be employed when downstream waterbodies will not be adversely impacted by the pulse of low oxygen water (which may include elevated levels of hydrogen sulfide, ammonia, and iron). **The dam at Findley Lake is not configured to release water from the hypolimnion.**

- *Aeration* involves pumping or lifting water from the lake bottom (hypolimnion) for exposure to the atmosphere, with the oxygenated waters returning to the lake bottom. The airlift device is usually quite expensive, and operating costs can be quite high. There is also a risk of breaking down the thermocline, which can result in an increase in algae levels and loss of fish habitat for many cold-water species. However, most of the limited number of aeration projects have been quite successful. Since CSLAP does not collect dissolved oxygen data for most program lakes, it is not definitively known whether aeration (or hypolimnetic withdrawal) would benefit this lake. *Artificial circulation* is the process by which air is injected into the hypolimnion to eliminate thermal stratification- it is aeration by circulation.

- *Dilution/flushing* involves using high quality dilution water to reduce the concentration of limiting nutrients and increase the rate at which these nutrients are flushed through the lake. This strategy requires the availability of high quality dilution water and works best when the lake is small, eutrophic, and no downstream waterbodies that may be affected by the pulse of nutrients leaving the lake. For these lakes, high quality dilution water is probably not available from the surrounding watershed, because such an input would already be flushing the lake. **It is unlikely that there is a sufficient nearby source of high quality water to flush Findley Lake.**

- *Food web manipulation* involves altering the population of one component within the food web, most frequently algae, by altering the populations of other components in the same web. For algae control, this would most frequently involve stocking the lake with herbivorous (algae-eating) fish, but this may be at the expense of other native fish. While this procedure has worked in some situations, as with most attempts at biomanipulation, altering the food chain may be risky to the whole ecosystem, and not recommended at lakes in which the native fisheries serve as a valuable local resource.

POTENTIAL WATERSHED CONTROLS

These strategies are directed to controlling the source of the problem, with the goal of reducing the nutrient loading to the lake. Implementation of these strategies usually takes much longer than in-lake controls, and the apparent visibility of the improvements may be delayed, but the long term benefits are often more apparent. *Controls include monitoring, nutrient control, land use controls to limit urban runoff, limiting use of lawn fertilizers, and reducing waterfowl feeding.*

Monitoring may be necessary to quantify the problem and pinpoint the source of pollutants. This may be quantitative (water quality data in tributaries or near-shore areas), semi-quantitative (use of biological indicators to determine stressed stream segments), or qualitative (windshield surveys and stream walks to identify suspect areas).

Nutrient controls can take several forms, depending on the original source of the nutrients:

- Septic systems can be regularly pumped or upgraded to reduce the stress on the leach fields which can be replaced with new 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 can be expensive, but may be necessary to handle the increased loading from 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. **It is not known by the report authors if any septic management strategies have been employed in the Findley Lake watershed.**
- 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. 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. **It is not known by the report authors if stormwater control strategies have been employed at Findley Lake.**
- There are numerous agriculture management practices such as fertilizer controls, soil erosion practices, and control of animal wastes, which either reduce nutrient export or retain particles lost from agricultural fields. 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.
- 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 include: floodplain management, development contained in "clusters" within less environmentally-sensitive areas in the watershed; restricted access to the lake as contained within deeds or regulations, setback requirements for dwellings, and restrictions for cuttings, used to reduce pollutant loading to lakes. This 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

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

Problem	Probable Cause	Probable Source
Moderate to Excessive weed growth	Shallow water depth, excessive nutrients and sediment	Excessive pollutant loading from watershed runoff (stormwater, construction sites, agriculture, etc.), septics, bottom disturbance,...

Perception data indicate that aquatic weed growth is perceived to inhibit recreational use of this lake, at least in some parts of the lake or during certain times of the year. Nuisance weed growth in lakes is influenced by a variety of factors- water clarity, sediment characteristics, wave action, competition between individual plant species, sediment nutrient levels, etc. In most cases, excessive weed growth is associated with the presence of exotic, (non-native) submergent plant species such as Eurasian watermilfoil (*Myriophyllum spicatum*), although some lakes are inhibited by dense growth of native species. Some of these factors cannot be controlled by lake association activities, while others can only be addressed peripherally. For example, sediment characteristics can be influenced by the solids loading to the lake. With the exception of some hand harvesting activities, aquatic plant management should only be undertaken when lake uses (recreational, municipal, economic, etc.) are significantly and regularly threatened or impaired. Management strategies can be costly and controversial, and a variety of factors should be weighed. Aquatic plant management most efficiently involves a mix of immediate, in-lake controls, and long-term measures to address the causes and sources of this excessive weed growth.

Findley Lake has been harvested to control Eurasian watermilfoil. In 1999, an experimental stocking of herbivorous weevils was undertaken- at this point, it is too early to evaluate the results from this study.

IN –LAKE CONTROL TECHNIQUES

The following strategies primarily address the cause, but not the ultimate source, of problems related to nuisance aquatic plant growth. As such, their effectiveness is necessarily short-term, but perhaps more immediately realized, than strategies that control the source of the problem. Until the sources of the problem are addressed, however, it is likely that these strategies will need to be continuously employed. Some of these are listed in the **Watershed Controls**, since many of the same pollutants contribute to excessive algae growth as well as nuisance weed growth. Except where noted, most of these in-lake techniques do not require permits in most parts of the state, but, as always, the NYDEC Regional Offices and the Adirondack Park Agency should be consulted before undertaking these strategies. These techniques are presented within the context of potential management for the conditions (types of nuisance plants, extent of problem) reported through CSLAP. In-lake control methods include*: physical/mechanical plant management techniques, chemical plant management techniques, and biological plant management techniques*

Physical/mechanical control techniques utilize several modes of operation to remove or reduce the growth of nuisance plants. The most commonly employed procedures are the following:

- *Mechanical harvesters* physically remove rooted aquatic plants by using a mechanical machine to cut and transport plants to the shore for proper storage. Mechanical harvesters are probably the most common "formal" plant management strategy in New York State. While it is essentially akin to "mowing the (lake) lawn", it usually provides access to the lake surface and may remove some lake nutrients if the cut plants are disposed out of the watershed. However, if some shallow areas of the lake are not infested with weeds, they will likely become infested after mechanical harvesting, since fragments frequently wander from cut areas to barren sediment and colonize new plant communities. Harvesters are very expensive, but can be rented or leased. *Rotovators* are rotovating mechanical harvesters, dislodging and removing plants and roots. *Mechanical cutters* cut, but don't remove, vegetation or fragments. Box springs, sickles, cutting bars, boat props, and anchors often serve as mechanical cutters. **This strategy has been employed at Findley Lake.**
- *Hand harvesting* is the fancy term for lake weeding- pulling out weeds and the root structure by hand. It is very labor intensive, but very plant selective (pull the "weeds", leave the "plants"); and can be effective if the entire plant is pulled and if the growth area is small enough to be fully cleared of the plant. *Diver dredging* is like hand harvesting with a vacuum cleaner- in this strategy, scuba divers hand-pull plants and place them into a suction hose for removal into a basket in a floating barge. It is also labor intensive and can be quite expensive, but it can be used in water deeper than about 5ft (the rough limit for hand harvesting). It works best where plant beds are dense, but is not very efficient when plant beds or stems are scattered. **It is certain that this strategy is regularly employed by individual shoreline owners at Findley Lake.**
- *Water level manipulation* is the same thing as *drawdown*, in which the lake surface is lowered, usually over the winter, to expose vegetation and sediments to freezing and drying conditions. Over time this affects the growing characteristics of the plants, and in many cases selectively eliminates susceptible plants. This is obviously limited to lakes that have a mechanism (dam structure, controlled culvert, etc.) for manipulating water level. It is usually very inexpensive, but doesn't work on all plants and there is a risk of insufficient lake refill the following spring (causing docks to be orphaned from the waterfront). **It is not believed by the report authors that Findley Lake can be sufficiently drawn down to utilize this technique.**
- *Bottom barriers* are screens or mats that are placed directly on the lake bottom to prevent the growth of weeds by eliminating sunlight needed for plant survival. The mats are held in place by anchors or stakes, and must be periodically cleaned or removed to detach any surface sediment that may serve as a medium for new growth. The mats, if installed properly, are almost always effective, with

relatively few environmental side-effects, but are expensive and do not select for plant control under the mats. It is best used when plant communities are dense but small in area, and is not very efficient for lake-wide control.

- *Sediment removal*, also referred to as dredging, controls aquatic plants by physically removing vegetation and by increasing the depth of the lake so that plant growth is limited by light availability. Dredging projects are usually very successful at increasing depth and controlling vegetation, but they are very expensive, may result in significant side effects (turbidity, algal blooms, potential suspension of toxic materials), and may require significant area for disposal. This procedure usually triggers an extensive permitting process.

Chemical control techniques involve the use of aquatic herbicides to kill undesired aquatic vegetation and prevent future nuisance weed growth. These herbicides come in granular or liquid formulations, and can be applied in spot- or whole-lake treatments. Some herbicides provide plant control by disrupting part of the plants life cycle or ability to produce food, while others have more toxicological effects. Aquatic herbicides are usually effective at controlling plants, but other factors in considering this option include the long term control (longevity), efficiency, and plant selectivity. Effectiveness may also depend on dosage rate, extent of non-target (usually native) plant growth, flushing rate, and other factors. The use of herbicides is often a highly controversial matter frequently influenced by personal philosophies about introducing chemicals to lakes. Some of the more recently registered herbicides appear to be more selective and have fewer side effects than some of the previously utilized chemicals. Chemical control of nuisance plants can be quite expensive, and, with only few exceptions, require permits and licensed applicators. **Herbicides have historically been used at Findley Lake (at least the 1950s), although it is not known if they are still being considered for use given the efforts devoted to biological control and harvesting.**

Biological control techniques presently involve the stocking of sterile grass carp, which are herbivorous fish that feed exclusively on macrophytes (and macroalgae). Grass carp, when stocked at the appropriate rate, have been effective at controlling nuisance weeds in many southern states, although their track record in NYS is relatively short, particularly in lakes with shallow or adjacent wetlands or in larger (>100 acre) lakes. These carp may not prefer the nuisance plant species desired for control (in particular Eurasian watermilfoil), and they are quite efficient at converting macrophyte biomass into nutrients that become available for algae growth. This is, however, one of the less expensive means of plant control.

Naturally occurring biological controls may include native species of *aquatic weevils and moths* which burrow into and ultimately destroy some weeds. 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 a severe negative impact on the population. Research continues about their natural occurrence, and their effectiveness both as a natural or deliberately- introduced control mechanism for Eurasian watermilfoil. **Herbivorous weevils are found in large quantities in Findley Lake, and were also commercially stocked in 1999.**

WATERSHED ACTIVITIES CONTROL TECHNIQUES

The primary watershed “pollutant” contributing to nuisance aquatic weed growth is probably sediment and silt, particularly since these particles frequently carry nutrients that are necessary for aquatic plant growth. Watershed controls include: monitoring, sediment control, land use controls to limit urban runoff, cleaning boat props, discouraging the feeding of waterfowl, and “weed watcher” signs. These strategies are effective at controlling the source of the problem, and thus afford more long-term relief. Implementation of these strategies usually takes much longer than in-lake controls.

Boat propellers frequently get entangled by weeds and weed fragments. Propellers not cleaned after leaving an “infected” lake or before entering an “uncontaminated” lake may introduce plant fragments to the lake. This is a particular management consideration because many nuisance plant species spread by propagation, requiring only a fragment of the plant to grow**.**

Waterfowl introduce nutrients, plant fragments, and bacteria to the lake water through their feces. Encouraging the congregation of waterfowl by feeding 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.

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.

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

LNum	PName	Date	Zbot	Zsd	Zsamp	Tot.P	NO3	TColor	pH	Cond25	Chl.a	TAir	TH20	QA	QB	QC	QD
24	Findley L	6/15/86	11.5	3.00	1.5	0.026	0.12	5	6.92	190	2.22	18	19				
24	Findley L	6/21/86	11.5	3.13	1.5	0.013	0.11	5	7.50	180	2.29	23	20				
24	Findley L	6/29/86	11.5	2.25	1.5	0.011	0.09	10	7.62	185	2.00	22	21				
24	Findley L	7/3/86	11.5	2.75	1.5	0.022	0.11	15	7.82	194	0.80	15	20				
24	Findley L	7/11/86	11.5	2.00	1.5	0.021	0.03	2	7.84	185	5.03	15	20				
24	Findley L	7/18/86	11.5	1.50	1.5	0.030	0.06	5	8.38	194		30	24				
24	Findley L	7/24/86	11.5	2.63								30	25				
24	Findley L	8/1/86	11.5	1.63	1.5	0.028	0.03	14	8.05	197		26	24				
24	Findley L	8/5/86	11.5	1.13	1.5	0.018	0.03	11	7.75	191	53.30	26	25				
24	Findley L	8/12/86			1.5	0.023	0.03	13	8.15	199	15.30						
24	Findley L	8/16/86	11.5	0.75	1.5	0.035	0.03	12	8.98	195	36.30	24	24				
24	Findley L	8/21/86	11.5	0.63	1.5	0.037	0.03	15	8.12	198	40.00	26	25				
24	Findley L	8/30/86	11.5	1.00	1.5	0.034	0.03	3	7.60	205	29.60	20	19				
24	Findley L	9/5/86	11.5	0.75	1.5	0.033	0.03	3	8.17	206	25.90	21	20				
24	Findley L	9/14/86	11.5	0.63	1.5	0.036	0.03	13	7.55	215	22.20	14	19				
24	Findley L	9/21/86	11.5	0.75	1.5	0.039	0.03	8	7.29	214	34.00	17	18				
24	Findley L	6/8/87	11.5	2.75	1.5	0.023	0.03	15	8.10	201		22	24				
24	Findley L	6/14/87	11.5	3.00	1.5	0.018		12	8.22	198		25	22				
24	Findley L	6/21/87	11.5	2.00	1.5	0.023	0.01	15	7.83	203	17.00	27	25				
24	Findley L	6/28/87	11.8	1.25	1.5	0.021	0.01	15	7.76	202	37.70	19	23				
24	Findley L	7/5/87	11.8	0.75	1.5	0.032	0.01	11	7.70	206		23	23				
24	Findley L	7/12/87	11.5	0.63	1.5	0.033		11	7.86	206	116.00	30	27				
24	Findley L	7/19/87	11.5	0.75	1.5	0.040	0.01	15	7.49	206	109.00	27	26				
24	Findley L	7/26/87	11.5	1.00	1.5	0.052		13	7.63	209	45.10	24	27				
24	Findley L	7/30/87	11.5	0.75	1.5	0.056		12	7.38	210	73.30	25	27				
24	Findley L	8/9/87	11.5	0.75	1.5	0.042	0.01	7	7.33	208	116.00	24	24				
24	Findley L	8/16/87	11.5	0.50	1.5	0.060		6	7.14	216	274.00	27	27				
24	Findley L	8/23/87	11.5	0.75	1.5	0.054	0.01	10	7.42	208		18	22				
24	Findley L	8/30/87	11.5	0.75	1.5	0.052		12	7.46	204	73.00	21	20				
24	Findley L	9/6/87	11.5	0.75	1.5	0.059	0.17	8	7.36	221	99.00	19	19				
24	Findley L	10/1/87	11.5	0.75	1.5	0.049	0.03	11	7.30	215	73.20	14	17				
24	Findley L	6/21/88	12.0	2.25	1.5	0.022	0.01	8	7.72	213	17.50	25	24				
24	Findley L	6/28/88	11.5	1.75	1.5	0.022	0.01	7	7.77	219	10.10	20	24				
24	Findley L	7/5/88	11.5	1.50	1.5	0.020	0.01	9	8.10	220	10.40	29	25				
24	Findley L	7/12/88	11.0	1.00	1.5	0.023	0.01	11	8.19	234		28	27				
24	Findley L	7/19/88	11.5	1.00	1.5	0.025	0.01	7	8.31	223	20.70	26	28				
24	Findley L	7/26/88	12.0	1.50	1.5	0.029	0.01	10	7.71	221	1.78	26	25				
24	Findley L	7/31/88	11.5	1.25	1.5	0.031	0.01	10	8.10	223	17.80	24	26				
24	Findley L	8/8/88	11.5	1.00	1.5	0.037	0.01	11	7.97	219	31.10	27	28				
24	Findley L	8/12/88	11.5	0.75	1.5	0.042	0.01	10	7.96	221	52.50	26	27				
24	Findley L	8/21/88	11.8	0.75	1.5	0.042	0.01	6	8.32	227	49.60	20	25				
24	Findley L	8/30/88	11.5	2.25	1.5	0.032	0.02	11	7.97	227	10.10	18	23				
24	Findley L	9/6/88	11.3	1.75	1.5	0.037	0.03	14	7.86	227	18.50	15	20				
24	Findley L	9/12/88	11.5	1.50	1.5	0.035	0.03	12	7.95	229	24.40	24	20				
24	Findley L	9/19/88	11.8	1.00	1.5	0.040	0.01	8	8.09	230	38.50	24	20				
24	Findley L	9/25/88	11.8	1.00	1.5	0.039	0.01	6	8.27	227	30.30	24	18				
24	Findley L	6/26/89	11.0	3.25	1.5	0.017	0.14	7	7.94	198	2.16	29	27				
24	Findley L	7/2/89	11.0	2.25	1.5	0.015		12	7.98	199	18.50	22	23				
24	Findley L	7/9/89	11.0	2.25	1.5	0.022		15	7.76	204	6.45	27	25				
24	Findley L	7/16/89	11.5	2.50	1.5	0.020		11	7.85	210	6.18	25	24				
24	Findley L	7/27/89	11.5	2.50	1.5	0.025		10	8.13	200	9.77	27	25				
24	Findley L	7/31/89	11.0	2.00	1.5	0.026		8	7.82	210	6.36	21	24				
24	Findley L	8/7/89	10.5	2.50	1.5	0.029	0.06	8	8.18	214	7.19	17	23				

LNum	PName	Date	Zbot	Zsd	Zsamp	Tot.P	NO3	TColor	pH	Cond25	Chl.a	TAir	TH20	QA	QB	QC	QD
24	Findley L	8/14/89	11.3	2.00	1.5	0.020		7	7.98	211	6.45	24	22				
24	Findley L	8/20/89	11.5	2.00	1.5	0.024		2	8.24	212	6.65	20	23				
24	Findley L	8/29/89	11.5	2.25	1.5	0.028		2	8.24	208	11.30	26	24				
24	Findley L	9/11/89	11.0	1.75	1.5	0.025	0.01	5	8.16	211	17.80	21	22				
24	Findley L	9/25/89	11.5	1.00	1.5	0.029		6	8.18	203	19.60	14	16				
24	Findley L	10/11/89	11.0	1.25	1.5	0.038		5	8.16	210	18.50	11	12				
24	Findley L	7/10/90	11.5	1.25	1.5	0.046	0.01		7.95			22	23				
24	Findley L	7/17/90	11.3	1.25	1.5	0.037	0.01	13	7.72	209	36.60	25	23				
24	Findley L	7/31/90	11.5	0.75	1.5	0.048	0.01	10	7.40	199	57.40	21	24				
24	Findley L	8/14/90	11.5	0.81	1.5	0.044		10	7.24	199	45.10	22	23				
24	Findley L	8/28/90	11.5	0.75	1.5	0.053	0.01	10	7.50	206	58.60	23	23				
24	Findley L	9/11/90	11.0	0.75	1.5	0.051	0.01	12	8.11	205	62.70	21	22				
24	Findley L	9/25/90	11.0	1.50	1.5	0.048	0.02	17	7.78	222	26.90	14	15				
24	Findley L	10/10/90	11.0	2.50	1.5	0.062			8.23	205	9.40	21	16				
24	Findley L	7/22/91	11.3	1.00	1.5	0.049	0.01	10	8.22	215	30.90	26	27				
24	Findley L	8/5/91	13.0	0.75	1.5	0.055	0.01	14	7.63	220	82.80	24	23				
24	Findley L	8/19/91	11.0	0.75	1.5	0.054	0.01	11	8.28	224	68.80	23	24				
24	Findley L	9/4/91	11.7	0.33	1.5	0.079	0.01	9	7.59	219	149.00	20	22				
24	Findley L	9/18/91	11.0	0.67	1.5	0.065			7.90	221	132.00	20	22				
24	Findley L	10/1/91	11.5	0.58	1.5	0.064		7	7.81	220	126.00	19	17				
24	Findley L	6/29/92	11.5	2.00	1.5	0.023		6	7.81	237	9.18	22	21	3	2	3	1
24	Findley L	7/18/92	11.5	1.50	1.5	0.013		6	8.05	232	15.40	22	23	3	2	3	14
24	Findley L	8/11/92	11.3	1.33	1.5	0.025		8	8.34	223	11.60	23	24				
24	Findley L	8/31/92	11.5	1.75	1.5	0.035		9	8.23	228	10.20	17	20	3	2	2	15
24	Findley L	9/28/92	11.5	1.75	1.5	0.024		8	8.24	218	15.80	20	18	2	2	2	5
24	Findley L	10/10/92	11.6	1.50	1.5	0.034		11	8.06	225	28.50	14	15	2	3	3	5
24	Findley L	7/6/93	11.5	1.50	1.5	0.030		7	8.20	210	21.70	26	25	3	2	2	
24	Findley L	7/20/93	11.5	1.50	1.5	0.043		2	7.75	210	15.50	21	24	3	2	3	5
24	Findley L	8/9/93	11.0	1.00	1.5	0.049		7	8.15	211	49.30	24	23	3	2	3	1
24	Findley L	8/30/93	11.3	0.75	1.5	0.063		7	8.16	202	45.90	27	26	3	3	4	123
24	Findley L	9/21/93	11.5	1.25	1.5	0.044		6	8.26	214	33.20	15	18	2	4	4	25
24	Findley L	10/4/93	11.5	1.29	1.5	0.048		5	8.07	216	18.90	17	14	3	3	4	125
24	Findley L	6/14/94	11.3	3.63	1.5	0.015	0.12	6	8.60	222	3.73	31	23	2	2	2	
24	Findley L	7/5/94	11.5	2.00	1.5	0.023		7	7.90	221	10.20	27	24	2	2	3	56
24	Findley L	7/25/94	11.5	1.50	1.5	0.031		4	8.04	224	21.50	23	25	3	2	3	14
24	Findley L	8/15/94	11.8	1.25	1.5	0.039	0.03	11	7.96	206	32.70	21	21	3	2	4	135
24	Findley L	9/5/94	11.5	1.00	1.5	0.048		10	7.70	206	39.40	19	20	4	2	3	134
24	Findley L	9/26/94	13.0	0.80	1.5	0.059		12	7.83	208	50.30	19	19	3	3	4	135
24	Findley L	6/5/95	11.0	2.00	1.5	0.020		6			9.86	25	22	2	2	2	
24	Findley L	6/20/95	11.0	1.00	1.5	0.028		7	8.16	230	24.40	30	27	3	2	4	14
24	Findley L	7/10/95	11.3	0.77	1.5	0.037			7.76	235	51.30	23	23	3	3	3	15
24	Findley L	7/17/95	11.4	0.75	1.5	0.053	0.01	5	8.07	237	53.80	28	27	3	2	3	14
24	Findley L	7/31/95	11.0	0.55	1.5	0.059		10	8.07	231	86.70	30	28	3	3	3	134
24	Findley L	8/14/95	11.5	0.33	1.5	0.082		5	7.48	232	172.00	31	27	4	2	3	134
24	Findley L	6/17/96	11.3	4.75	1.5	0.013	0.05	5	8.18	225	3.50	24	22	1	2	1	
24	Findley L	7/12/96	11.5	1.65	1.5	0.023	0.08	10	7.84	218	20.50	27	25	2	2	3	14
24	Findley L	7/17/96	11.0	3.25	1.5	0.015	0.07	20	7.85	220	8.20	32	25	2	2	3	
24	Findley L	7/29/96	11.0	3.25	1.5	0.018	0.04	10	8.03	218	5.90	22	23	2	2	2	5
24	Findley L	8/12/96	11.0	2.75	1.5	0.023	0.01	20	7.93	217	7.70	22	23	2	2	3	2
24	Findley L	8/26/96	11.0	3.75	1.5	0.018	0.01	5	8.43	214	5.20	23	24				
24	Findley L	9/9/96	11.0	2.25	1.5	0.024	0.01	10	7.95	212	14.10	25	22	3	4	4	24
24	Findley L	9/23/96	11.5	2.28	1.5	0.056	0.01	10	7.96	210	19.10	19	17	3	4	4	24
24	Findley L	6/9/97	11.0	4.25	1.5	0.013	0.10	10	7.52	190	2.60	24	19	1	3	3	2
24	Findley L	6/23/97	11.0	5.13	1.5	0.015	0.08	10	8.07	186	3.08	24	23	1	3	3	2
24	Findley L	7/7/97	11.3	1.50	1.5	0.031	0.01	10	7.56	200	18.50	20	23	3	2	3	1
24	Findley L	7/21/97	11.8	1.28	1.5	0.030	0.01	10	7.83	202	19.70	26	25	3	3	3	134
24	Findley L	8/4/97	11.0	1.42	1.5	0.029	0.01	10	7.39	207	27.80	20	23	3	3	3	2334
24	Findley L	8/18/97	11.5	1.71	1.5	0.032	0.01	7	7.56	206	20.20	19	22	3	3	4	124

LNum	PName	Date	Zbot	Zsd	Zsamp	Tot.P	NO3	TColor	pH	Cond25	Chl.a	TAir	TH20	QA	QB	QC	QD
24	Findley L	9/1/97	11.7	1.40	1.5	0.032	0.01	7	8.48	202	21.90	26	22	3	3	4	124
24	Findley L	9/15/97	11.3	1.75	1.5	0.025	0.01	9	8.41	200	13.90	24	21	3	3	4	12
24	Findley L	6/8/98	12.0	2.42	1.5	0.025	0.01	5	8.41	178	9.34	17	18	2	4	4	2
24	Findley L	9/14/98	10.8	0.80	1.5	0.067		6	7.80	194	43.20	22	20	4	3	4	1234
24	Findley L	6/22/98	11.5	3.13	1.5	0.020	0.01	3	7.51	185	6.32	25	24	2	4	4	24
24	Findley L	7/7/98	11.5	1.38	1.5	0.038	0.01	2	8.53	186	22.10	26	25	3	4	4	124
24	Findley L	7/20/98	11.5	0.78	1.5	0.044	0.14	5	8.61	173	40.50	29	26	3	4	4	1234
24	Findley L	8/3/98	11.5	0.83	1.5	0.053	0.01	5	8.13	181	51.60	25	23	5	4	4	1234
24	Findley L	8/17/98	11.8	0.83	1.5	0.070		14	9.05	183	57.10	30	25	4	3	4	124
24	Findley L	8/31/98	11.5	0.94	1.5	0.067		12	8.96	184	47.20	24	23	4	4	4	1234
24	Findley L	6/7/99	11.5	1.05	1.5	0.031	0.01	8	7.47	211	19.20	35	25	3	3	3	234
24	Findley L	6/21/99	11.8	1.19	1.5	0.035	0.01	6	8.21	204	21.90	20	22	3	3	3	24
24	Findley L	7/5/99	11.3	0.78	1.5	0.061	0.02	10	7.54	196	63.50	33	24	3	3	4	124
24	Findley L	7/19/99	11.7	0.71	1.5	0.081	0.01	12	7.36	198	69.00	27	26	3	3	3	1234
24	Findley L	8/2/99	11.0	0.50	1.5	0.069	0.01	11	8.33	202	53.50	23	26	4	3	4	134
24	Findley L	8/16/99	11.0	0.55	1.5	0.068	0.01	7	7.33	215	45.90	28	22	3	3	4	134
24	Findley L	8/30/99	11.0	0.85	1.5	0.050	0.01	10	7.85	221	43.80	20	22	4	2	4	134
24	Findley L	9/12/99	11.0	0.68	1.5	0.054	0.01	6	7.21	227	57.00	22	21	4	3	3	134
24	Findley L	6/22/98			10.0	0.211							14				
24	Findley L	7/20/98				0.465							15				
24	Findley L	8/17/98				0.618											
24	Findley L	9/14/98				0.960							12				

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 µmho/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 (Φ), 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?

Statistics:

Parameter	**Non-Parametric**		**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 Findley Lake

Statistics:

Parameter	**Non-Parametric**		**Parametric**	
	Tau b	**Significance**	**Correlation Coeff**	**Slope/Max SD**
Zsd	-0.10	>>2.5%	<0.01	<0.01
TP	0.13	>>2.5%	-0.08	0.41
Chl.a	0.01	>>2.5%	0.01	0.10

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$_{\text{special}}$:	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$_{\text{special}}$:	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.

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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 QD = 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.