LAKE WALLENPAUPACK
WATER QUALITY MANAGEMENT STUDY
2006 MONITORING REPORT

February 2007

PREPARED FOR:

Lake Wallenpaupack Watershed
Management District

F. X. Browne, Inc.
Engineers • Planners • Scientists

LWWMD

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Prepared for:

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ACKNOWLEDGMENTS

The water quality monitoring activities of Lake Wallenpaupack during 2006 were funded by PPL. The remainder of the financial support for other District activities was provided by contributions from the counties and townships that comprise the Lake Wallenpaupack Watershed Management District (LWWMD).

Appreciation is extended to all Directors and their organizations for their cooperation and dedication toward preserving water quality in Lake Wallenpaupack and its watershed.

Special gratitude is extended to PPL for the provision of a boat for lake sampling, rainfall and climactic data, and the contribution of funds to perform this monitoring program. Finally, we wish to thank Karen Mandeville, Administrator of the Lake Wallenpaupack Watershed Management District, for her administrative service and assistance with field monitoring and sample collection.

Lake Wallenpaupack Watershed Management District Board of Directors

Administrator	**Solicitor**	**Consultant**
Karen Mandeville	R. Anthony Waldron	Dr. Frank Browne, P.E.

Executive Summary

Lake Wallenpaupack was monitored at Station 3 – Nemanie, monthly during 2006, and twice monthly during the growing season (May through October). Additional samples were collected at Station 5 – Ledgedale monthly during the growing season. During all sampling events, samples were collected at the surface, middle, and bottom of the water column at each station.

A comparison of the 2006 monthly precipitation data to the monthly long-term average precipitation data is presented in Figure A. The total rainfall in 2006 was 52.31 inches, which was 10.84 inches above the long-term average of 41.47 inches at Paupack, PA and the second highest annual rainfall total since 1980. 2006 had the highest growing season rainfall during the period of record. June was the wettest month, with 9.89 inches of rain measured at the PPL Lake Superintendent's Office. This was the highest June total rainfall in the period of record. May was also extremely wet, with 7.29 inches of rain. Lake elevations were above the target elevations during the entire year except for the fall.

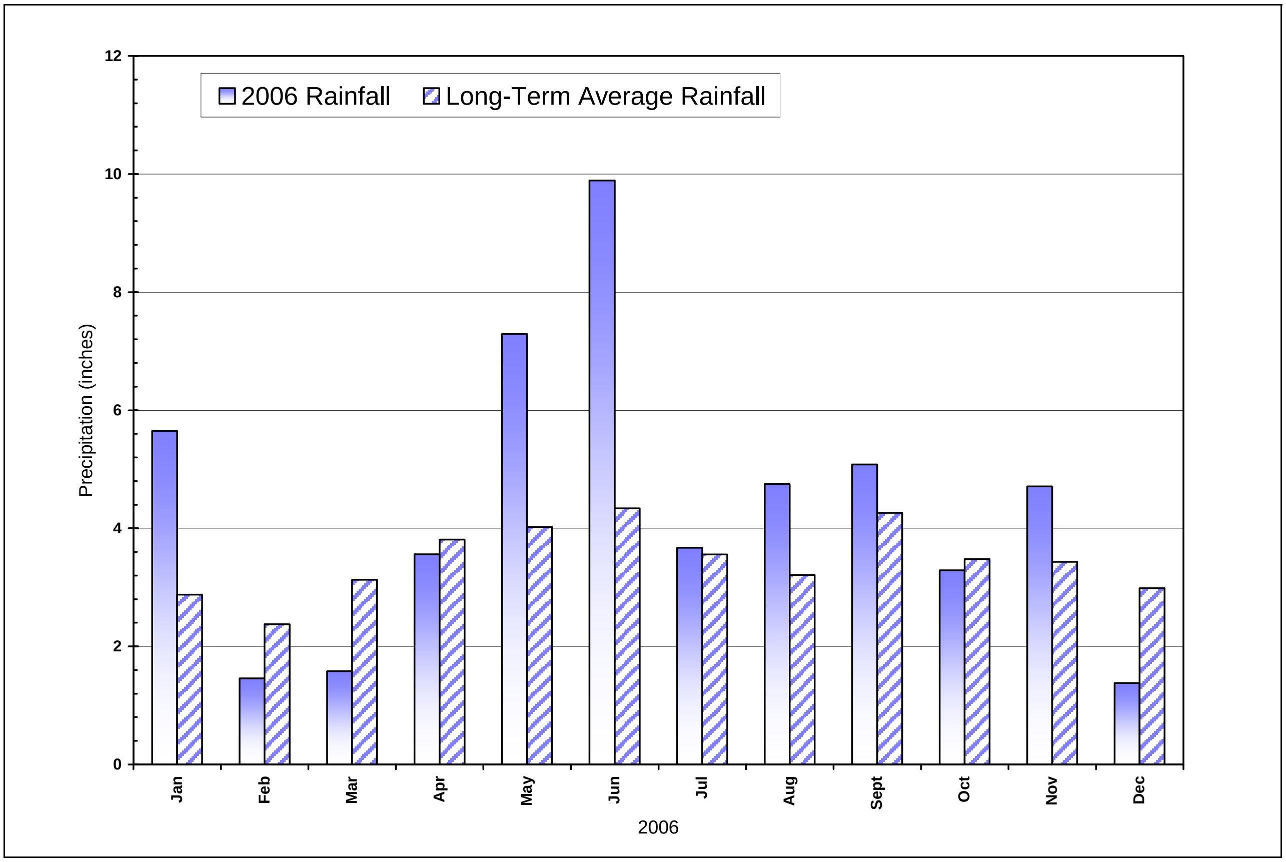


Figure A 2006 Monthly and Long-Term Average Precipitation at Lake Wallenpaupack

By mid-May, Lake Wallenpaupack was thermally stratified. Strong stratification of the water column was observed from mid-May through mid-September at Station 3. The thermocline occurred at a depth of approximately 4.0 to 9.0 meters throughout the growing season at Station 3. Dissolved oxygen concentrations in the bottom half of the hypolimnion were depleted by microbial activity to levels below 2 mg/L from late July through mid- September. In mid-September, the epilimnetic and hypolimnetic layers began to mix and consequent degradation of the thermocline occurred. Temperature and dissolved oxygen concentrations subsequently became uniform throughout the water column by October 2, 2006 at Station 3. The overall periods of stratification and hypolimnetic dissolved oxygen depletion showed similar patterns to previous years at both stations. Total phosphorus was released into the water column from the sediments during the period of anoxia in the hypolimnion of Lake Wallenpaupack.

Average total phosphorus concentrations measured in Lake Wallenpaupack at Station 3 during the 2006 growing season were higher than those measured in recent years, as shown in Figure B. The mean growing season total phosphorus concentration in Lake Wallenpaupack during 2006 was 0.026 mg/L, which was higher than the long-term average.

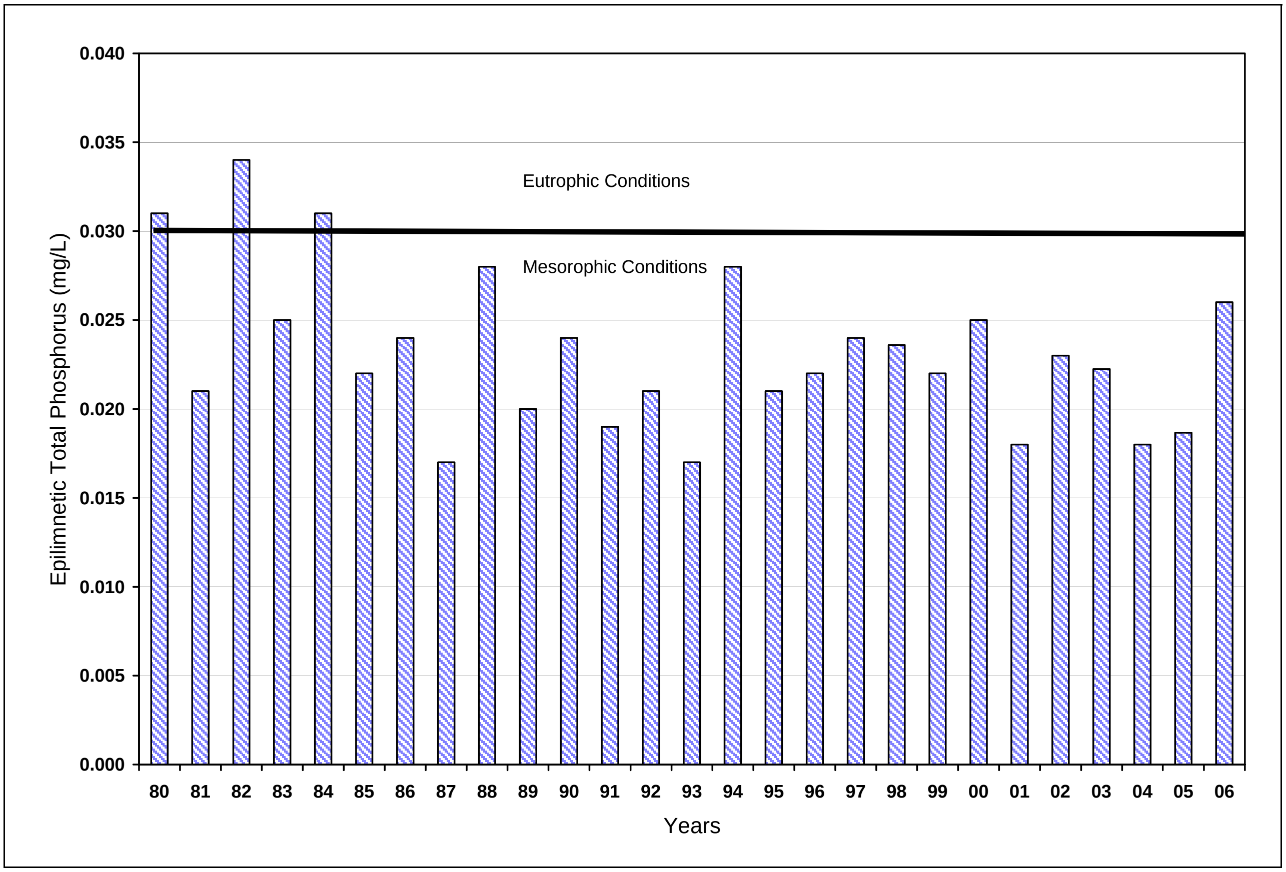


Figure B Trends in Seasonal Average Surface Total Phosphorus Concentrations at Station 3 in Lake Wallenpaupack

Despite the increase in average total phosphorus concentration in 2006, total phosphorus concentrations remained within the mesotrophic range and it appears that phosphorus concentrations in Lake Wallenpaupack have stabilized at levels at or below those observed during the years prior to the Phase II Lake Restoration project, which began in 1987. Phosphorus levels show a general decreasing trend over time. The high total phosphorus concentrations in 2006 may have been due to the above-average rainfall during the 2006 growing season.

Inorganic nitrogen levels were low in the lake during 2006, particularly during the growing season. Average surface total nitrogen concentrations had been decreasing in recent years but increased in 2006, as shown in Figure C. The growing season average surface total nitrogen concentration at Station 3 in Lake Wallenpaupack during 2006 was 0.63 mg/L, which was higher than the long-term average. This trend mirrors the trend in chlorophyll a concentration and phytoplankton density seen during the same time period, which supports the theory that Lake Wallenpaupack may be nitrogen-limited during at least part of the year.

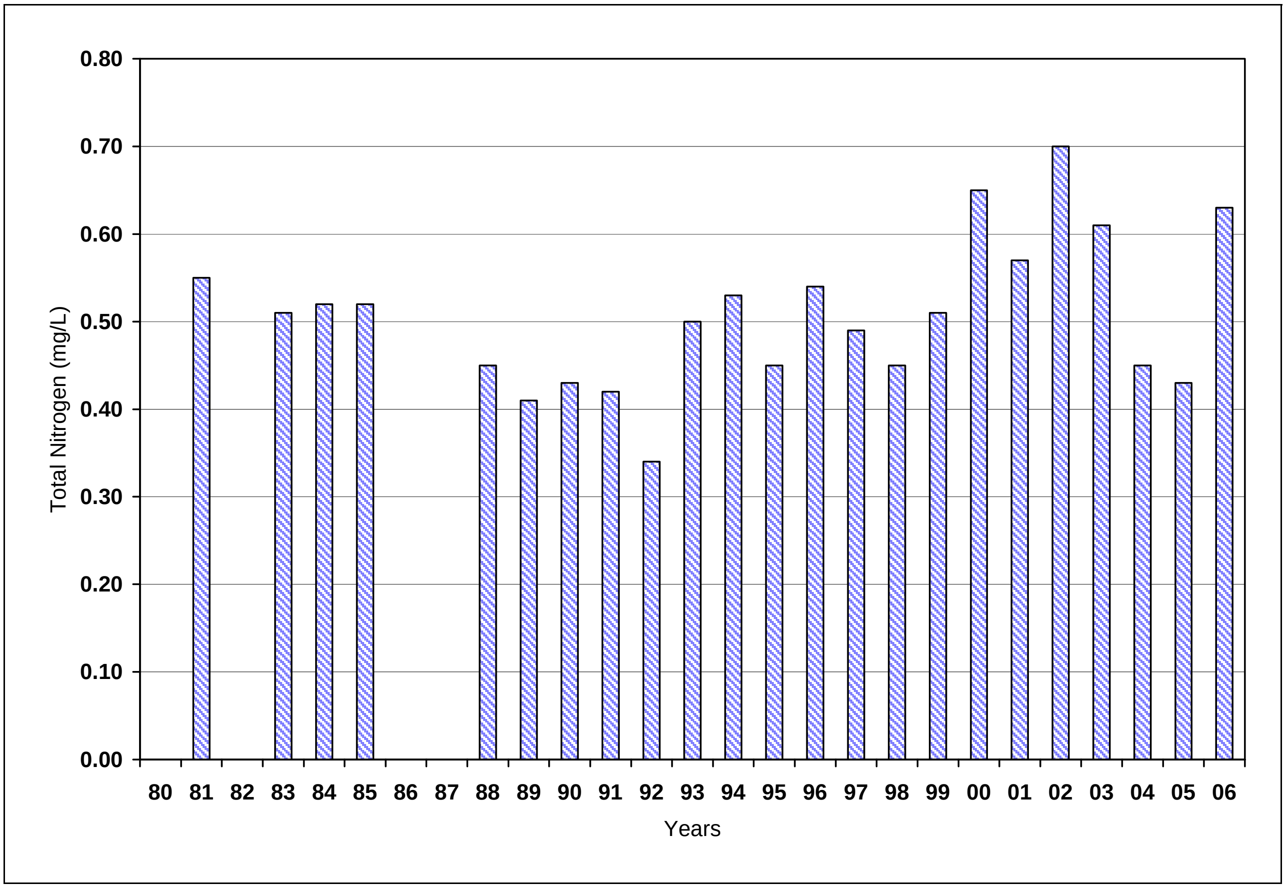


Figure C Trends in Seasonal Average Epilimnetic Total Nitrogen Concentrations at Station 3 in Lake Wallenpaupack

The average Secchi disk transparency at Station 3 in Lake Wallenpaupack during the 2006 growing season was 2.08 meters, which was comparable to the long-term average. Overall, Lake Wallenpaupack shows an increasing (improving) trend in transparency over the period of record. The growing season average Secchi disk transparencies for 1980 through 2006 are presented in Figure D.

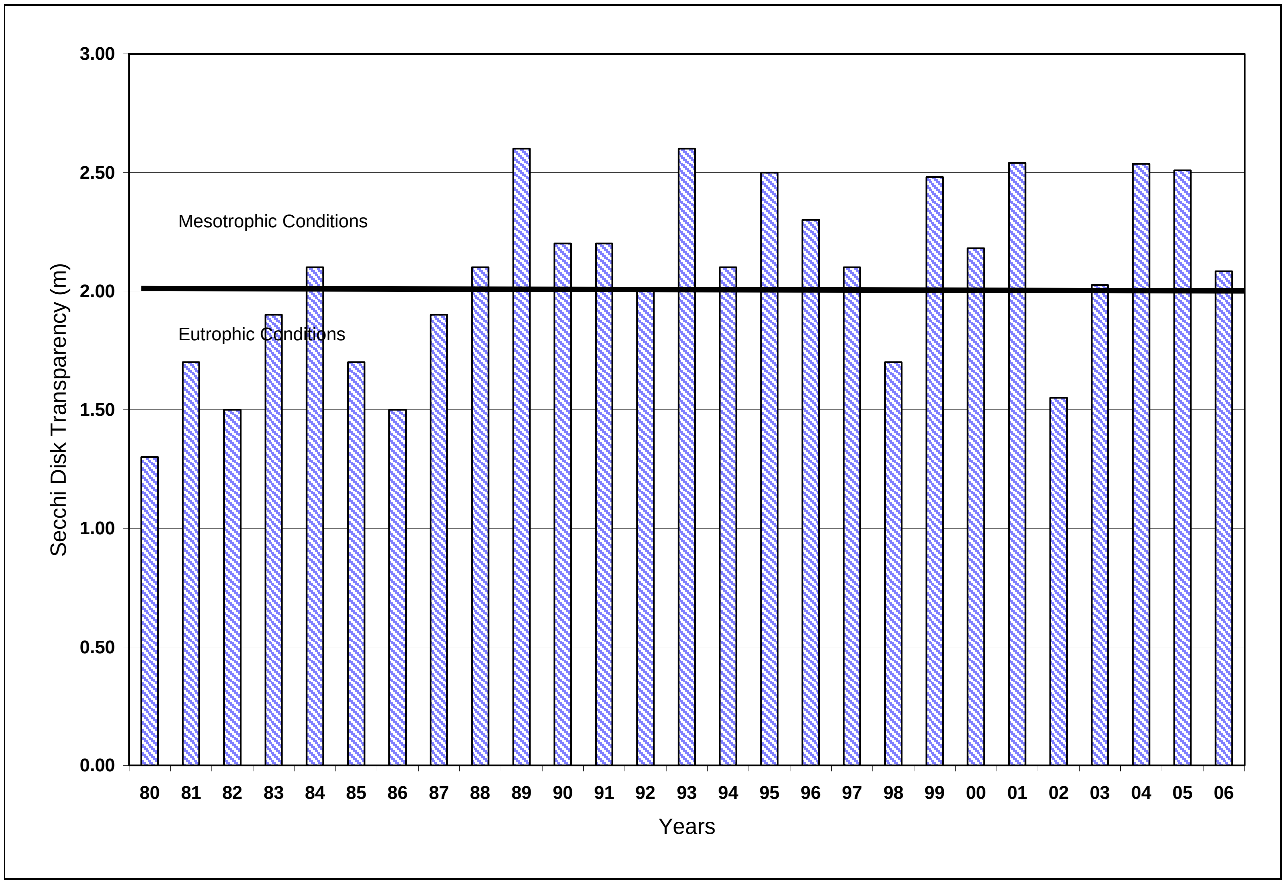


Figure D Trends in Seasonal Average Secchi Disk Transparency at Station 3 in Lake Wallenpaupack

The phytoplankton population in Lake Wallenpaupack during 2006 was again dominated by blue-green algae during the majority of the growing season. The peak annual and growing season total phytoplankton density at Station 3 occurred on September 18, measuring 38,960 cells/mL. Phytoplankton densities were low to moderate during the early and late parts of 2006, but densities increased during the growing season and peaked during September.

As shown in Figure E, both seasonal average phytoplankton densities and peak phytoplankton densities have been high in recent years. Phytoplankton populations in a lake can be limited by phosphorus or nitrogen availability, but they are also strongly influenced by climatic conditions such as the amount of sunlight, precipitation, and water temperatures. Lake Wallenpaupack has experienced more frequent algae blooms and higher peak phytoplankton populations in recent years. The duration of blue-green algae dominance through not just the growing season but the majority of the year has increased in the last 10 years as well.

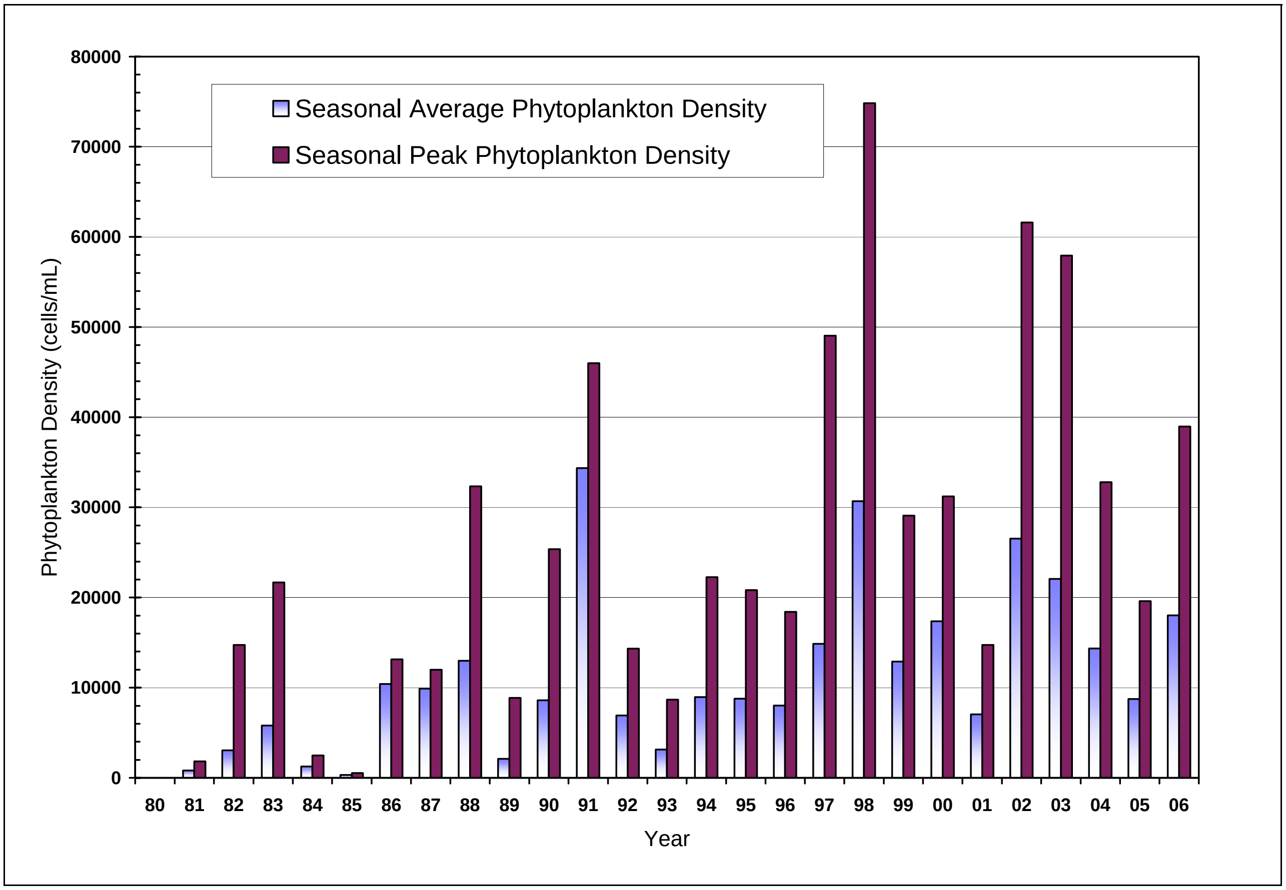


Figure E Trends in Seasonal Average and Seasonal Peak Phytoplankton Densities at Station 3 in Lake Wallenpaupack

Chlorophyll a is widely used as an index of algal biomass in lakes. The mean growing season chlorophyll a concentration for 2006 at Station 3 was 16.03 μg/L, which was higher than the long-term average. According to the EPA classification index, the 2006 seasonal average chlorophyll a concentrations were within the eutrophic range at both Stations. Seasonal average chlorophyll a concentrations have generally been in the eutrophic range since 1994, as presented in Figure F.

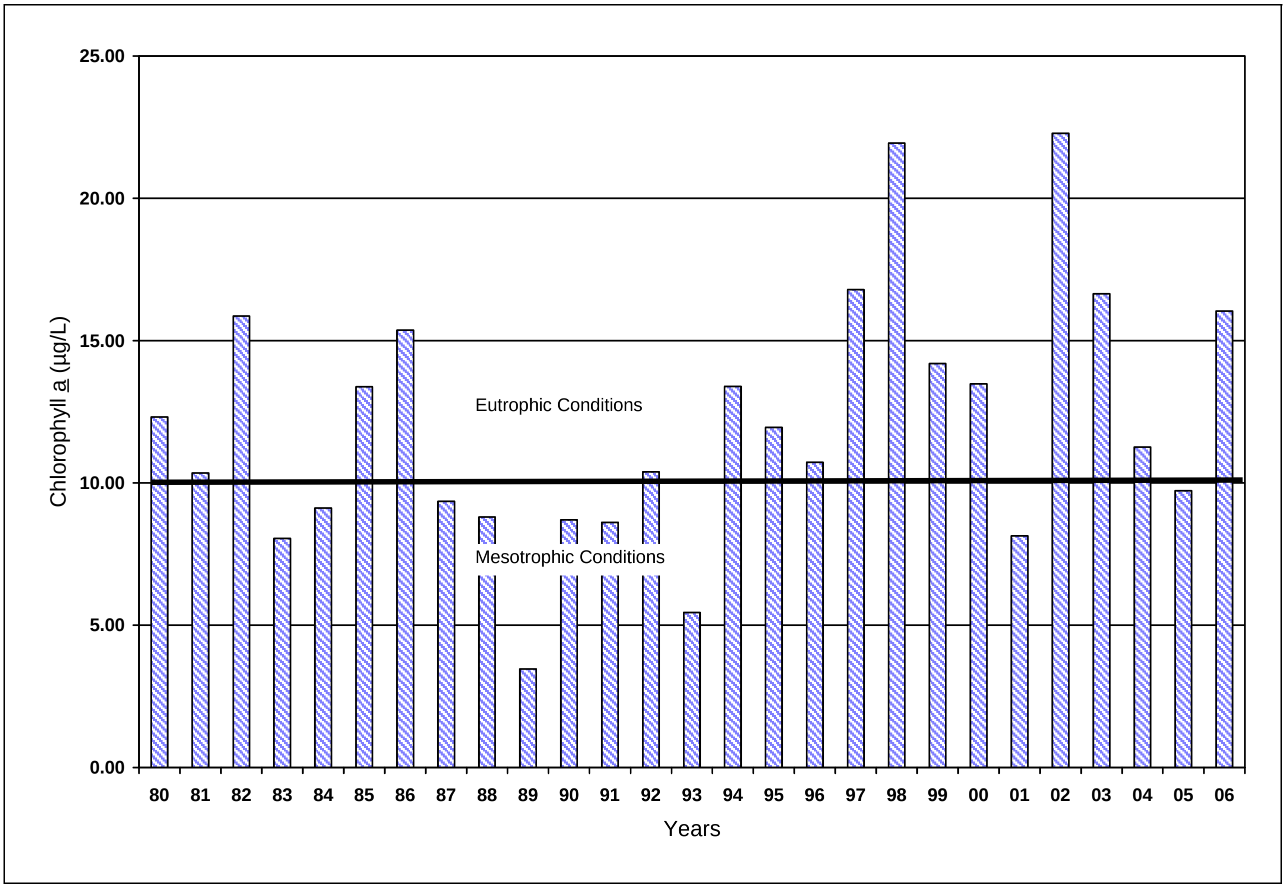


Figure F Trends in Seasonal Average Chlorophyll a Concentrations at Station 3 in Lake Wallenpaupack

Average growing season TSI values were examined to determine if the trophic state of Lake Wallenpaupack has changed during the 1980-2006 monitoring period. The Carlson's Trophic State Index (TSI) was calculated from seasonal averages of Secchi disk transparency, total phosphorus concentrations, and chlorophyll a concentrations at Station 3. As shown in Figure G, the total phosphorus and Secchi disk transparency TSI values indicate that the productivity of Lake Wallenpaupack was generally lower in the most recent 17 years (1990-2006) than in the previous ten years (1980s). Conversely, however, the chlorophyll a TSI values indicate that Lake Wallenpaupack has generally been more productive in recent years. All three TSI values increased in 2006, although it was one of the wettest years on record and environmental conditions may have been a factor in the increased productivity. According to EPA criteria based on TSI values, Lake Wallenpaupack can be classified as borderline eutrophic during 2006.

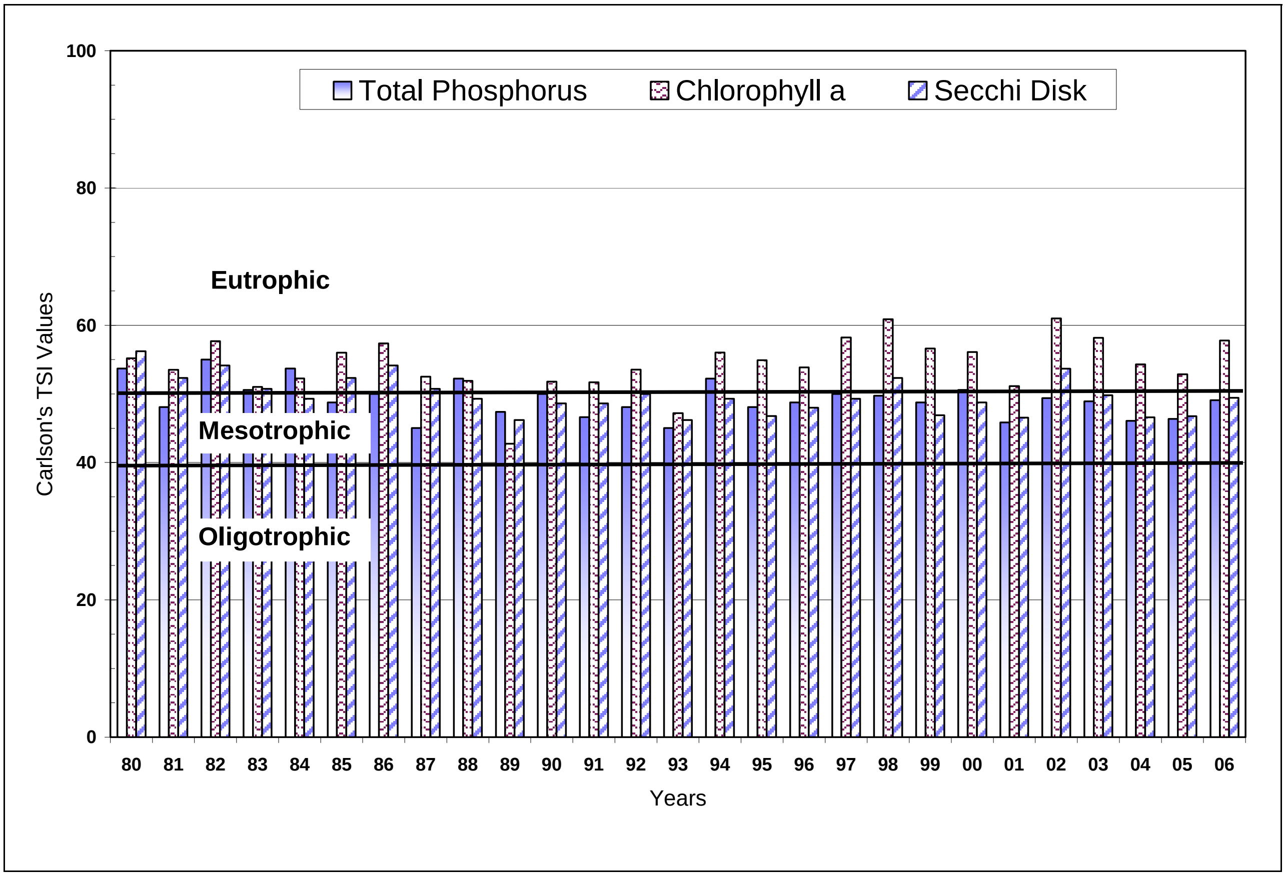


Figure G Trends in Seasonal Average Carlson’s TSI Values at Station 3 in Lake Wallenpaupack

In conclusion, the overall water quality of Lake Wallenpaupack continues to be improved from the early 1980s. Phosphorus has been reduced and maintained at lower concentrations in the surface waters with respect to the growing season averages of the early 1980s. Transparency is also generally improved over historic levels. However, the fact that chlorophyll a levels and total nitrogen concentrations have been showing increasing trends, and the increase in both peak and frequency of blue-green algae blooms in the lake is a concern.

The continued control of nonpoint source pollution and other nutrient inputs throughout the Lake Wallenpaupack watershed must remain a top priority to maintain the desired uses of the lake and a healthy aquatic ecosystem. Best Management Practices (BMPs) that reduce phosphorus inputs to the lake seem to be helping and should be continued. In addition, sources of nitrogen loading to the lake should be investigated as a possible cause of algae blooms in Lake Wallenpaupack during the growing season. LWWMD should investigate the wastewater treatment plant DMRs to see whether or not any further nitrogen reductions can be made. BMPs that provide both phosphorus and nitrogen reduction, such as constructed wetlands, should be targeted. Increased efforts should be made to implement agricultural nonpoint source BMPs in the watershed to further reduce nitrogen loadings, since agricultural runoff tends to be one of the biggest sources of nitrogen. Finally, lake monitoring should be continued to determine the effects of environmental conditions on the trophic state parameters in Lake Wallenpaupack and to document any improvements in water quality now that more BMPs have been implemented within the watershed.

1.0 Introduction

Lake Wallenpaupack, located in Pike and Wayne Counties, is an important natural and economic resource in northeastern Pennsylvania. The political boundaries within the Lake Wallenpaupack watershed are shown in Figure 1. In the late 1970s, the Lake Wallenpaupack Watershed Management District (LWWMD) was formed to provide guidance in the protection and improvement of water quality in Lake Wallenpaupack and its tributaries. The goals of the LWWMD include performing diagnostic studies to evaluate Lake Wallenpaupack and its watershed, and implementing a continuing watershed management program.

In 1980 and 1981, F. X. Browne, Inc. conducted a Phase I Diagnostic-Feasibility Study of Lake Wallenpaupack to classify water quality, identify potential areas of excessive nutrient inputs, and develop a comprehensive lake and watershed management program. Since the Phase I Study, Lake Wallenpaupack has been monitored annually to establish and document water quality trends.

An EPA Phase II Lake Restoration Project for the lake began in 1987 and was completed in 1993. As part of the Phase II project, agricultural waste storage and management facilities were constructed, stormwater control projects were undertaken, and stormwater ordinances were developed for the townships in the lake's watershed. An updated Lake Management Plan was completed in January 2007. Annual lake monitoring was recommended as part of the Lake and Watershed Management Plan as a means assessing the positive impacts of BMP installation.

This report presents the results of the 2006 monitoring program for Lake Wallenpaupack. Due to the technical nature of this report, a brief lake ecology primer is provided in Appendix A and a glossary of lake and watershed management terms is provided in Appendix B.

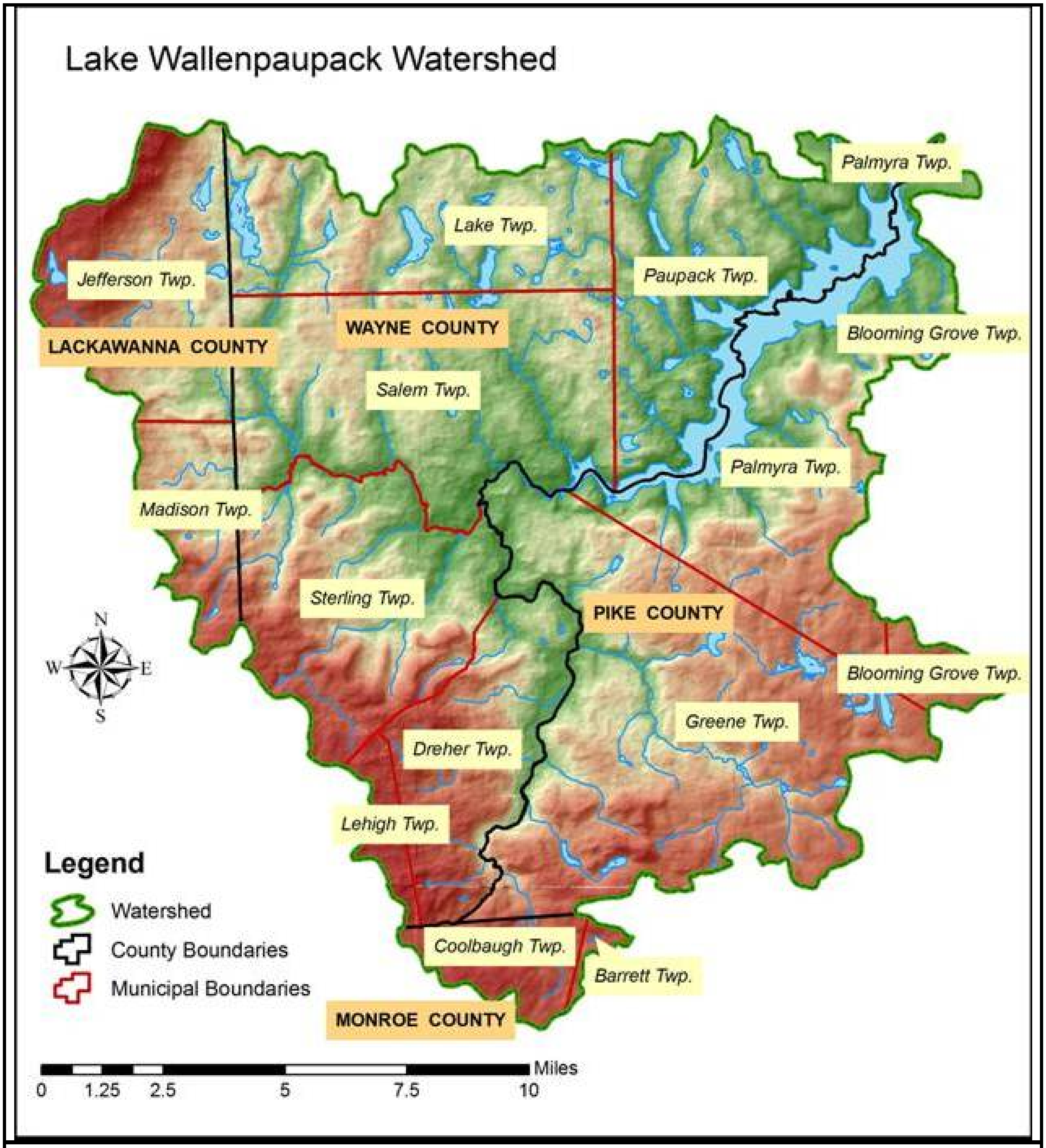


FIGURE 1 LAKE WALLENPAUPACK WATERSHED POLITICAL BOUNDARY MAP

2.0 Hydrology

Seasonal hydrology strongly influences the water quality in Lake Wallenpaupack. During rain events, suspended solids, phosphorus, and nitrogen are transported from the watershed to the lake via its tributaries and direct overland flow. Phosphorus and nitrogen are the nutrients essential for the growth and reproduction of algae; therefore, when these nutrients are present in large amounts, algal blooms can occur. The quantity of pollutants and nutrients that enter the lake during storm events largely depends on surrounding land uses and the intensity and duration of the precipitation events.

A comparison of the 2006 monthly precipitation data to the monthly long-term average precipitation data is presented in Figure A. The total rainfall in 2006 was 52.31 inches, which was 10.84 inches above the long-term average of 41.47 inches at Paupack, PA and the second highest annual rainfall total since 1980. 2006 had the highest growing season total rainfall in the period of record. June was the wettest month, with 9.89 inches of rain measured at the PPL Lake Superintendent's Office. This was the highest June total rainfall in the period of record. May was also extremely wet, with 7.29 inches of rain.

March was the driest month with 1.38 inches of rain. The overall monthly average rainfall in 2006 was 4.36 inches. This was the highest annual monthly average in the period of record. Precipitation was higher than the long-term monthly averages during the entire growing season, May through September. Table 1 lists the 2006 monthly precipitation at Lake Wallenpaupack and compares those data to the long-term averages measured at the Paupack Station.

Table 1
Comparison of 2006 Monthly Precipitation Data at Lake Wallenpaupack to Long-Term Averages

Month	2006 Rainfall*	Paupack Station Long-Term Average**	Departures from Long-Term Average
January	5.65	2.88	2.78
February	1.46	2.38	-0.92
March	1.58	3.13	-1.55
April	3.56	3.81	-0.25
May	7.29	4.02	3.27
June	9.89	4.34	5.55
July	3.67	3.56	0.11
August	4.75	3.21	1.54
September	5.08	4.26	0.82
October	3.29	3.48	-0.19
November	4.71	3.43	1.28
December	1.38	2.98	-1.60
TOTAL	**52.31**	**41.47**	**10.84**
MONTHLY AVERAGE	**4.36**	**3.46**	**0.90**

* 2006 rainfall data were collected by PPL at the Lake Wallenpaupack Superintendent's Office
** Data were collected at the Paupack Station during 1980-2000 by Paul Buehler

Target and actual water levels for Lake Wallenpaupack during 2006 are presented in Table 2. Actual elevations were above the scheduled elevations during the entire year with the exception of September through November, when the actual elevations were well below the scheduled elevations. Variation in water elevation from the target elevations ranged from 2.40 feet higher in January to 3.50 feet lower in November.

Table 2
2006 Lake Wallenpaupack Mean Water Levels

Month	2006 Scheduled Elevation (ft above MSL)	2006 Actual Elevation (ft above MSL)	Elevation Difference (ft)
January	1183.0	1185.4	2.40
February	1182.0	1183.3	1.30
March	1181.5	1182.4	0.90
April	1182.3	1182.7	0.40
May	1185.6	1186.5	0.90
June	1187.0	1187.2	0.20
July	1185-1186.5	1186.7	1.70-0.20
August	1182.0	1182.0	0.00
September	1181.0	1180.3	-0.70
October	1179.0	1176.3	-2.70
November	1181.0	1177.5	-3.50
December	1182.0	1183.7	1.70
MONTHLY AVERAGE	**1182.4**	**1182.8**	**0.22**

3.0 2006 Monitoring Results

Lake Wallenpaupack was monitored at two sampling stations during 2006 in a similar manner as past years. The sampling stations provide a representative areal coverage of the lake as illustrated in Figure 2. Samples were collected at a central, representative station (Station 3 - Nemanie) once per month throughout the year, and twice per month during the growing season. In addition, samples were collected at Station 5-Ledgedale once per month during the growing season. Station 1 was found to be fairly similar to Station 3 in terms of water quality, and was therefore excluded from monitoring this year. However, Station 5 is shallower and closer to the primary inlet, so the Station was included in the monitoring program.

During all monitoring events, water quality samples were collected at the surface, middle, and bottom of the water column at each station. Parameters measured as part of the 2006 Lake Wallenpaupack water quality monitoring program are listed below. The 2006 water quality data are presented in Appendix C.

Temperature
Dissolved Oxygen
Secchi Disk Depth
Total Unfiltered Phosphorus
Dissolved Reactive Phosphorus
Nitrate/Nitrite Nitrogen
Ammonia
Total Kjeldahl Nitrogen
Fecal Coliform
Fecal Streptococcus
Chlorophyll a
Pheophytin a
Phytoplankton
Zooplankton
pH
Alkalinity

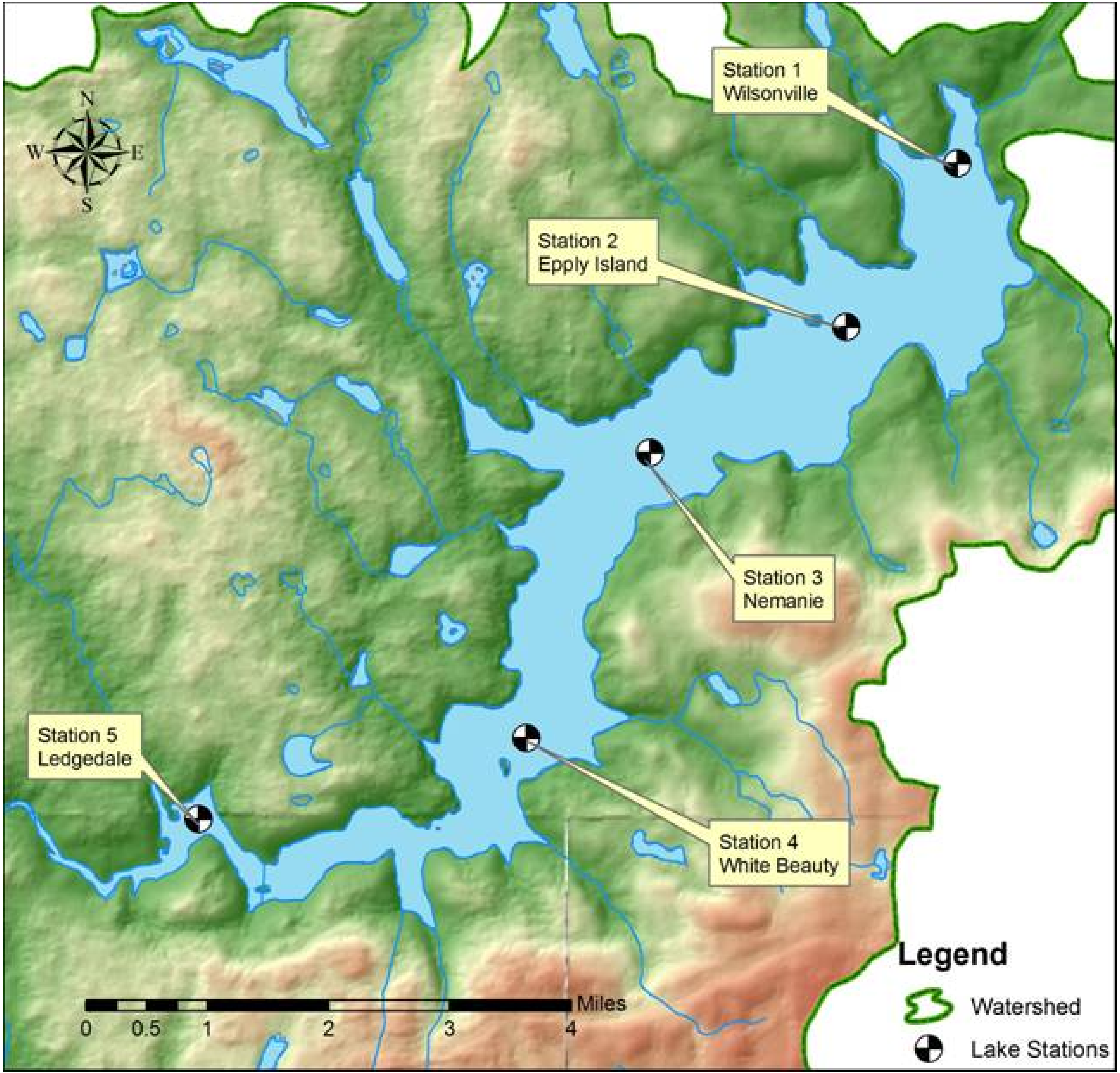


FIGURE 2 LOCATION OF SAMPLING STATIONS AT LAKE WALLENPAUPACK

3.1 Dissolved Oxygen and Temperature

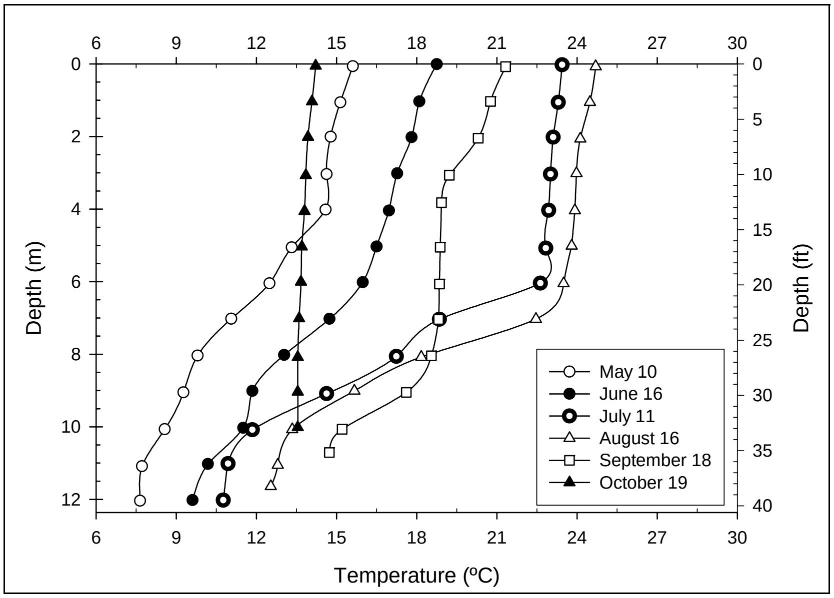


Figure 3 Temperature Profiles at Station 3 in Lake Wallenpaupack During the 2006 Growing Season

By mid-May, Lake Wallenpaupack was thermally stratified, as shown in Figure 3. Strong stratification of the water column was observed from mid-May through mid-September at Station 3. Station 5 was thermally stratified from early July through mid-September. The thermocline occurred at a depth of approximately 4.0 to 9.0 meters throughout the growing season at Station 3. Temperatures within the warm, upper layer (epilimnion) ranged from 15.6°C (60°F) in May to 27.5°C (81°F) in August and back to 14.2ºC (58ºF) in mid-October. Temperatures in the cold, lower layer (hypolimnion) ranged from 7.7°C (46°F) in May to 16.5°C (62°F) in early October during the period of stratification at Station 3.

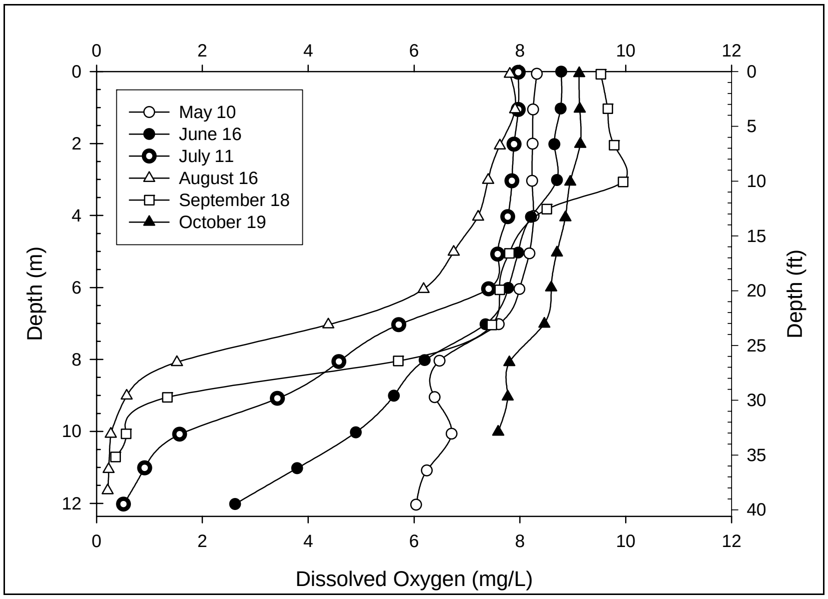


Figure 4 Dissolved Oxygen Profiles at Station 3 in Lake Wallenpaupack During the 2006 Growing Season

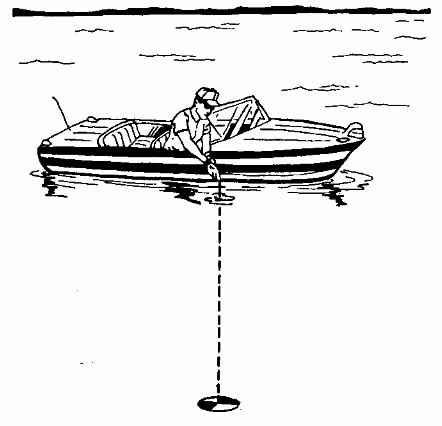
In mid-September, the epilimnetic and hypolimnetic layers began to mix and consequent degradation of the thermocline occurred. When this "fall turnover" occurred, temperature and dissolved oxygen stratification disappeared and the entire water column was completely uniform by the October 2 sampling event at Station 3.

Dissolved oxygen concentrations in the hypolimnion began to be depleted by microbial activity in early July and the oxygen depletion continued through late September, as shown in Figure 4. The bottom 2 to 3 meters of the hypolimnion remained nearly anoxic (without oxygen) from late July through mid- September at Station 3. The anoxia occurred to a much lesser extent in July and August at Station 5. This is understandable considering Station 5 is shallower and influenced to a greater extent by nearby inlets.

The overall periods of stratification and hypolimnetic dissolved oxygen depletion showed similar patterns to previous years at all both stations. Dissolved oxygen and temperature profile data for Lake Wallenpaupack are presented in Appendix D.

Coldwater fish such as trout, walleye, and northern pike function best at temperatures below 22°C (72°F) and dissolved oxygen levels above 5.0 mg/L. During the summer stratification period, these fish probably experienced some stress as surface water temperatures warmed and bottom water dissolved oxygen concentrations declined. Coldwater fish most likely found refuge around cold springs near shore and at the bottom of the epilimnion in open water. The bottom of the epilimnion is a desirable location for coldwater fish because temperatures are cooler than at the surface while dissolved oxygen concentrations are still high enough to allow life-sustaining activities. The coldwater fish in Lake Wallenpaupack may also migrate during these times of stress to Wallenpaupack Creek and other significant tributaries to the lake where dissolved oxygen levels are higher and water temperatures are generally cooler.

3.2 Secchi Disk Transparency



Secchi disk transparency is an indirect measurement of the total amount of organic and inorganic turbidity in a lake. This measurement is obtained by lowering a 20-centimeter white or white and black patterned disk, known as a Secchi disk, into the water column until it can no longer be clearly seen and then recording the depth from the surface to where the disk is suspended. Higher Secchi disk readings represent higher water transparency. The "photic zone", or portion of the water column in which there is enough light for algae to photosynthesize, is theoretically considered to be twice the Secchi depth. Transparencies less than 2.0 meters are considered to be indicative of eutrophic conditions by the US EPA (US EPA, 1980).

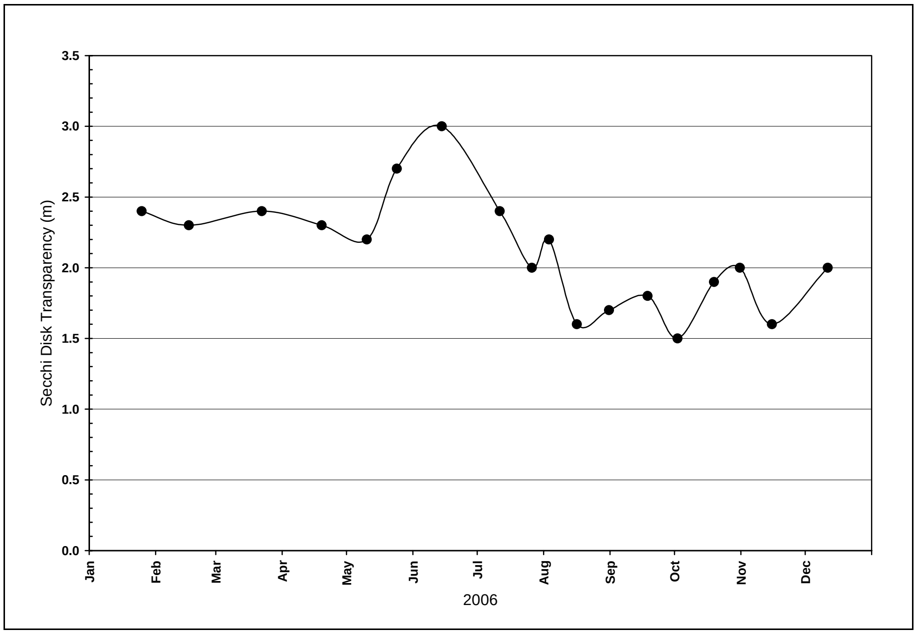


Figure 5 2006 Secchi Disk Transparency Values at Station 3 in Lake Wallenpaupack

The average Secchi disk transparency at Station 3 in Lake Wallenpaupack during the 2006 growing season was 2.09 meters, which was comparable to the long-term average. The 2006 Secchi disk transparency values for Lake Wallenpaupack are presented in Table 3 and shown graphically in Figure 5 (for Station 3). The highest growing season Secchi disk reading was 3.0 meters at Station 3 during mid-June while the lowest reading was 1.1 meters at Station 5 during September. At Station 3, Secchi disk readings were at their lowest (least favorable) during August through October. The transparency measurements at Station 3 were generally highest (most favorable) when total phosphorus and chlorophyll a concentrations were lowest, and vice versa.

Table 3
Secchi Disk Transparency Values for Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Station 3	Station 5	EPA Standard Range for Eutrophy
2.1 [1.5 – 3.0]	**1.6** [1.1 – 2.2]	Less than 2.0

3.3 pH and Alkalinity

The pH scale is an index of the negative log of the free hydrogen ion concentration in water. Each pH unit represents a thousand-fold change in the free hydrogen ion concentration. Levels of pH below 7 are considered acidic, while those above 7 are considered basic. In most lakes, pH values range between 6 and 9. Factors that can significantly affect the pH in a lake include the mineral composition of the surrounding watershed soils and the amount of algal growth occurring in the lake. Intense algal growth can drastically lower CO_2 concentrations in the water, which causes a rise in pH and alkalinity. High CO_2 concentrations cause alkalinity and pH to decrease in water.

Average growing season pH values in Lake Wallenpaupack during 2006 were generally similar at all stations during each monitoring event. The one exception was a low pH of 5.9 at Station 3 in November. The pH was highest at Station 3 in April, and at Station 5 in September. As in past years, the pH decreased with depth at each station due to the biological uptake of CO_2 by algae at the lake surface and the production of CO_2 by respiring organisms at the lake bottom. The averages and ranges of pH values at both stations during the growing season are provided in Table 4.

Table 4
pH and Alkalinity Values for Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Parameter	Station 3	Station 5
Surface pH (std. units)	**6.9** [6.7 – 7.2]	**6.8** [6.5 – 7.2]
Bottom pH (std. units)	**6.6** [6.3 – 6.8]	**6.5** [6.3 – 6.9]
Surface Alkalinity (mg/L)	**14** [11 – 16]	**17** [14 – 20]

Alkalinity is a measure of the buffering capacity or acid-neutralizing capability of water. As alkalinity increases, the ability of the water to neutralize acid also increases. The most common measure of alkalinity is the sum of the carbonate, hydroxyl, and bicarbonate ion concentrations minus the concentration of hydrogen ions. Alkalinity is equivalent to the concentration of bicarbonate ions and is usually expressed in terms of calcium carbonate ($CaCO_3$) concentration. In well-buffered lakes, alkalinity values are 100 mg/L as $CaCO_3$. Lakes with low buffering capacity have alkalinity values less than 10 mg/L as $CaCO_3$. Many lakes in the northeastern United States fall into this category. These lakes are susceptible to acid precipitation and may be acidic year-round or subject to spring acidification due to snowmelt runoff.

Alkalinity was measured in the surface waters at both stations in Lake Wallenpaupack. The averages and ranges of alkalinity concentrations at both stations are provided in Table 4. While Lake Wallenpaupack has a relatively low buffering capacity, the water has enough buffering ability to prevent aquatic life from being subjected to stress caused by acidic conditions. Since the pH values in the lake are not particularly acidic, this is even less of a concern.

3.4 Total Suspended Solids

The total suspended solids in a water sample refer to the total weight of all the organic and inorganic particulate matter found in the sample. When measured in lakes, total suspended solids include all particulate matter found suspended in the water column. In most lakes, total suspended solids concentrations are less than 25 mg/L and can often be less than 10 mg/L. Lakes that receive significant amounts of erosion from stormwater runoff and those with high phytoplankton biomass usually have high total suspended solids concentrations. The 2006 growing season average total suspended solids concentrations at both stations, and the range of concentrations, are provided in Table 5.

Table 5
Total Suspended Solids Concentrations in Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Lake Layer	Station 3	Station 5
Surface (mg/L)	**4.5** [2.4 – 8.2]	**4.7** [2.4 – 9.6]
Bottom (mg/L)	**3.5** [<1.0 – 6.0]	**6.0** [4.0 – 9.6]

During the 2006 growing season, total suspended solids in Lake Wallenpaupack were low at the surface and although they sometimes increased in deeper waters, the values still remained low. Total suspended solids concentrations were similar at both stations during 2006, although they were slightly higher in the bottom waters of Station 5 than the bottom waters of Station 3. This may be due to the fact that Station 5 is near a major inlet, where more sediment enters the lake. The total suspended solids concentrations were comparable in the surface and bottom waters at Station 3, fluctuating throughout the year as shown in Figure 6.

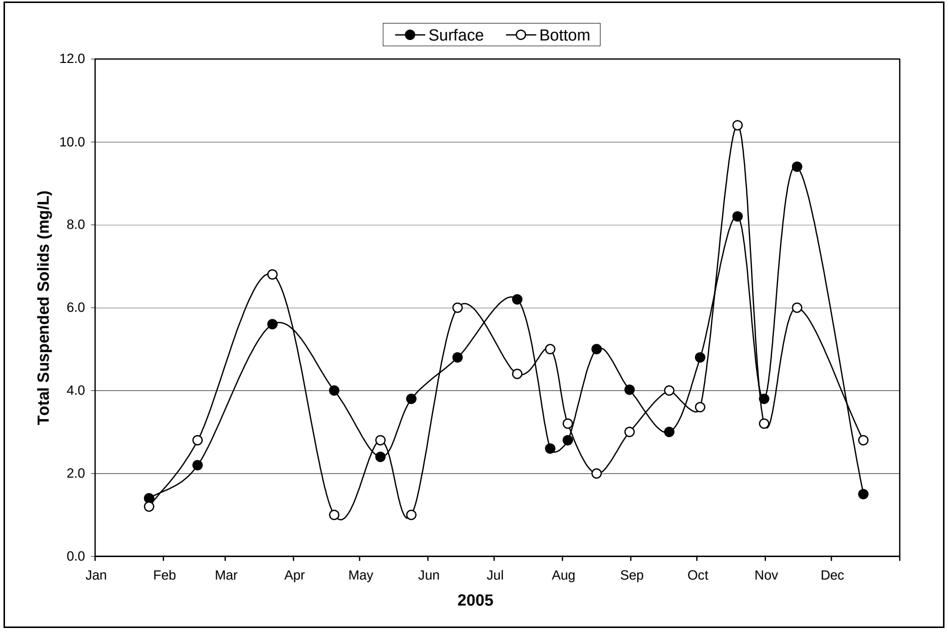


Figure 6 Total Suspended Solids Concentrations at Station 3 in Lake Wallenpaupack During 2006

3.5 Nutrients

The trophic state of a lake is largely dependent upon nutrient levels in the water column. Phosphorus and nitrogen are two nutrients that are essential for phytoplankton growth. During the 2006 monitoring period, several fractions of both phosphorus and nitrogen were monitored. The fractions of phosphorus analyzed for this study were soluble, or dissolved, reactive phosphorus (DRP, also called SRP or filtered orthophosphate) and total unfiltered phosphorus (total phosphorus). The nitrogen fractions analyzed were nitrate/nitrite nitrogen, ammonia nitrogen, and total Kjeldahl nitrogen. Phosphorus is often the limiting nutrient in most freshwater systems. Because of the importance of phosphorus with respect to phytoplankton growth, phosphorus is usually the nutrient targeted by lake managers for reduction. Often phosphorus reduction is the goal of many lake managers overseeing lakes that are not phosphorus limited, because phosphorus is an easier input to control than nitrogen.

It is important to examine nutrient concentrations with a focus on the growing season (May through October), since phytoplankton and weed growth rates are highest during this time. The growing season in Lake Wallenpaupack also corresponds to the period of highest recreational activity at the lake. Therefore, the perception of the general health of Lake Wallenpaupack by its users is formed during this season. Nutrient data are provided in Appendix C.

3.5.1 Phosphorus

Total unfiltered phosphorus concentrations (referred to as total phosphorus in this report) measured in the surface waters during 2006 were lowest at Station 3 and highest at Station 5, as illustrated in Table 6. Bottom water total phosphorus concentrations were highest at Station 3 and lowest at Station 5.

Table 6
Total Phosphorus Concentrations in Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Lake Layer	Station 3	Station 5
Surface (mg/L)	**0.026** [0.008-0.038]	**0.029** [0.021-0.040]
Bottom (mg/L)	**0.060** [0.018-0.185]	**0.031** [0.013-0.043]

The 2006 surface total phosphorus concentrations at Station 3 are shown graphically in Figure 7 and the 2006 bottom total phosphorus concentrations at Station 3 are shown in Figure 8. Surface total phosphorus concentrations were variable during 2006 but generally increased during the growing season. Hypolimnetic total phosphorus concentrations increased rapidly and dramatically at Station 3 during the stratified period indicating that phosphorus was released from the bottom sediments under anoxic conditions during the summer months. As evidenced by the high surface total phosphorus concentrations late in the 2006 growing season at Station 3, it appears that phosphorus may have been transported to the epilimnion during the end of the growing season.

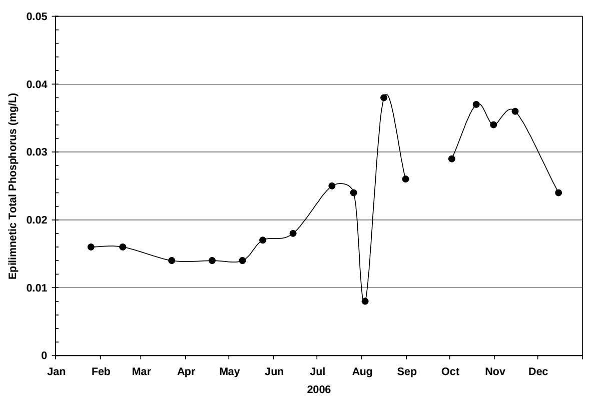


Figure 7 2006 Epilimnetic Total Phosphorus Concentrations at Station 3 in Lake Wallenpaupack

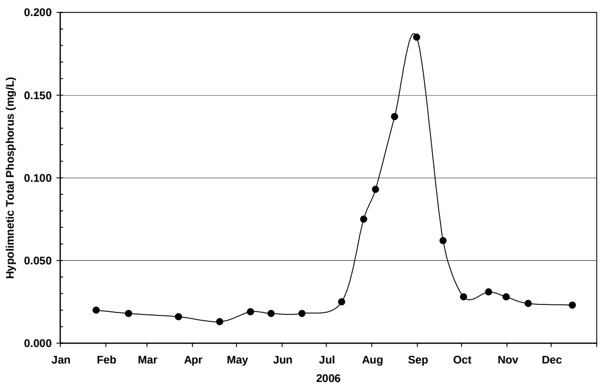


Figure 8 2006 Hypolimnetic Total Phosphorus Concentrations at Station 3 in Lake Wallenpaupack

The U.S. Environmental Protection Agency (US EPA) has established a classification criterion for total phosphorus concentrations in lakes. According to this classification, lakes that have surface total phosphorus concentrations of greater than 0.030 mg/L are indicative of eutrophic conditions. Therefore, according to the US EPA classification, surface total phosphorus concentrations in Lake Wallenpaupack for the 2006 monitoring period were characteristic of mesotrophic lakes.

Dissolved reactive phosphorus (DRP, or soluble reactive phosphorus) is the dissolved inorganic fraction of phosphorus. This is the form most readily available for uptake by phytoplankton. Epilimnetic DRP concentrations at both Lake Wallenpaupack stations were generally low, with most samples lower than 0.004 mg/L, as shown in Table 7. This is most likely due to the fact that the algae populations in the lake during much of the year consumed most of the available DRP. However, high DRP concentrations did occur during late August in the surface waters. It is unclear what caused the high DRP at that time.

Table 7
Dissolved Reactive Phosphorus Concentrations in Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Lake Layer	Station 3	Station 5
Surface (mg/L)	**0.006** [<0.001-0.025]	**0.005** [<0.001-0.012]
Bottom (mg/L)	**0.030** [<0.001-0.136]	**0.007** [0.002-0.012]

The hypolimnetic DRP concentrations at Station 3 were higher than the epilimnetic concentrations, especially during late August and early September when Station 3 exhibited strong thermal stratification, anoxic conditions were in effect in the bottom waters, and hypolimnetic DRP was released from the sediments, as shown in Figure 9. Hypolimnetic DRP concentrations did not show the same dramatic late-summer increase at Station 5, presumably because the bottom waters were not anoxic and internal phosphorus release did not occur.

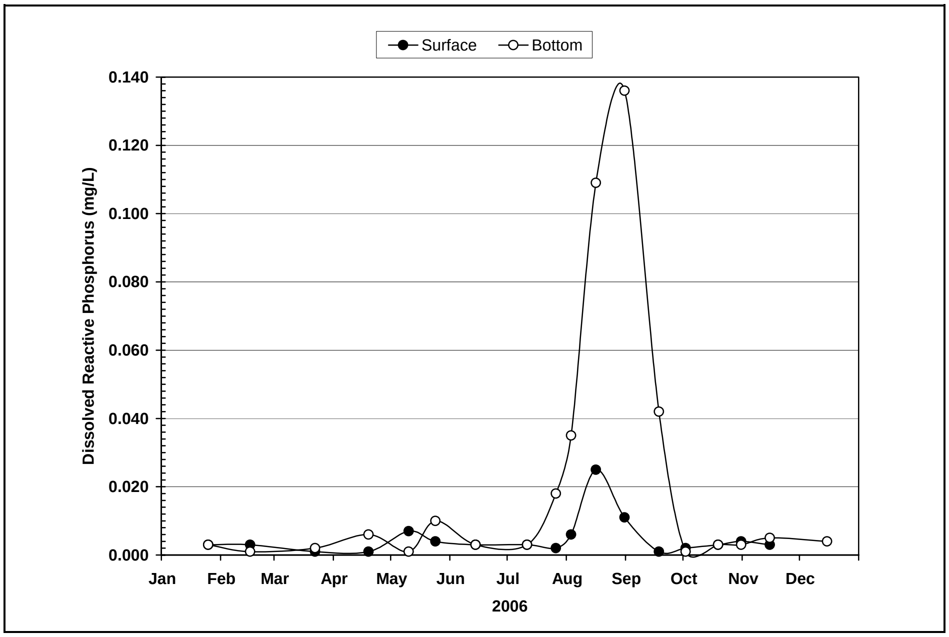


Figure 9 Dissolved Reactive Phosphorus Concentrations at Station 3 in Lake Wallenpaupack during 2006

3.5.2 Nitrogen

The most common sources of the nitrogen entering a lake are agricultural runoff, wastewater, and atmospheric sources such as rainfall, snowfall, and nitrogen gas. Nitrogen in the form of ammonia or nitrate is taken up directly from the water by plants. Atmospheric nitrogen can also be converted to ammonia by certain plant and algae species through nitrogen fixation. Once within the plants, ammonia and nitrate are incorporated into a variety of organic nitrogen compounds, i.e. amino acids (the building blocks of proteins) and nucleic acids, which then travel through food webs. When organic nitrogen compounds are released into the lake water, either through excretion or decomposition, the nitrogen is recycled and the cycle continues. In addition to ammonia and nitrate+nitrite measurements in Lake Wallenpaupack during 2006, the concentration of total Kjeldahl nitrogen (TKN) was measured at each lake station and used to calculate the amount of total and organic nitrogen present in the lake water.

Ammonia nitrogen was not measured in the epilimnion of Lake Wallenpaupack in 2006 since historically ammonia has been below detection limits in the surface waters at all stations on all sampling occasions. This absence of detectable ammonia is common in the surface waters of most lakes because algae and macrophytes quickly use any available ammonia for growth and reproduction. During 2006, ammonia was measured in the bottom

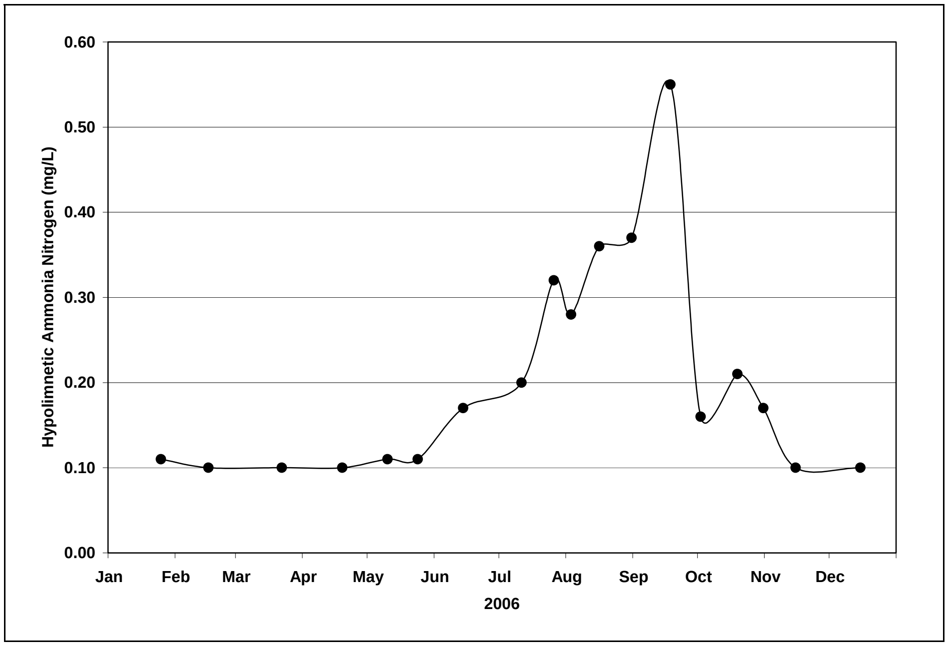


Figure 10 Hypolimnetic Ammonia Nitrogen Concentrations at Station 3 in Lake Wallenpaupack during 2006

waters. The 2006 ammonia concentrations (growing season averages and ranges) at both stations are provided in Table 8. Ammonia concentrations increased in the bottom waters during the period of lake stratification, as shown in Figure 10, indicating that ammonia was released from the sediments under anoxic conditions in late summer.

Table 8
Inorganic Nitrogen Concentrations in Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Lake Layer	Station 3	Station 5
Bottom Ammonia (mg/L)	**0.25** [0.11-0.55]	**0.15** [0.10-0.25]
Surface Nitrate+Nitrite (mg/L)	**0.02** [<0.01-0.09]	**0.03** [<0.01-0.12]
Bottom Nitrate+Nitrite(mg/L)	**0.05** [<0.01-0.13]	**0.08** [<0.01-0.14]

Nitrate+nitrite concentrations were measured together during the 2006 Lake Wallenpaupack monitoring program because nitrite is an unstable form of nitrogen that is quickly converted into nitrate. The 2006 nitrate+nitrite concentrations (growing season averages and ranges) at both stations and lake layers are provided in Table 8.

Epilimnetic nitrate+nitrite concentrations were highest in January at Station 3, as shown in Figure 11. Concentrations were near or below their detection limit (0.01 mg/L) at all three stations during the height of the growing season. This indicates that the inorganic nitrogen was being consumed by algae in the surface waters at that time. The nitrate and nitrite concentrations were comparable to previous years.

Hypolimnetic nitrate+nitrite concentrations showed the same overall annual trend that was observed in the epilimnion, with the lowest concentrations documented during the period of peak water column stratification. Nitrate+nitrite concentrations in the hypolimnion were comparable to those seen in the epilimnion during early winter and during the growing season; however, bottom water nitrate+nitrite concentrations were higher during March through June. Overall, the nitrate+nitrite concentrations in Lake Wallenpaupack were fairly low at all levels.

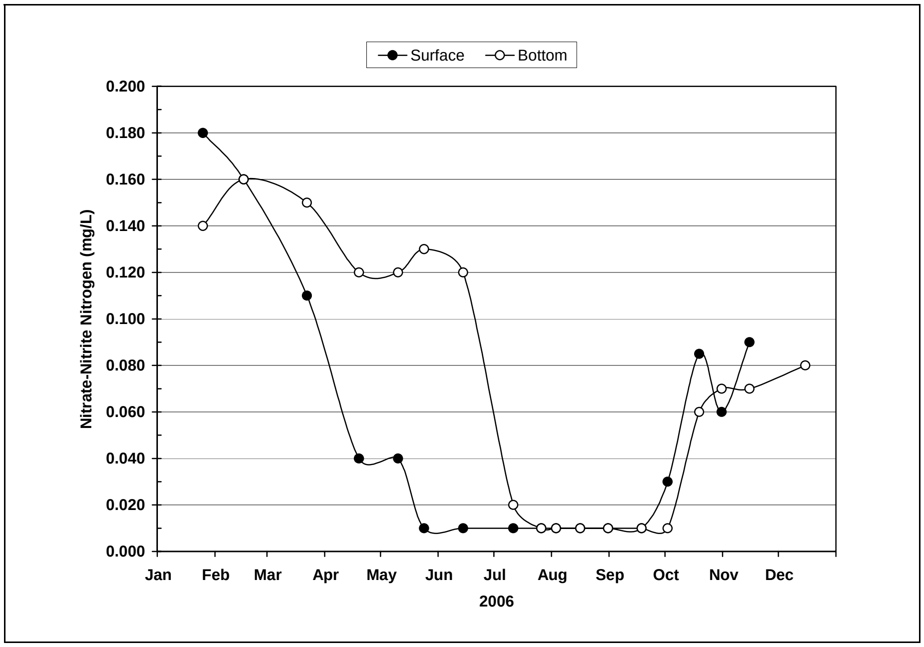


Figure 11 Nitrate+Nitrite Nitrogen Concentrations at Station 3 in Lake Wallenpaupack during 2006

Total nitrogen is made up of a dissolved, inorganic component (e.g. nitrate+nitrite and ammonia) and an organic component (e.g. organic nitrogen). Total nitrogen was calculated by summing the total Kjeldahl nitrogen and nitrate+nitrite nitrogen concentrations. Total and organic nitrogen concentrations in Lake Wallenpaupack are shown in Table 9 for both stations. Organic nitrogen was calculated by subtracting ammonia concentrations from total Kjeldahl nitrogen concentrations. Total and organic nitrogen concentrations at Station 3 in Lake Wallenpaupack during 2006 are shown in Figure 12.

Table 9
Total and Organic Nitrogen Concentrations in Lake Wallenpaupack during 2006
Growing Season Average and [Range]

Lake Layer	Station 3	Station 5
Surface Total Nitrogen (mg/L)	**0.68** [0.44-1.16]	**0.69** [0.39-0.96]
Bottom Total Nitrogen (mg/L)	**0.77** [0.53-1.53]	**0.71** [0.55-0.94]
Bottom Organic Nitrogen (mg/L)	**0.47** [0.28-0.98]	**0.48** [0.31-0.70]

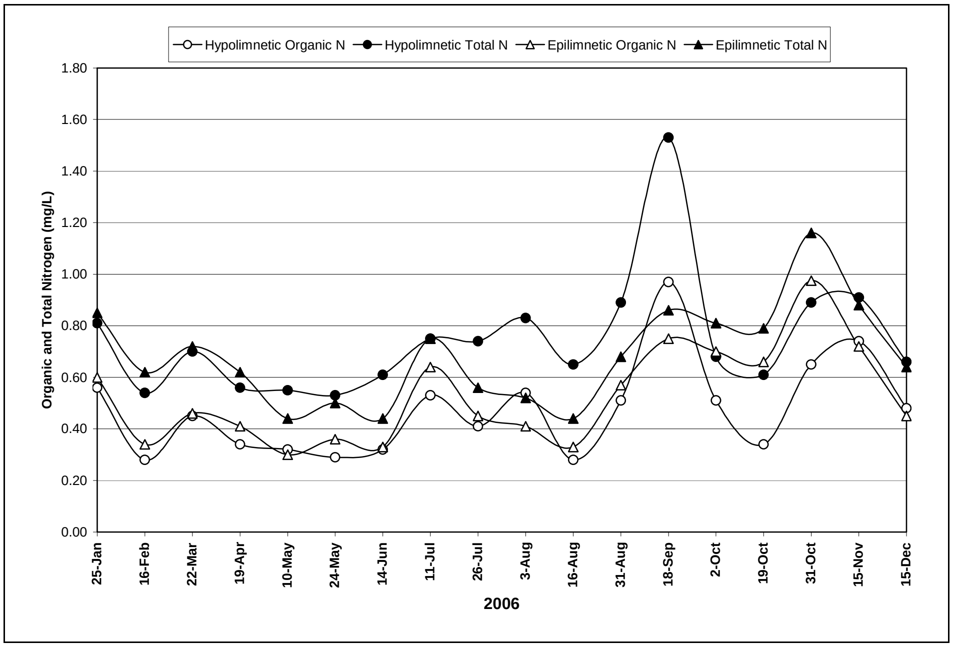


Figure 12 Organic and Total Nitrogen Concentrations at Station 3 in Lake Wallenpaupack during 2006

In general, the ammonia nitrogen, nitrate+nitrite nitrogen, and total and organic nitrogen concentrations measured in Lake Wallenpaupack during 2006 were typical of concentrations found in moderately productive lakes. Because the usable forms of both phosphorus and nitrogen (DRP, nitrate+nitrite and ammonia nitrogen) were low and often below detectable levels in the photic zone of the lake at all sampling stations during the growing season, it is difficult to determine which nutrient limited algal growth. According to limiting nutrient calculations, it appears that phosphorus was the limiting nutrient during most of the year; however, the dominance of nitrogen (atmospheric) fixing, blue-green phytoplankton during the summer and fall suggests that nitrogen became depleted during the summer, and therefore, became limiting during this time. As seen in Figure 12, the majority of the nitrogen in Lake Wallenpaupack during 2006 occurred in the organic form. This indicates that nitrogen inputs to the lake via runoff were high and algae populations were actively consuming the inorganic fractions.

3.6 Chlorophyll a and Pheophytin a

Water samples containing phytoplankton, which are microscopic plants, can be processed to extract chlorophyll a from algal cells for analysis. Chlorophyll a is a green pigment used by plants to convert sunlight to chemical energy during photosynthesis. Chlorophyll a constitutes about 1 to 2 percent of the dry weight of planktonic algae, so the amount of chlorophyll a in a water sample is an indicator of phytoplankton biomass. Pheophytin a is a degradation product of chlorophyll a. Determining the pheophytin a concentration in a water sample enables a more accurate measurement of the chlorophyll a concentration in the sample.

As shown in Table 10, chlorophyll a concentrations were similar at both stations in 2006. The average growing season chlorophyll a concentration was highest at Station 3, measuring 16.03 Fg/L. The U.S. Environmental Protection Agency (US EPA) has established a classification criterion for chlorophyll a concentrations in lakes. According to this classification, lakes that have chlorophyll a concentrations of between 4 and 10 Fg/L are indicative of mesotrophic conditions, and lakes with chlorophyll a concentrations greater than 10 Fg/L are considered to be eutrophic. According to the EPA classification index, the 2006 seasonal average chlorophyll a concentrations were within the eutrophic range at both stations. The annual average pheophytin a concentration at Station 3 during 2006 was 1.25 Fg/L, which indicates that very little of the chlorophyll a concentrations can be attributed to pheophytin a. Both chlorophyll a and pheophytin a data for 2006 are presented in Appendix C.

Table 10
Chlorophyll a Values for Lake Wallenpaupack during 2006
Growing Season Average and [Range] in µg/L

Station 3	Station 5	EPA Standard Range for Eutrophy
16.03 [6.10 – 25.00]	**14.00** [5.00 – 35.00]	Greater than 10.0

Chlorophyll a concentrations fluctuated throughout the season, remaining relatively low early in the year and increasing in late summer, as shown in Figure 13. Small spikes in chlorophyll a concentrations occurred in May and November, but the highest chlorophyll a concentrations occurred in late August and September during the period of greatest stratification and anoxia. The fluctuations in chlorophyll a concentrations appear to be related to both environmental conditions and algae blooms. Chlorophyll a concentrations were highest at both stations during mid-September, which corresponded to an algae bloom in the lake. However, the spike in chlorophyll a during early May and November do not correspond to algae blooms.

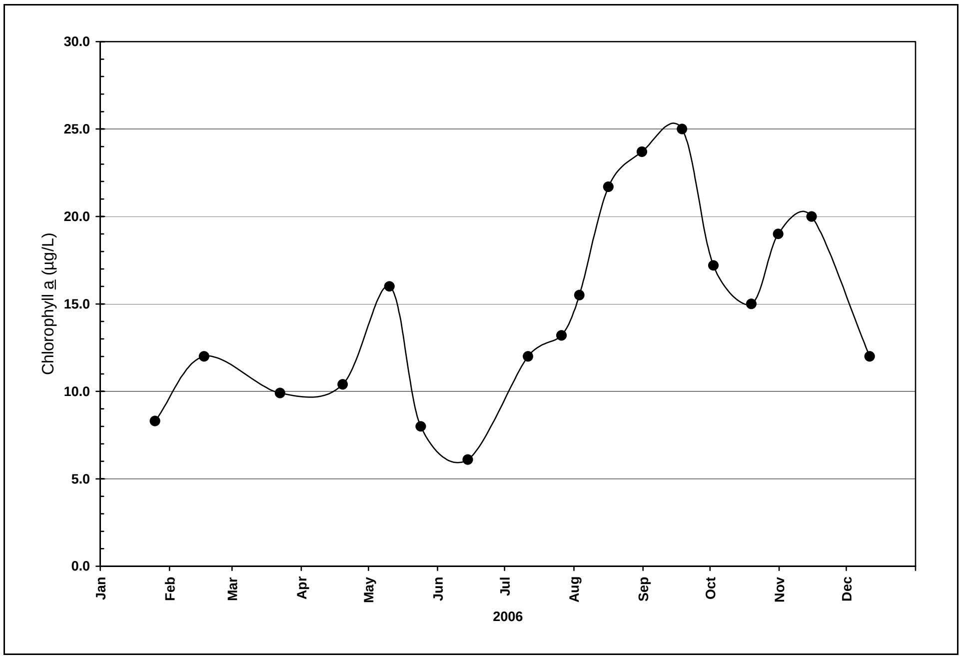


Figure 13 2006 Chlorophyll a Concentrations at Station 3 in Lake Wallenpaupack

3.7 Phytoplankton

Phytoplankton are microscopic algae that have little or no resistance to currents and live free-floating, suspended in open water. Algal cells may be unicellular, colonial, or filamentous. As photosynthetic organisms (primary producers), phytoplankton form the basis of the aquatic food-web and are grazed upon by zooplankton and herbivorous fish.

Lake Wallenpaupack phytoplankton samples were collected once a month at Station 3 in January through April and in November through December, and twice a month from May through October 2006. Phytoplankton samples were also collected monthly from May through October at Station 5. All phytoplankton data are presented in Appendix E.

Lake Wallenpaupack phytoplankton samples were composite samples collected from the photic zone as measured on each sampling date. Organisms were identified to the genus level and enumerated. Biomass for each genus was determined from size and density calculations. Total and blue-green phytoplankton densities measured at Station 3 during 2006 are listed in Table 11 and the phytoplankton genera found in Lake Wallenpaupack during 2006 are listed in Table 12.

Table 11
Phytoplankton Densities in Lake Wallenpaupack during 2006
Growing Season Average and [Range] in cells/mL

Parameter	Station 3	Station 5
Average Total Phytoplankton	18,025	19,654
Average Blue-Green Phytoplankton	16,004	18,172
Peak Total Phytoplankton	38,960	65,020
Peak Blue-Green Phytoplankton	37,400	64,200

Phytoplankton counts were moderate at both stations during the 2006 growing season. Blue-green phytoplankton species dominated the phytoplankton population during most of 2006. Blue-green algae populations were higher at Station 3 than at Station 5 during every sampling event except the September 18 sampling event. The algae bloom that occurred at Station 3 on that date was twice as severe at Station 5. This may be due to the fact that Station 5 is located closest to the main lake inlet where surface nutrient concentrations were highest. The peak annual and growing season total phytoplankton density at Station 3 occurred on Setpember 18, measuring 38,960 cells/mL.

February and March were the only months in 2006 when blue-green algae were not the dominant species, as shown in Figure 14. In January, the blue-green *Pseudanabaena* dominated the phytoplankton population at Station 3. In February, the diatom *Asterionella* was dominant, and remained so through March. The blue-green *Pseudanabaena* increased again in March, and was the dominant species through early July. The blue-green algae *Aphanizomenon* dominated the population from late July through the end of the year, with *Anabaena* populations also high in August and September.

The highest growing season concentration of blue-green algae occurred during mid-September at Station 3, with an *Anabaena* bloom of 9,600 cells/mL and an *Aphanizomenon* bloom of 27,000 cells/mL. At Station 5 on the same sampling date, the Aphanizomenon bloom was much greater, measuring 58,200 cells/mL.

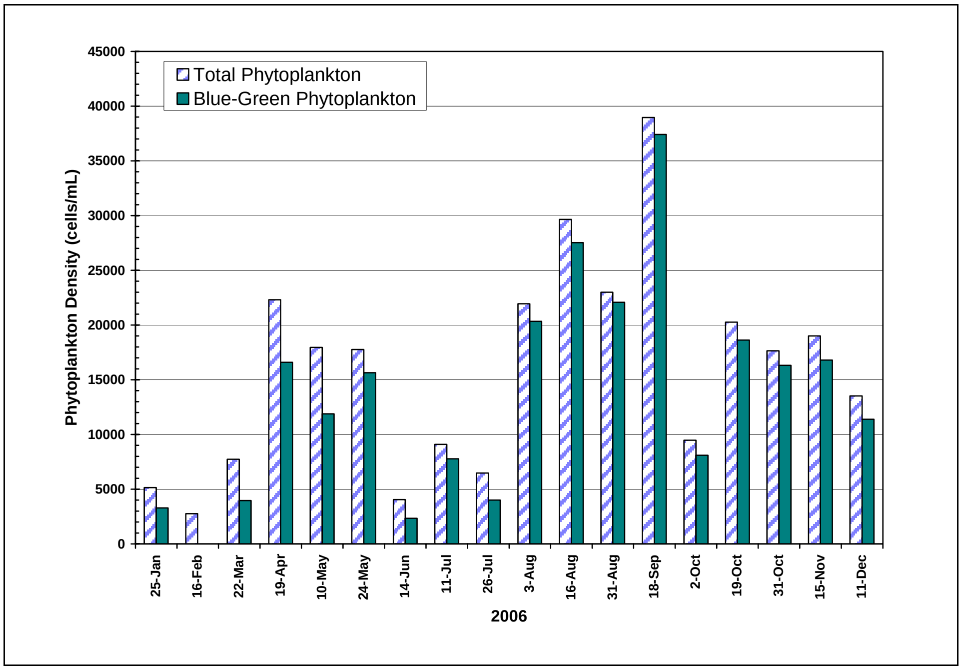


Figure 14 2006 Total and Blue-Green Phytoplankton Densities at Station 3 in Lake Wallenpaupack

The total phytoplankton biomass showed a slightly different pattern to the total phytoplankton density in 2006, although the highest biomasses occurred during August and September, and the phytoplankton biomass was dominated by blue-green algae during the latter part of the growing season and through the end of the year. During the first half of the year, diatoms and chrysophytes dominated the phytoplankton biomass. The maximum total biomass in Lake Wallenpaupack during 2006 was 9,814 µg/L at Station 5 on September 18. The biomasses were fairly low at both stations during 2006. All phytoplankton data are presented in Appendix E.

Table 12
Genera of Phytoplankton in Lake Wallenpaupack During 2006

BACILLARIOPHYTA
Centric Diatoms
Aulacoseira
Cyclotella
Stephanodiscus
Urosolenia

Araphid Pennate Diatoms
Asterionella
Fragilaria/related taxa
Synedra
Tabellaria

Monoraphid Pennate Diatoms
***Achnanthidium*/related taxa**

Biraphid Pennate Diatoms
Navicula/related taxa
Nitzschia
Surirella

CRYPTOPHYTA
Cryptomonas

CYANOPHYTA
Unicellular and Colonial Forms
Aphanocapsa
Coelosphaerium
Microcystis

Filamentous Nitrogen Fixers
Anabaena
Aphanizomenon
Limnothrix

Filamentous Non-Nitrogen Fixers
Oscillatoria
Planktolyngbya
Psuedanabaena

CHLOROPHYTA
Flagellated Chlorophytes
Chlamydomonas

Coccoid/Colonial Chlorophytes
Ankistrodesmus
Botryococcus
Closteriopsis
Coelastrum
Crucigenia
Elakatothrix
Golenkinia
Paulschulzia
Pediastrum
Quadrigula
Scenedesmus
Schroederia
Sphaerocystis

Desmids
Cosmarium
Mougeotia/Debarya
Staurastrum
Staurodesmus

CHRYSOPHYTA
Flagellated Classic Chrysophytes
Dinobryon
Ochromonas
Synura

EUGLENOPHYTA
Trachelomonas

PYRRHOPHYTA
Peridinium

3.8 Zooplankton

Zooplankton are small aquatic invertebrates that graze on phytoplankton and are in turn preyed upon by larger invertebrates and planktivorous fish. During 2006, the zooplankton population of Lake Wallenpaupack was sampled monthly from May through October by compositing samples collected from the entire water column at Stations 3 and 5. The density and biomass of each zooplankton genera found were measured in the same manner as they were for the phytoplankton. All zooplankton data are presented in Appendix F.

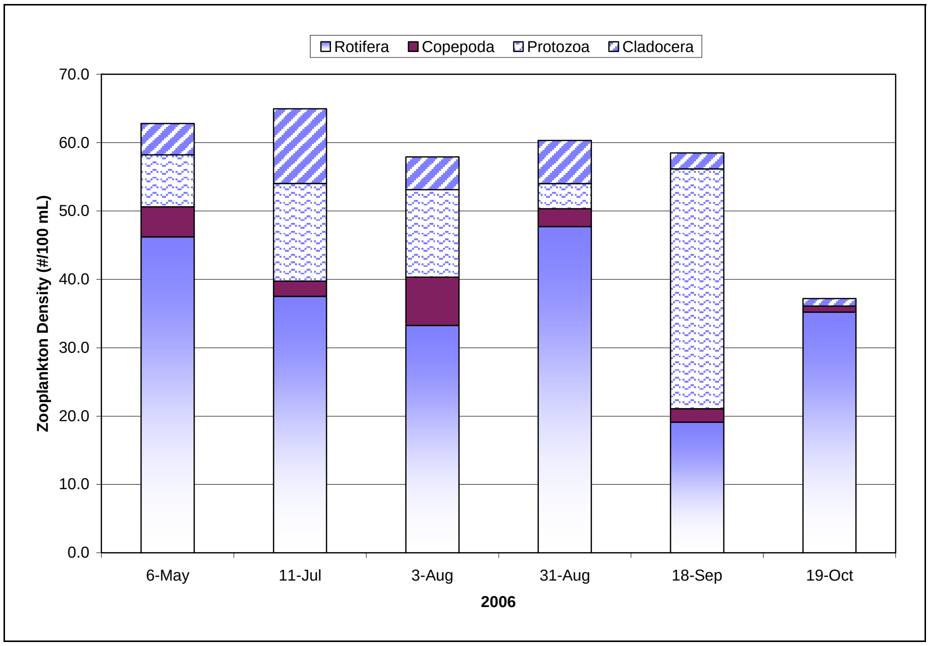


Figure 15 2006 Zooplankton Densities in Lake Wallenpaupack

As shown in Figure 15, zooplankton populations were fairly low, ranging from 37.2 individuals per liter (ind/L) in October to 65.0 ind/L in early July. Rotifers dominated the zooplankton density during most of 2006, with the exception of the late August sampling date when protozoans were dominant. The average zooplankton density for all of the sampling dates was 57.0 ind/L, which was lower than the long-term average density of 97.7 ind/L. Typically, zooplankton populations are low when blue-green algae populations are high since blue-green algae are not palatable to most zooplankton. Blue-green algae did dominate algae populations in Lake Wallenpaupack during most of the year, so the phytoplankton and zooplankton results did correlate.

Copepods did not dominate in overall biomass during the 2006 growing season, as during past years in Lake Wallenpaupack. Rather, the species composition was variable with respect to biomass throughout the growing season. The seasonal maximum zooplankton biomass of 39.2 micrograms per liter (µg/L) occurred on July 11. The average seasonal zooplankton biomass during 2006 was 20.3 µg/L. Both the peak and average zooplankton biomasses were well below the long term averages in 2006.

The average zooplankton mean body length was 0.14 mm during 2006. This was lower than the long-term average mean body length of 0.21 mm. Typically, average zooplankton mean body lengths less than 0.5 mm indicate an unbalanced fishery, with an abundance of panfish.

3.9 Trophic State Indices

Carlson's Trophic State Index values (TSI values) (Carlson, 1977) are used to describe the trophic state of a lake in terms of the relationships among phytoplankton biomass, water transparency, nutrient concentrations, and chlorophyll a concentrations. TSI values are calculated using Secchi disk transparency readings, chlorophyll a concentrations, and total phosphorus concentrations. Carlson TSI values are based on a scale of 0 to 100. Lakes with TSI values of less than 40 are classified as oligotrophic, while lakes with TSI values of 50 or greater are classified as eutrophic, according to the US EPA.

All three trophic state indices were calculated using 2006 growing season data (May through October) collected at Station 3 of Lake Wallenpaupack. TSI values at Station 3 for the 2006 growing season are shown in Figure 16. According to US EPA criteria, Lake Wallenpaupack can be classified as borderline eutrophic for total phosphorus and Secchi disk transparency, and eutrophic for chlorophyll a in 2006.

Trophic state indices are useful for examining deviations in relationships between the three parameters measured. The fact that the chlorophyll a TSI value was higher than the phosphorus and the Secchi disk TSI value indicates that either algal growth was not severely limited by phosphorus or transparency, or that the algal population was dominated by large, chlorophyll-rich species. Since the phytoplankton testing results showed that the latter was not the case, it is possible that Lake Wallenpaupack may have been nitrogen-limited rather than phosphorus-limited during at least part of the growing season. This pattern is similar to those seen during previous years.

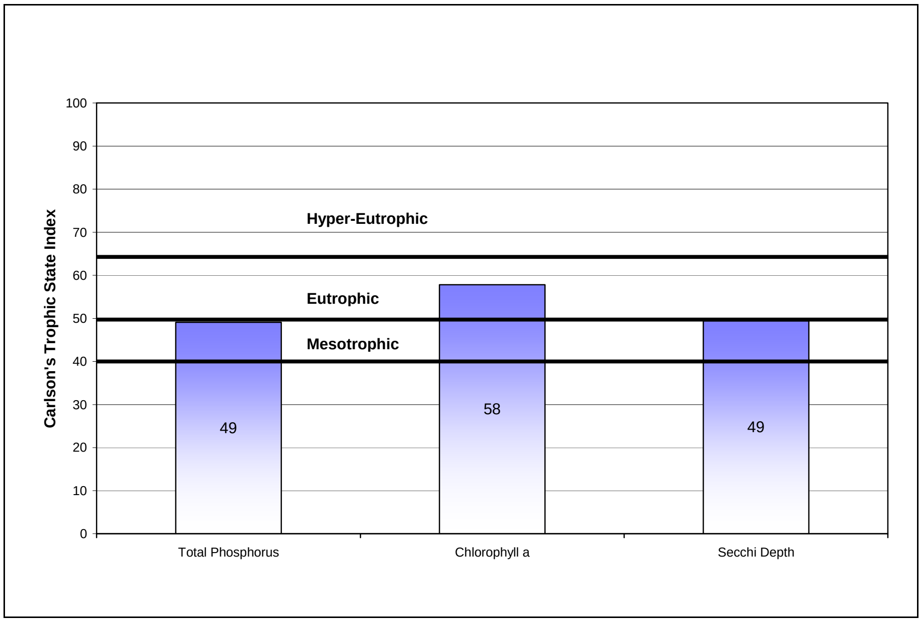


Figure 16 2006 Carlson's TSI Values at Station 3 in Lake Wallenpaupack

3.10 Bacteria

Fecal coliform and fecal streptococcus bacteria were measured in the surface waters of Lake Wallenpaupack at both stations during the growing season. Both fecal coliform and fecal streptococci are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in lakes and ponds suggests that pathogenic microorganisms might also be present and that swimming might be a health risk. Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and stormwater runoff.

During 2006, both fecal coliform and fecal streptococcus counts in Lake Wallenpaupack were below detection limits for the majority of the sampling events as shown in Table 13. Bacteria counts were slightly higher at Station 3 on the October 31 sampling date; however, the PA Code Chapter 93 water quality standard for recreational water contact of 200 colonies per 100 mL was not exceeded during any sampling event.

Table 13
Bacteria Cell Counts in Lake Wallenpaupack during 2006
Growing Season Average and [Range] in cells/100 mL

Parameter	Station 3	Station 5
Fecal coliform	3 [<2 – 12]	2 [<2 – 4]
Fecal streptococcus	2 [<2 – 4]	Below detection

4.0 Historical Water Quality Data Analysis

Annual growing season data from Station 3 were used for the long-term analyses of Secchi disk transparency, total phosphorus concentrations, chlorophyll a concentrations, TSI, nitrogen concentrations, and phytoplankton and zooplankton counts. Growing season data were used for these analyses because they reflect trophic conditions observed by most lake users. Data collected at Station 3 were used because this has been the station most consistently documented during the Lake Wallenpaupack long-term monitoring program. Station 3 also exhibits water quality conditions that best approximate average conditions throughout the lake.

4.1 Secchi Disk Transparency Trends

Although the increasing (improving) trend in average growing season transparencies seen during the past few years in Lake Wallenpaupack did not continue in 2006, the overall trend since 1980 is still one of improvement, as illustrated in Figure 17. Higher Secchi disk transparencies indicate greater water clarity. The 2006 average growing season Secchi disk transparency at Station 3 was 2.08 meters, which was comparable to the long-term average of 2.07 meters and within the mesotrophic range. It is unclear whether or not the improvement in transparency in Lake Wallenpaupack is due to nutrient reduction strategies reducing algal populations or to environmental conditions.

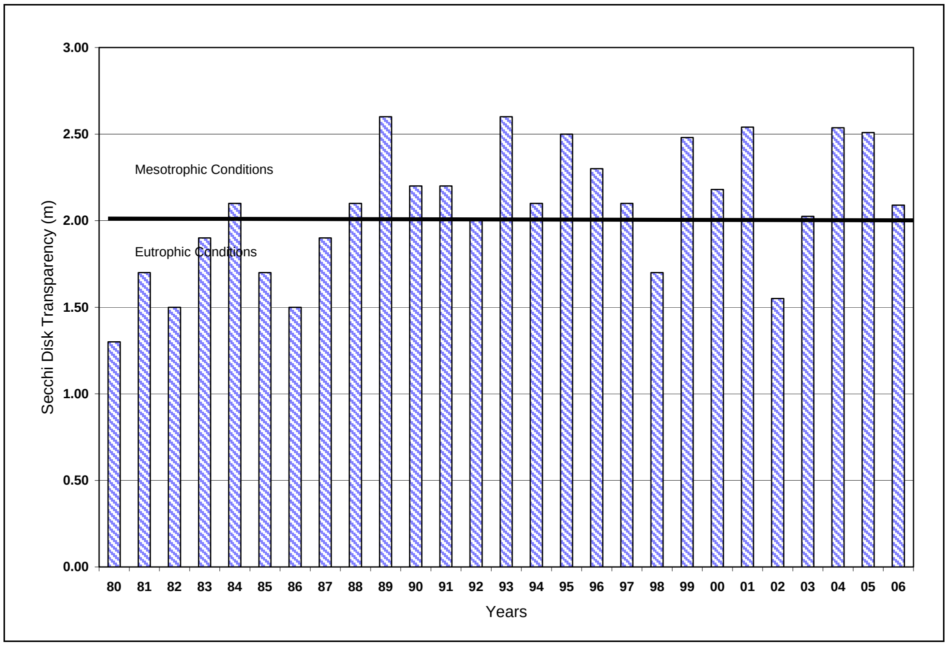


Figure 17 Trends in Seasonal Average Secchi Disk Transparency at Station 3 in Lake Wallenpaupack

4.2 Phosphorus Trends

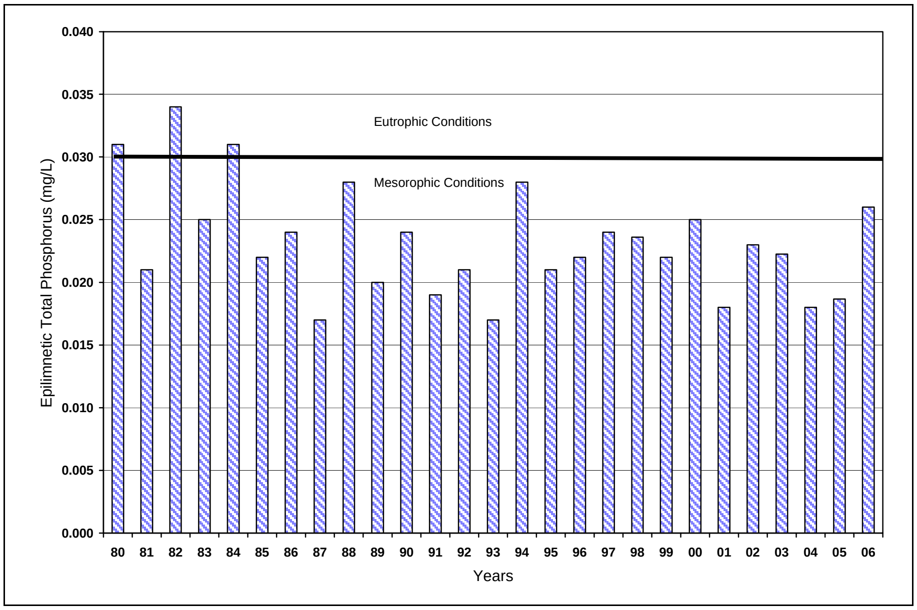


Figure 18 Trends in Seasonal Average Epilimnetic Total Phosphorus Concentrations at Station 3 in Lake Wallenpaupack

The average epilimnetic total phosphorus concentration at Station 3 was 0.026 mg/L during 2006, which was above the long-term average of 0.023 mg/L. The high total phosphorus average may have been related to the above-average rainfall during the 2006 growing season. The average surface total phosphorus concentrations at Station 3 in Lake Wallenpaupack have varied somewhat since 1980, but they continue to be stabilized within the mesotrophic range since the mid-1980s, and appear to be generally decreasing over time. The average total phosphorus concentrations continued to occur at or below 0.026 mg/L since 1995, as illustrated in Figure 18.

4.3 Chlorophyll a Trends

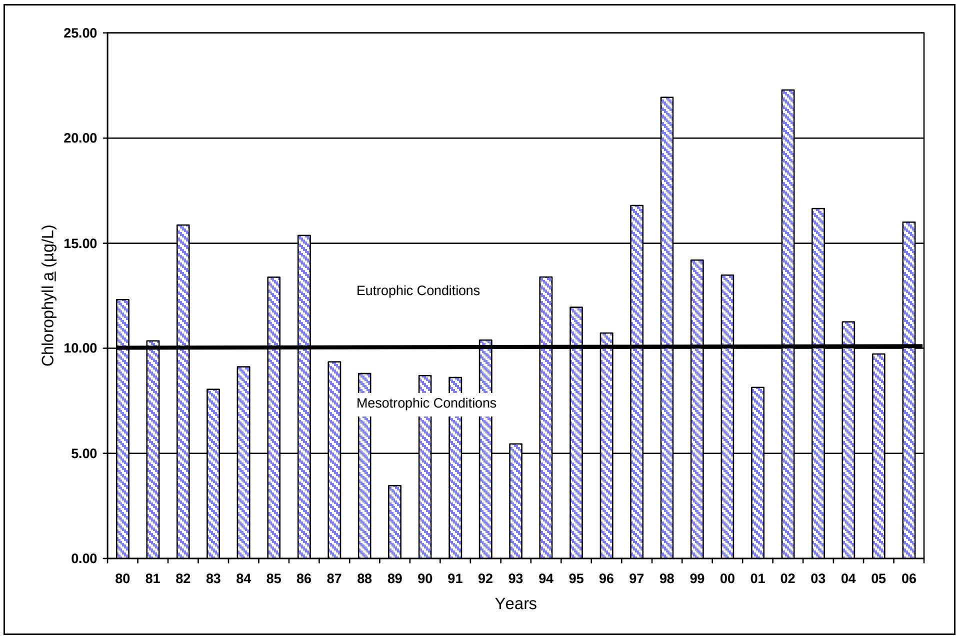


Figure 19 Trends in Seasonal Average Chlorophyll a Concentrations at Station 3 in Lake Wallenpaupack

The average growing season chlorophyll a concentrations have varied considerably at Station 3 since 1980, as shown in Figure 19. The 2006 average chlorophyll a concentration was 16.03 Fg/L, which was higher than the long-term average of 11.91 Fg/L and was within the eutrophic range. Climatic conditions, both favorable and unfavorable, have a strong effect on the phytoplankton populations, and therefore, the chlorophyll a concentration, in a given lake.

Chlorophyll a concentrations in Lake Wallenpaupack have been generally higher since the mid-1990s than they were between 1980 and 1993. Average chlorophyll a concentrations were within the EPA mesotrophic classification range of 6 to 10 Fg/L during 12 of the past 27 growing seasons. Therefore, according to the EPA criterion, Lake Wallenpaupack would be classified as eutrophic during 15 of the growing seasons. During the past 13 years, the seasonal average chlorophyll a concentration has been within the mesotrophic range only twice.

Average chlorophyll a concentrations have generally been higher since 1987 when the implementation of watershed BMPs was initiated by the Lake Wallenpaupack Watershed Management District. Since total phosphorus concentrations during 1997 through 2002 did not correspond to chlorophyll a concentrations, this deviation indicates that something other than phosphorus limited algal growth. Future years of monitoring will determine whether or not this improvement is the result of aberrant weather patterns or an improvement in water quality.

4.4 Trends in Trophic State Index (TSI)

Average growing season TSI values were examined to determine if the trophic state of Lake Wallenpaupack has changed during the 1980-2006 monitoring period. Indices were calculated from seasonal averages of Secchi disk transparency, total phosphorus concentrations, and chlorophyll a concentrations at Station 3. The total phosphorus and Secchi disk transparency TSI values indicate that the productivity of Lake Wallenpaupack was generally lower in the most recent 17 years (1990-2006) than in the previous ten years (1980s). Conversely, however, the chlorophyll a TSI values indicate that Lake Wallenpaupack has been more productive in recent years. This further indicates that something other than phosphorus may be limiting algal growth in Lake Wallenpaupack at certain times of the year. TSI values for each year are presented in Figure 20.

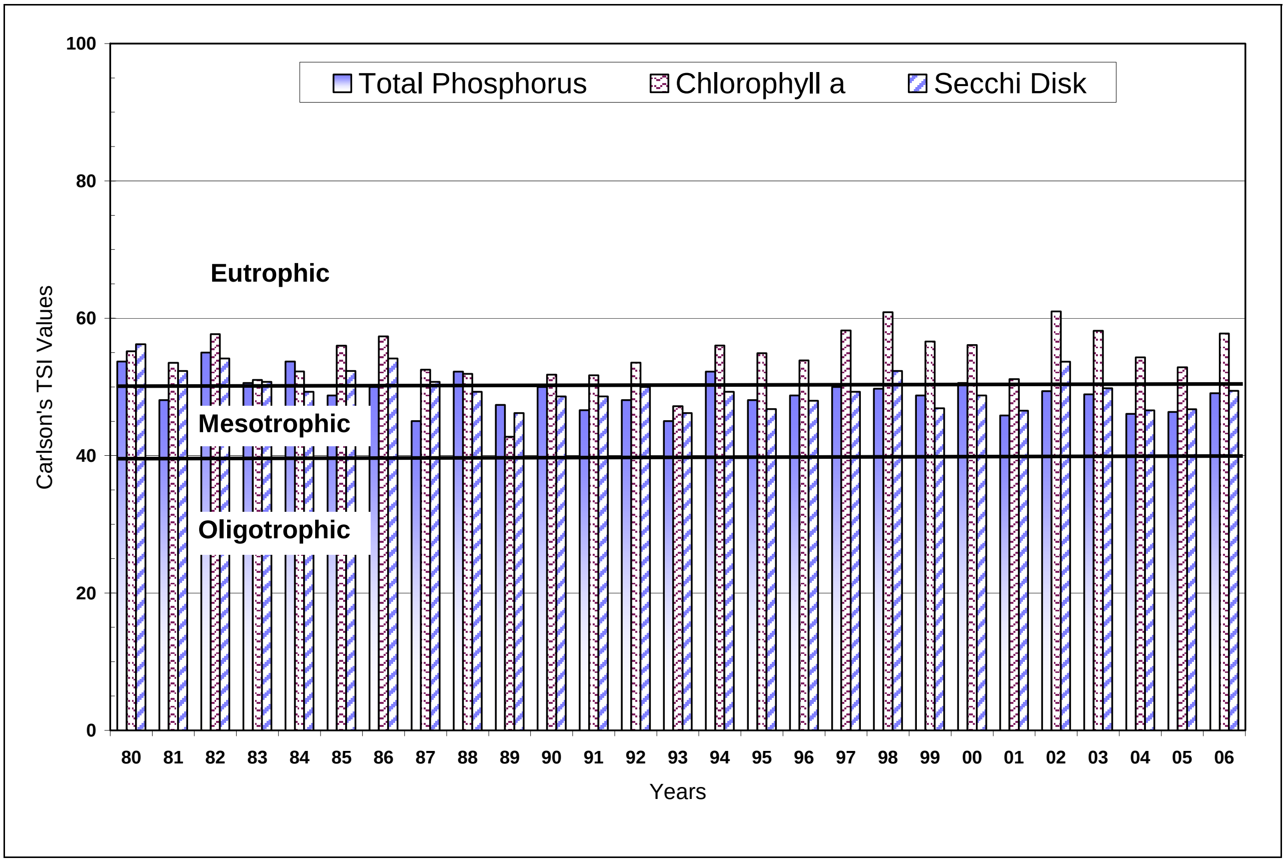


Figure 20 Seasonal Trends in Carlson's TSI Values at Station 3 in Lake Wallenpaupack

4.5 Total Nitrogen Trends

Total nitrogen is a measure of both the inorganic (ammonia, nitrate, and nitrite) and organic forms of nitrogen. This measurement determines the total amount of nitrogen in a lake, and examining trends in total nitrogen in conjunction with trends in other water quality parameters can provide an indication of whether or not nitrogen may be limiting algal growth in the lake. The average surface total nitrogen concentration during the growing season at Station 3 in Lake Wallenpaupack during 2006 was 0.63 mg/L. This was higher than the long-term average of 0.51 mg/L.

As shown in Figure 21, a general increase in seasonal average total nitrogen occurred between 1992 and 2002, and this trend continued in 2006. This trend mirrors the trends in chlorophyll a concentrations and phytoplankton densities seen during this time period, which supports the theory that Lake Wallenpaupack may be nitrogen-limited during part of the year. However, total phosphorus concentrations increased in 2006 as well. The majority of the nitrogen in Lake Wallenpaupack has historically occurred in the organic form, most likely entering the lake via runoff from agricultural operations and wastewater treatment plant discharges. 2006 was a particularly wet growing season, so excessive amounts of phosphorus and nitrogen likely entered the lake via stormwater runoff.

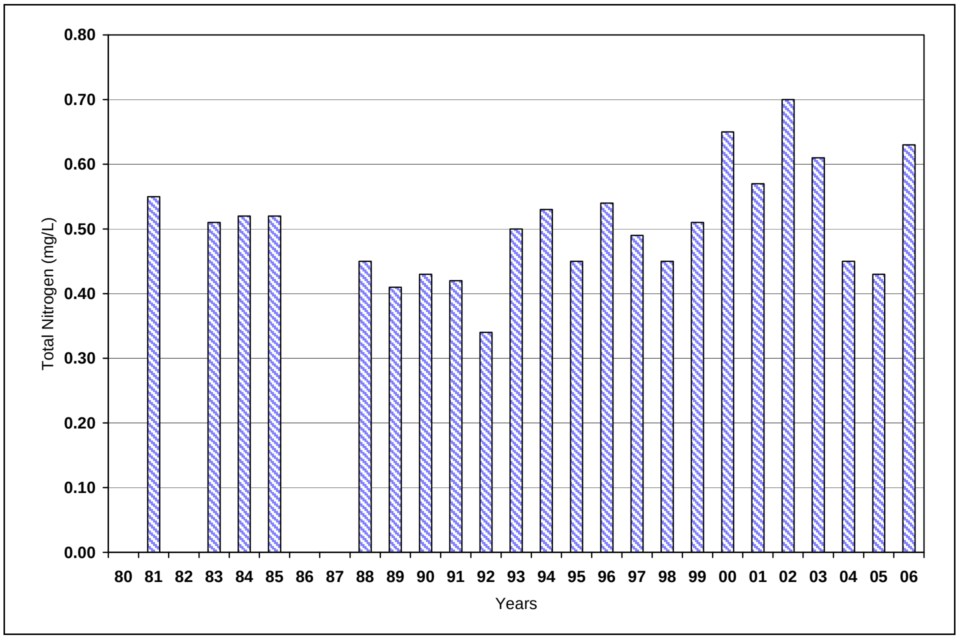


Figure 21 Trends in Seasonal Average Total Nitrogen Concentrations at Station 3 in Lake Wallenpaupack

4.6 Phytoplankton and Zooplankton Trends

A general increase in both the average phytoplankton density during the growing season, and the peak phytoplankton density during the growing season had been documented over the 26-year period of record in Lake Wallenpaupack, as shown in Figure 22. However, peak phytoplankton densities have decreased since 2002, mirroring the chlorophyll a and total nitrogen trends. As shown in Figure 23, blue-green algae dominated the phytoplankton population in 2006, but as in the past several years the blue-green algae domination has occurred to a lesser extent than during the 1980s.

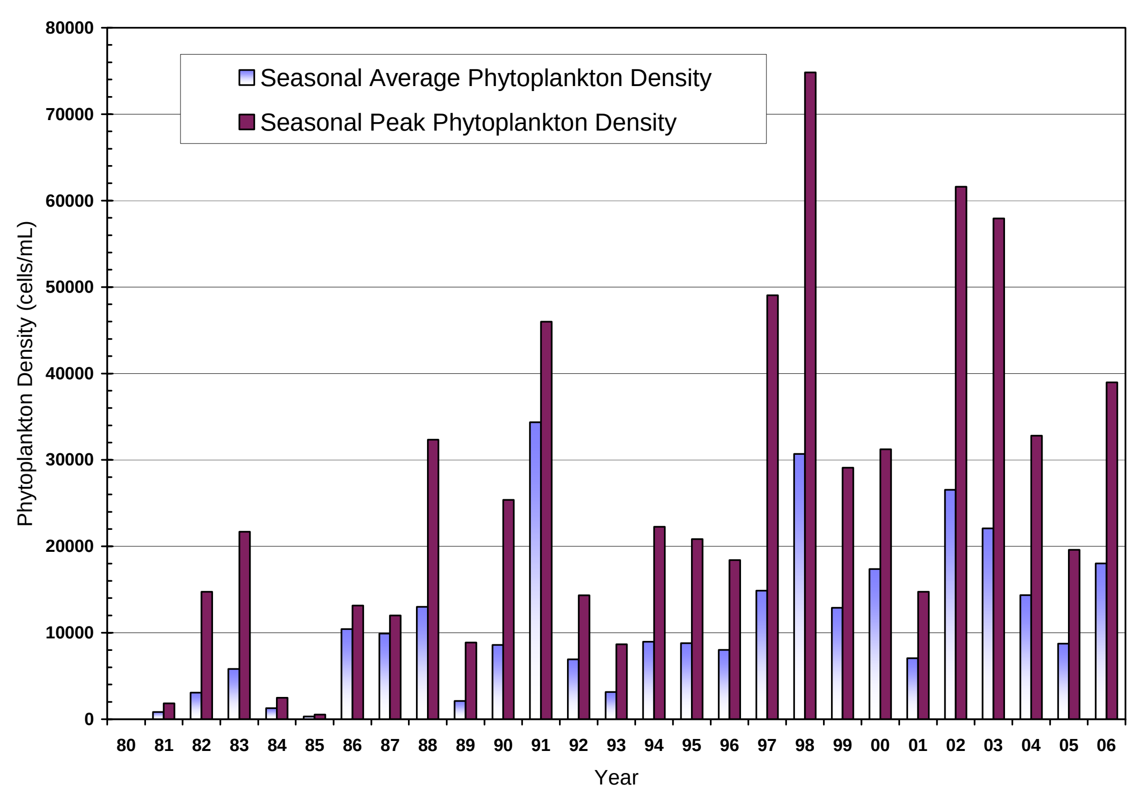


Figure 22 Trends in Seasonal Average and Peak Phytoplankton Density at Station 3 in Lake Wallenpaupack

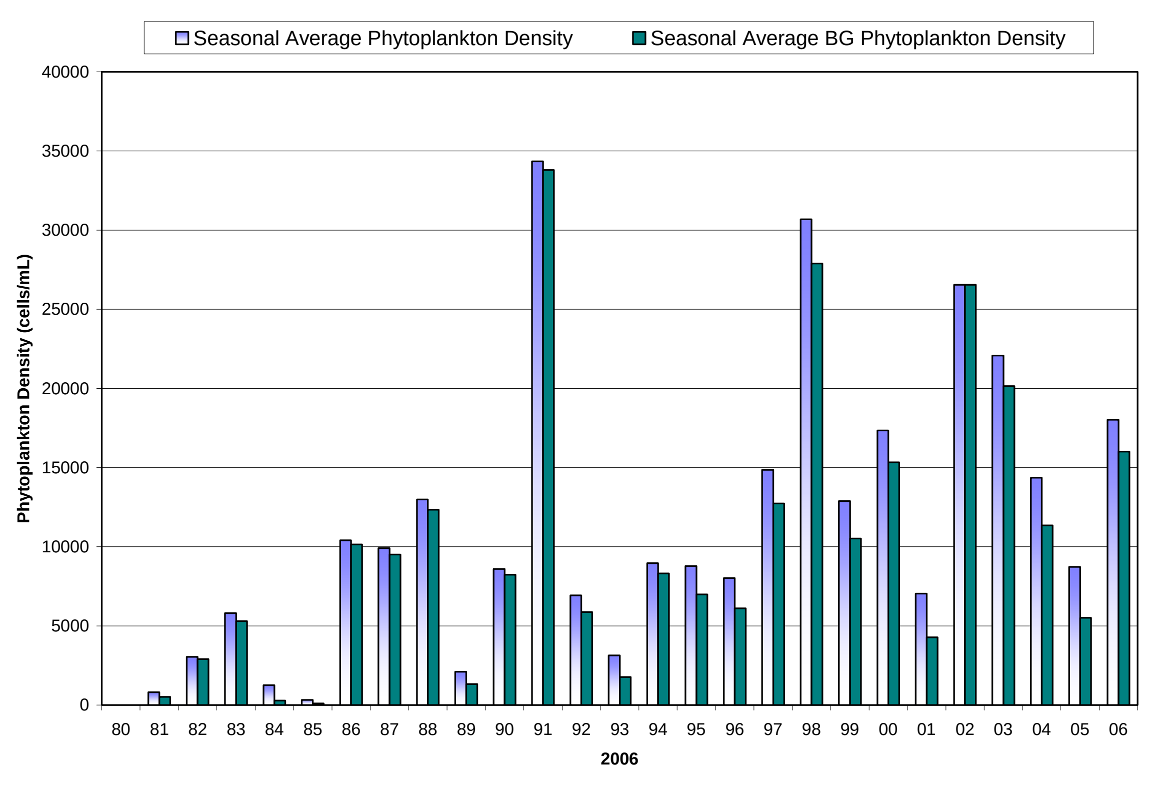


Figure 23 Trends in Seasonal Average Total and Bluegreen Phytoplankton Density at Station 3 in Lake Wallenpaupack

Zooplankton populations in Lake Wallenpaupack have been variable over the period of record. Seasonal average zooplankton biomass and seasonal peak zooplankton biomass over the past 19 years are shown in Figure 24. Zooplankton biomasses were high in both 1993 and 1997, but biomasses have been low in the past several years. It is difficult to determine what the cause of the trends might be, although both 1993 and 1997 were years when the seasonal average phytoplankton densities were relatively low. Zooplankton populations are strongly influenced by weather conditions, the availability of food sources (phytoplankton), and fish populations. Zooplankton prefer not to eat blue-green phytoplankton, so their numbers tend to be low when blue-green algae populations are high, which may have been the case in recent years.

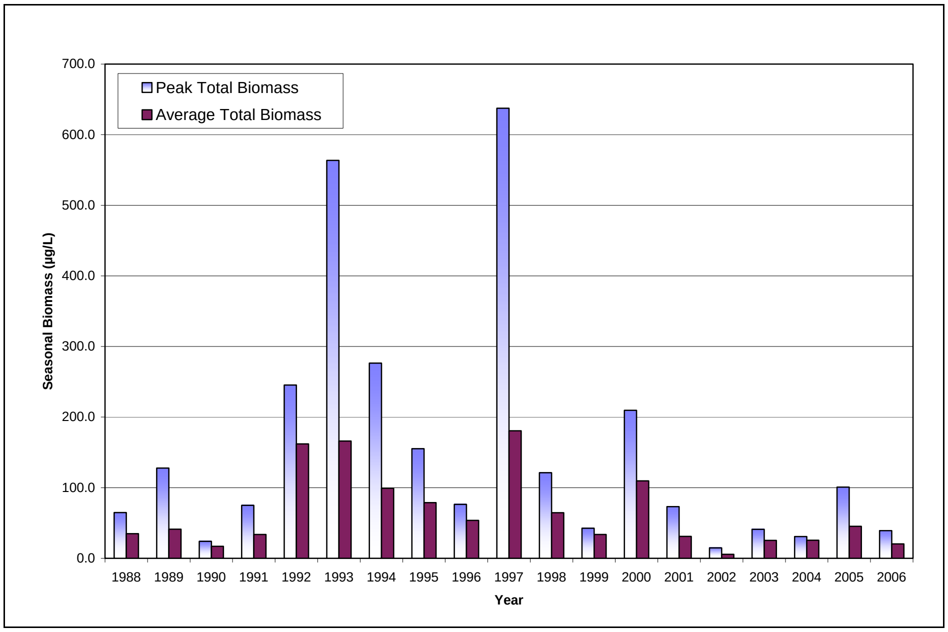


Figure 24 Trends in Seasonal Average and Peak Zooplankton Biomass at Station 3 in Lake Wallenpaupack

5.0 Conclusions

From 1976 to 1980, the water quality in Lake Wallenpaupack was reported to have declined rapidly. Since then, the water quality in Lake Wallenpaupack has not continued to deteriorate and appears to have improved slightly during more recent years, especially with respect to a reduction in total phosphorus concentrations in the lake. The improvement in water quality coincides with the ongoing installation of Best Management Practices within the Lake Wallenpaupack watershed that began in 1987. While average growing season total phosphorus concentrations at Station 3 have remained around 0.020 mg/L since the mid 1980s, maximum concentrations have decreased compared to the early 1980s. Although the 2006 growing season average was higher than the past several years, it remained in the mesotrophic range. Average growing season Secchi disk transparencies have generally been higher (more favorable) over the past 17 years, compared to the transparencies in the early 1980s, and that trend continued into 2006. Chlorophyll a concentrations decreased between 2002 and 2005, but increased in 2006, measuring well into the eutrophic range. Total nitrogen, chlorophyll a concentrations, and phytoplankton densities have shown a similar pattern during the past few years, which supports the theory that Lake Wallenpaupack may be nitrogen-limited during part of the year.

As observed in previous years, blue-green algae again dominated the phytoplankton in Lake Wallenpaupack during the 2006 growing season. Phytoplankton populations have been increasing in recent years, both in terms of average density and peak density during algae blooms. The 2006 phytoplankton densities and biomasses were higher than during the past two years.

Zooplankton densities and biomasses in Lake Wallenpaupack were low for the sixth year in a row, and the mean lengths indicated an unbalanced fishery in the lake with an overabundance of panfish consuming the zooplankton. Dissolved oxygen became depleted in the hypolimnion during the period of stratification, as during past years. This hypolimnetic oxygen depletion led to the release of phosphorus from the sediments on the lake bottom.

Overall, the water quality parameters and TSI values used to characterize the trophic state of Lake Wallenpaupack indicate that productivity was generally higher than long-term averages during 2006. However, it is possible that the record high rainfall during the 2006 growing season negatively impacted water quality in the lake. The trophic state of Lake Wallenpaupack during the 2006 growing season is best described as borderline eutrophic.

In conclusion, the overall water quality of Lake Wallenpaupack continues to be improved from the early 1980s. Phosphorus has been reduced and maintained at lower concentrations in the surface waters with respect to the growing season averages of the early 1980s. Transparency is also generally improved over historic levels. However, the fact that chlorophyll a levels and total nitrogen concentrations have been showing increasing trends, and the increase in both peak and frequency of blue-green algae blooms in the lake is a concern.

The continued control of nonpoint source pollution and other nutrient inputs throughout the Lake Wallenpaupack watershed must remain a top priority to maintain the desired uses of the lake and a healthy aquatic ecosystem. Best Management Practices (BMPs) that reduce phosphorus inputs to the lake seem to be helping and should be continued. In addition, sources of nitrogen loading to the lake should be investigated as a possible cause of algae blooms in Lake Wallenpaupack during the growing season. LWWMD should investigate the wastewater treatment plant DMRs to see whether or not any further nitrogen reductions can be made. BMPs that provide both phosphorus and nitrogen reduction, such as constructed wetlands, should be targeted. Increased efforts should be made to implement agricultural nonpoint source BMPs in the watershed to further reduce nitrogen loadings, since agricultural runoff tends to be one of the biggest sources of nitrogen. Finally, lake monitoring should be continued to determine the effects of environmental conditions on the trophic state parameters in Lake Wallenpaupack and to document any improvements in water quality now that more BMPs have been implemented within the watershed.

6.0 References

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APPENDIX A

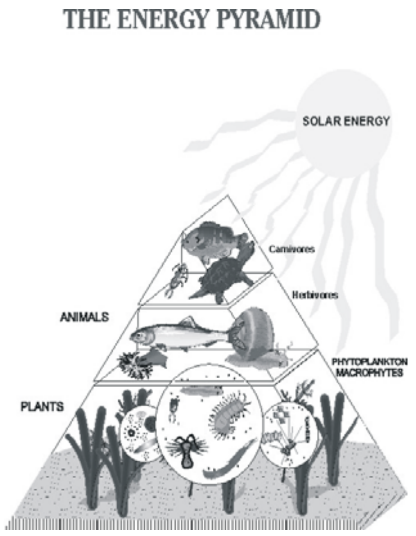
LAKE ECOLOGY PRIMER

Lake Ecology Primer

Ecological Cycle

In a lake, a basic ecological cycle exists. Nutrients such as phosphorus and nitrogen along with sunlight are used by the aquatic plants - algae (microscopic aquatic plants) and macrophytes (large aquatic plants) - to grow. Small aquatic animals such as invertebrates (rotifers, protozoa, etc.), snails, and insects eat the algae and reproduce. Small forage fish eat the small animals, and in turn are eaten by larger game fish and other animals.

In a healthy lake, there is a balance in this ecological system. However, when too many nutrients enter a lake, the algae and/or large aquatic plants grow to a point of excess. There are too many aquatic plants in the lake.



If the small animals ate all of the algae and weeds and were in-turn eaten by the small and large fish, then the lake would have a nice, large fishery. This relationship is called the ecological pyramid. With a larger population of algae you would expect a larger population of fish. But the problem is that the excessive plant life is not transferred up the food chain. The small aquatic animals do not eat much of the excess algae (they do not like some of the algae, especially the blue-green algae). Therefore, we get a buildup of algae and other plants that destroy the ecological balance of the lake ecosystem. This can result in a reduction in the fish population. It often results in a change in the type of fish found in the lake.

In order to understand the processes that occur in a lake, we must first understand the concept of lake succession or aging.

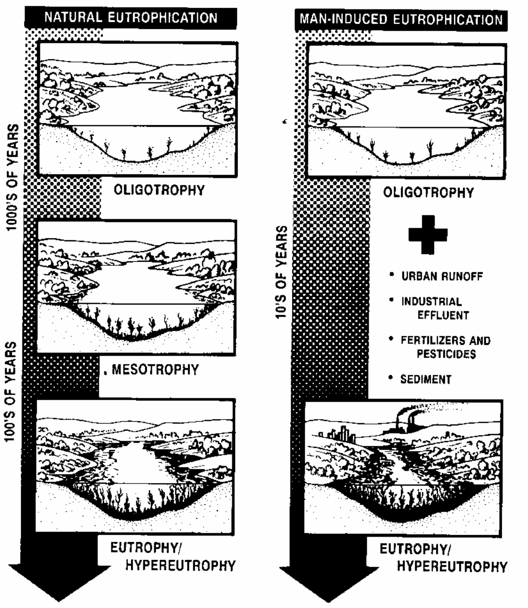
Lake Succession Over Time

All lakes go through an aging process called ecological succession. It is a natural process whereby a lake starts out as an “ecologically” young lake with little vegetation (such as algae and aquatic plants), low nutrients, clear water, and very little unconsolidated (loose) sediment on the bottom. It should be noted that ecological age is different than chronological age. It can be said, therefore, that lakes have both a chronological and ecological age. The chronological age is simply the number of years a lake has existed. The ecological age, on the other hand, is a measure of the physical, chemical, and biological conditions of a lake.

A lake may be young in actual chronological years (i.e. built only 3 years ago) but it could be ecologically old in the sense of having lots of algae and aquatic plants and bottom sediments.

As a lake ages, more nutrients and sediments enter the lake due to erosion and stormwater runoff from the lake's watershed. As more nutrients and sediments enter a lake, several things occur. Usually, the additional nutrients, such as phosphorus and nitrogen, cause an increase in the amount of algae and aquatic weeds. The additional sediment entering the lake settles to the bottom of the lake, increasing the amount of sediment on the lake's bottom.

Thus as a lake ages, it slowly starts to fill up with sediments, algae and aquatic weeds. Initially, the aquatic vegetation remains submerged beneath the water surface. As the lake further fills up with sediment, emergent vegetation appears above the water surface.



Ultimately, due to sedimentation of the lake (from incoming sediment from the watershed and from dying algae, aquatic plants, and animals), the lake transforms into a pond or swamp and eventually, over hundreds or thousands of years, into a forest.

Lake Aging

Lake succession or aging is a natural process that occurs in all lakes. However, the influence of man's activities in the watershed can significantly accelerate the aging process.

The lake aging process is accelerated by:

Wastewater Treatment Plant Discharges
Malfunctioning Septic Systems
Agricultural Activities (cropland and pastureland)
Construction Activities
Developed Land
Roadways
Streambank Erosion
Landfills

Thus, man's activities in a watershed can add sediments and nutrients (phosphorus and nitrogen) to a lake, resulting in accelerated aging or what we call "cultural eutrophication". Man-induced influences can significantly increase the rate at which a lake ages.

Lake Classification

Lakes are classified by the amount of nutrients (or food) contained in the lake. The Greek word for food is "trophic". Therefore, we classify lakes by their "trophic" or food/nutrient state. Such as:

Oligo = little (little nutrients)
Meso = medium (medium nutrients)
Eu = too much (too much nutrients)

The trophic state refers to the “ecological” age of the lake, not its chronological age. Therefore, an oligotrophic lake is a lake that is ecologically young. For example, a eutrophic, or ecologically old lake, could be 2 years old.

Lakes are classified by nutrient level and the presence of aquatic plants as described below.

Oligotrophic lake
- ecologically young lake
- low level of nutrients
- low population of algae and aquatic plants

Mesotrophic lake
- ecologically middle-aged lake
- moderate level of nutrients
- moderate population of algae and aquatic plants

Eutrophic lake
- ecologically old lake
- high level of nutrients
- high population of algae and aquatic plants

Lake Problems

Excessive nutrients entering a lake from its watershed cause algae blooms, excessive aquatic plants (macrophytes), lake siltation(settling of sediments in lake, loss of lake volume and capacity), and fishery problems (low dissolved oxygen levels change the fish from game fish to trash fish such as carp). All this results in loss of recreation.

Causes of Lake Problems

Lake problems are caused by point sources and nonpoint sources. Point sources are wastewater treatment plant discharges. Nonpoint sources come from are any activity that causes erosion and stormwater runoff or leaching from septic systems.

Nonpoint Sources

Nonpoint sources, as mentioned earlier, cause soil erosion and stormwater runoff. Nonpoint sources come from:

Agricultural Activities
Landfills

Construction Activities
Developed Land
Roadways
Streambank Erosion
Shoreline Erosion
Wildlife

APPENDIX B

GLOSSARY OF LAKE AND WATERSHED MANAGEMENT TERMS

Glossary of Lake and Watershed Terms

Acid neutralizing capacity (ANC): the equivalent capacity of a solution to neutralize strong acids. The components of ANC include weak bases (carbonate species, dissociated organic acids, alumino-hydroxides, borates, and silicates) and strong bases (primarily, OH-). In the National Surface Water Survey, as well as in most other recent studies of acid-base chemistry of surface waters, ANC was measured by the Gran titration procedure.

Acidic deposition: transfer of acids and acidifying compounds from the atmosphere to terrestrial and aquatic environments via rain, snow, sleet, hail, cloud droplets, particles, and gas exchange.

Adsorption: The adhesion of one substance to the surface of another: clays, for example, can adsorb phosphorus and organic molecules

Aerobic: Describes life or processes that require the presence of molecular oxygen.

Algae: Small aquatic plants that occur as single cells, colonies, or filaments. Planktonic algae float freely in the open water. Filamentous algae form long threads and are often seen as mats on the surface in shallow areas of the lake.

Alkalinity: (see *acid neutralizing capacity*).

Allochthonous: Materials (e.g., organic matter and sediment) that enter a lake from atmosphere or drainage basin (see *autochthonous*).

Anaerobic: Describes processes that occur in the absence of molecular oxygen.

Anoxia: A condition of no oxygen in the water. Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.

Anoxic: "Without oxygen." (see *anoxia*).

Autochthonous: Materials produced within a lake e.g., autochthonous organic matter from plankton versus allochthonous organic matter from terrestrial vegetation.

Bathymetric map: A map showing the bottom contours and depth of a lake; can be used to calculate lake volume.

Benthic: Macroscopic (seen without aid of a microscope) organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate. Also referred to as *benthos*.

Biochemical oxygen demand (BOD): The rate of oxygen consumption by organisms during the decomposition (respiration) of organic matter, expressed as grams oxygen per cubic meter of water per hour.

Biomass: The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

Biota: All plant and animal species occurring in a specified area.

Chemical oxygen demand (COD): Non-biological uptake of molecular oxygen by organic and inorganic compounds in water.

Chlorophyll: A green pigment in algae and other green plants that is essential for the conversion of sunlight, carbon dioxide and water to sugar (photosynthesis). Sugar is then converted to starch, proteins, fats and other organic molecules.

Chlorophyll a: A type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of algae.

Cluster development: Placement of housing and other buildings of a development in groups to provide larger areas of open space

Consumers: Animals that cannot produce their own food through photosynthesis and must consume plants or animals for energy (see *producers*).

Decomposition: The transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.

Delphi: A technique that solicits potential solutions to a problem situation from a group of experts and then asks the experts to rank the full list of alternatives.

Density flows: A flow of water of one density (determined by temperature or salinity) over or under water of another density (e.g. flow of cold river water under warm reservoir surface water).

Detritus: Non-living dissolved and particulate organic material from the metabolic activities and deaths of terrestrial and aquatic organisms.

Drainage basin: Land area from which water flows into a stream or lake (see *watershed*).

Drainage lakes: Lakes having a defined surface inlet and outlet.

Ecology: Scientific study of relationships between organisms and their environment: also defined as the study of the structure and function of nature.

Ecosystem: A system of interrelated organisms and their physical-chemical environment. In limnology, the ecosystem is usually considered to include the lake and its watershed.

Effluent: Liquid wastes from sewage treatment, septic systems or industrial sources that are released to a surface water.

Environment: Collectively, the surrounding conditions, influences and living and inert matter that affect a particular organism or biological community.

Epilimnion: Uppermost, warmest, well-mixed layer of a lake during summertime thermal stratification. The epilimnion extends from the surface to the thermocline.

Erosion: Breakdown and movement of land surface which is often intensified by human disturbances.

Eutrophic: From Greek for well-nourished; describes a lake of high photosynthetic activity and low transparency.

Eutrophication: The process of physical, chemical, and biological changes associated with nutrients, organic matter, silt enrichment, and sedimentation of a lake or reservoir. If the process is accelerated by man-made influences it is termed cultural eutrophication.

Fall overturn: The autumn mixing, top to bottom, of lake water caused by cooling and wind-derived energy.

Fecal coliform test: Most common test for the presence of fecal material from warm-blooded animals. Fecal coliforms are measured because of convenience; they are not necessarily harmful but indicate the potential presence of other disease-causing organisms.

Floodplain: Land adjacent to lakes or rivers that is covered as water levels rise and overflow the normal water channels.

Flushing rate: The rate at which water enters and leaves a lake relative to lake volume, usually expressed as time needed to replace the lake volume with inflowing water.

Flux: The rate at which a measurable amount of a material flows past a designated point in a given amount of time.

Food chain: The general progression of feeding levels from primary producers, to herbivores, to planktivores, to the larger predators.

Food web: The complex of feeding interactions existing among the lake's organisms.

Forage fish: Fish, including a variety of panfish and minnows, that are prey for game fish.

Groundwater: Water found beneath the soil surface; saturates the stratum at which it is located; often connected to lakes.

Hard water: Water with relatively high levels of dissolved minerals such as calcium, iron, and magnesium.

Hydrographic map: A map showing the location of areas or objects within a lake.

Hydrologic cycle: The circular flow or cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Runoff, surface water, groundwater, and water infiltrated in soils are all part of the hydrologic cycle.

Hypolimnion: Lower, cooler layer of a lake during summertime thermal stratification.

Hypoxia: A condition of low oxygen in the water (< 2.0 mg/L). Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.

Influent: A tributary stream.

Internal nutrient cycling: Transformation of nutrients such as nitrogen or phosphorus from biological to inorganic forms through decomposition, occurring within the lake itself. Also refers to the release of sediment-bound nutrients into the overlying water that typically occurs within the anoxic hypolimnion of stratified, mesotrophic and eutrophic lakes.

Isothermal: The same temperature throughout the water column of a lake.

Lake: A considerable inland body of standing water, either naturally formed or manmade.

Lake district: A special purpose unit of government with authority to manage a lake(s) and with financial powers to raise funds through mill levy, user charge, special assessment, bonding, and borrowing. May or may not have police power to inspect septic systems, regulate surface water use, or zone land.

Lake management: The practice of keeping lake quality in a state such that attainable uses can be achieved and maintained.

Lake protection: The act of preventing degradation or deterioration of attainable lake uses.

Lake restoration: The act of bringing a lake back to its attainable uses.

Lentic: Relating to standing water (versus lotic, running water).

Limnologist: One who studies limnology.

Limnology: Scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes. Also termed freshwater ecology.

Littoral zone: That portion of a waterbody extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

Loading: The total amount of material (sediment, nutrients, oxygen-demanding material) brought into the lake by inflowing streams, runoff, direct discharge through pipes, groundwater, the air, and other sources over a specific period of time (often annually).

Macroinvertebrates: Aquatic insects, worms, clams, snails, and other animals visible without the aid of a microscope, that may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.

Macrophytes: Rooted and floating aquatic plants, commonly referred to as waterweeds. These plants may flower and bear seed. Some forms, such as duckweed and coontail (*Ceratophyllum*), are free-floating forms without roots in the sediment.

Mandatory property owners association: Organization of property owners in a subdivision or development with membership and annual fee required by covenants on the property deed. The association will often enforce deed restrictions on members' property and may have common facilities such as bathhouse, clubhouse, golf course, etc.

Marginal zone: Area where land and water meet at the perimeter of a lake. Includes plant species, insects and animals that thrive in this narrow, specialized ecological system.

Mesotrophic: Describes a lake of moderate plant productivity and transparency; a trophic state between oligotrophic and eutrophic.

Metalimnion: Layer of rapid temperature and density change in a thermally stratified lake. Resistance to mixing is high in this region.

Morphometry: Relating to a lake's physical structure (e.g., depth, shoreline length).

Nekton: Large aquatic organisms whose mobility is not determined by water movement -- for example, fish and amphibians.

Nominal group process: A process of soliciting concerns/issues/ideas from members of a group and ranking the resulting list to ascertain group priorities. Designed to neutralize dominant personalities.

Nutrient: An element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus.

Nutrient budget: Quantitative assessment of nutrients (e.g., nitrogen or phosphorus) moving into, being retained in, and moving out of an ecosystem; commonly constructed for phosphorus because of its tendency to control lake trophic state.

Nutrient cycling: The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic: "Poorly nourished," from the Greek. Describes a lake of low plant productivity and high transparency.

Ooze: Lake bottom accumulation of inorganic sediments and the partially decomposed remains of algae, weeds, fish, and aquatic insects. Sometimes called muck (see *sediment*).

Ordinary high water mark: Physical demarcation line, indicating the highest point that water level reaches and maintains for some time. Line is visible on rocks, or shoreline, and by the location of certain types of vegetation.

Organic matter: Molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.

Paleolimnology: The study of the fossil record within lake sediments.

Pathogen: A microorganism capable of producing disease. They are of great concern to human health relative to drinking water and swimming beaches.

Pelagic zone: This is the open area of a lake, from the edge of the littoral zone to the center of the lake.

Perched: A condition where the lake water is isolated from the groundwater table by impermeable material such as clay.

pH: A measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH = 1) to very alkaline (pH = 14). pH 7 is neutral and most lake waters range between 6 and 9. pH values less than 6 are considered acidic, and most life forms can not survive at pH of 4.0 or lower.

Photic zone: The lighted region of a lake where photosynthesis takes place. Extends down to a depth where plant growth and respiration are balanced by the amount of light available.

Phytoplankton: Microscopic algae and microbes that float freely in open water of lakes and oceans.

Plankton: Microscopic plants, microbes and animals floating or swimmng freely about in lakes and oceans.

Primary productivity: The rate at which algae and macrophytes fix or convert light, water and carbon dioxide to sugar in plant cells (through photosynthesis). Commonly measured as milligrams of carbon per square meter per hour.

Primary producers: Green plants that manufacture their own food through photosynthesis.

Profundal zone: Area of lake water and sediment occurring on the lake bottom below the depth of light penetration.

Reservoir: A manmade lake where water is collected and kept in quantity for a variety of uses, including flood control, water supply, recreation and hydroelectric power.

Residence time: Commonly called the hydraulic residence time -- the amount of time required to completely replace the lake's current volume of water with an equal volume of new water.

Respiration: Process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.

Secchi depth: A measure of transparency of water obtained by lowering a black and white, or all white, disk (Secchi disk, 20 cm in diameter) into water until it is no longer visible. Measured in units of meters or feet.

Sediment: Bottom material in a lake that has been deposited after the formation of a lake basin. It originates from remains of aquatic organisms, chemical precipitation of dissolved minerals, and erosion of surrounding lands (see *ooze* and *detritus*).

Seepage lakes: Lakes having either an inlet or outlet (but not both) and generally obtaining their water from groundwater and rain or snow.

Soil retention capacity: The ability of a given soil type to adsorb substances such as phosphorus, thus retarding their movement to the water.

Stratification: Layering of water caused by differences in water density. Thermal stratification is typical of most deep lakes during summer. Chemical stratification can also occur.

Swimmers itch: A rash caused by penetration into the skin of the immature stage (cercaria) of a flatworm (not easily controlled due to complex life cycle). A shower or alcohol rubdown should minimize penetration.

Thermal stratification: Lake stratification caused by temperature-created differences in water density.

Thermocline: A horizontal plane across a lake at the depth of the most rapid vertical change in temperature and density in a stratified lake (see *metalimnion*.).

Topographic map: A map showing the elevation of the landscape at specified contour intervals (typically 10 or 20 foot intervals, may be expressed in feet or meters). Can be used to delineate the watershed.

Trophic state: The degree of eutrophication of a lake. Transparency, chlorophyll a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion can be used to assess state.

Voluntary lake property owners association: Organization of property owners in an area around a lake that members join at their option.

Water column: Water in the lake between the interface with the atmosphere at the surface and the interface with the sediment layer at the bottom. Idea derives from vertical series of measurements (oxygen, temperature, phosphorus) used to characterize lake water.

Water table: The upper surface of groundwater; below this point, the soil is saturated with water.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Zooplankton: Microscopic animals that float or swim freely in lake water, graze on detritus particles, bacteria, and algae, and may be consumed by fish.

APPENDIX C

2006 WATER QUALITY DATA

Lake Wallenpaupack Watershed Management District

2006 Lake Wallenpaupack Water Quality Summary
Surface Water Quality Data - 2006 All Stations
FXB Project No. PA1012-66

SURFACE

Date	Station	Layer code	Depth (m)	TP (mg/L)	DRP (mg/L)	NO2/NO3 (mg/L)	NH3 (mg/L)	TKN (mg/L)	ON (mg/L)	TN (mg/L)	ALK (mg/L)	pH (std. units)	TSS (mg/L)	FC (#/100 mL)	FS (#/100 mL)
25-Jan-06	3	S	0.5	0.016	0.003	0.150		0.70	0.60	0.85	14	6.7	1.4		
16-Feb-06	3	S	0.5	0.016	0.003	0.180		0.44	0.34	0.62	14	6.6	2.2		
22-Mar-06	3	S	0.5	0.014	0.003	0.160		0.56	0.46	0.72	13	6.8	5.6		
19-Apr-06	3	S	0.5	0.014	0.001	0.110		0.51	0.41	0.62	15	7.4	4.0		
10-May-06	3	S	0.5	0.014	< 0.001	0.040		0.40	0.30	0.44	16	6.7	2.4		
24-May-06	3	S	0.5	0.017	0.007	0.040		0.46	0.36	0.50	13	6.8	3.8	< 2	< 2
14-Jun-06	3	S	0.5	0.018	0.004	0.010		0.43	0.33	0.44	14	6.9	4.8	< 2	< 2
11-Jul-06	3	S	0.5	0.025	0.003	< 0.010		0.74	0.64	0.75	14	6.8	6.2	< 2	< 2
26-Jul-06	3	S	0.5	0.024	0.003	< 0.010		0.55	0.45	0.56	12	7.1	2.6	< 2	< 2
3-Aug-06	3	S	0.5	0.008	0.002	< 0.010		0.51	0.41	0.52	15	7.0	2.8	< 2	< 2
16-Aug-06	3	S	0.5	0.038	0.006	< 0.010		0.43	0.33	0.44	13	7.0	5.0	< 2	< 2
31-Aug-06	3	S	0.5	0.026	0.025	< 0.010		0.67	0.57	0.68	11	6.8	4.0	< 2	< 2
18-Sep-06	3	S	0.5		0.011	0.010		0.85	0.75	0.86	16	7.0	3.0	< 2	< 2
2-Oct-06	3	S	0.5	0.029	0.001	< 0.010		0.80	0.70	0.81	12	6.7	4.8	< 2	< 2
19-Oct-06	3	S	0.5	0.037	0.002	0.030		0.76	0.66	0.79	15	7.2	8.2	< 2	< 2
31-Oct-06	3	S	0.5	0.034	0.003	0.085		1.08	0.98	1.16	15	6.9	3.8	12	4
15-Nov-06	3	S	0.5	0.036	0.004	0.060		0.82	0.72	0.88	13	5.9	9.4		
15-Dec-06	3	S	0.5	0.024	0.003	0.090		0.55	0.45	0.64	13	7.0	1.5		
ANNUAL		**MEAN**		**0.023**	**0.005**	**0.06**		**0.63**	**0.53**	**0.68**	**14**	**6.9**	**4.2**	**3**	**2**
		MINIMUM		**0.008**	**0.001**	**0.01**		**0.40**	**0.30**	**0.44**	**11**	**5.9**	**1.4**	**< 2**	**< 2**
		MAXIMUM		**0.038**	**0.025**	**0.18**		**1.08**	**0.98**	**1.16**	**16**	**7.4**	**9.4**	**12**	**4**
GROWING SEASON		**MEAN**		**0.025**	**0.006**	**0.02**		**0.64**	**0.54**	**0.66**	**14**	**6.9**	**4.3**	**3**	**2**
		MINIMUM		**0.008**	**0.001**	**0.01**		**0.40**	**0.30**	**0.44**	**11**	**6.7**	**2.4**	**2**	**2**
		MAXIMUM		**0.038**	**0.025**	**0.09**		**1.08**	**0.98**	**1.16**	**16**	**7.2**	**8.2**	**12**	**4**
24-May-06	5	S	0.5	0.021	0.010	0.120		0.39		0.51	16	6.5	3.6	4	< 2
11-Jul-06	5	S	0.5	0.040	0.001	0.010		0.72		0.73	14	6.8	3.6	2	2
3-Aug-06	5	S	0.4	0.021	0.002	< 0.010		0.38		0.39	20	7.0	4.4	< 2	< 2
31-Aug-06	5	S	0.4	0.039	0.003	< 0.010		0.85		0.86	14	6.5	4.8	2	2
18-Sep-06	5	S	0.5	0.028	0.012	< 0.010		0.95		0.96	18	7.2	2.4	2	< 2
19-Oct-06	5	S	0.5	0.027	0.002	0.040		0.64		0.68	20	7.0	9.6	< 2	< 2
ANNUAL & GROWING SEASON		**MEAN**		**0.029**	**0.005**	**0.03**		**0.66**		**0.69**	**17**	**6.8**	**4.7**	**2**	**2**
		MINIMUM		**0.021**	**0.001**	**0.01**		**0.38**		**0.39**	**14**	**6.5**	**2.4**	**2**	**2**
		MAXIMUM		**0.040**	**0.012**	**0.12**		**0.95**		**0.96**	**20**	**7.2**	**9.6**	**4**	**2**

TP = Total phosphorus
DRP = Dissolved reactive phosphorus (filtered)
NO2/NO3 = Nitrate/Nitrite nitrogen
NH3 = Ammonia nitrogen
TN = Total Nitrogen
ON = Organic Nitrogen
TKN = Total Kjeldahl nitrogen
ALK = Alkalinity
pH = pH
TSS = Total suspended solids
FC = Fecal Coliform
FS = Fecal Streptococci
S = Surface (epilimnion)

Lake Wallenpaupack Watershed Management District

2006 Lake Wallenpaupack Water Quality Summary
Water Quality Data - 2006 All Stations
FXB Project No. PA1012-66

BOTTOM

Date	Station	Layer (m)	Depth (m)	TP (mg/L)	DRP (mg/L)	NO2/NO3 (mg/L)	NH3 (mg/L)	TKN (mg/L)	ON (mg/L)	TN (mg/L)	pH (std. units)	TSS (mg/L)
25-Jan-06	3	B	12.0	0.020	0.003	0.140	0.11	0.67	0.56	0.81	6.6	1.2
16-Feb-06	3	B	11.0	0.018	0.001	0.160	< 0.10	0.38	0.28	0.54	6.6	2.8
22-Mar-06	3	B	11.0	0.016	0.002	0.150	< 0.10	0.55	0.45	0.70	6.7	6.8
19-Apr-06	3	B	11.5	0.013	0.006	0.120	< 0.10	0.44	0.34	0.56	6.9	< 1.0
10-May-06	3	B	12.0	0.019	0.001	0.120	0.11	0.43	0.32	0.55	6.5	2.8
24-May-06	3	B	12.0	0.018	0.010	0.130	0.11	0.40	0.29	0.53	6.3	< 1.0
14-Jun-06	3	B	12.0	0.018	0.003	0.120	0.17	0.49	0.32	0.61	6.5	6.0
11-Jul-06	3	B	11.5	0.025	0.003	0.020	0.20	0.73	0.53	0.75	6.5	4.4
26-Jul-06	3	B		0.075	0.018	< 0.010	0.32	0.73	0.41	0.74	6.6	5.0
3-Aug-06	3	B	11.0	0.093	0.035	< 0.010	0.28	0.82	0.54	0.83	6.3	3.2
16-Aug-06	3	B	11.0	0.137	0.109	< 0.010	0.36	0.64	0.28	0.65	6.7	2.0
31-Aug-06	3	B	10.5	0.185	0.136	< 0.010	0.37	0.88	0.51	0.89	6.3	3.0
18-Sep-06	3	B	10.0	0.062	0.042	< 0.010	0.55	1.52	0.97	1.53	6.6	4.0
2-Oct-06	3	B	9.0	0.028	< 0.001	< 0.010	0.16	0.67	0.51	0.68	6.8	3.6
19-Oct-06	3	B	10.0	0.031	0.003	0.060	0.21	0.55	0.34	0.61	6.7	10.4
31-Oct-06	3	B	10.0	0.028	0.003	0.070	0.17	0.82	0.65	0.89	6.8	3.2
15-Nov-06	3	B	11.0	0.024	0.005	0.070	< 0.10	0.84	0.74	0.91	5.7	6.0
15-Dec-06	3	B	11.0	0.023	0.004	0.080	< 0.10	0.58	0.48	0.66	6.9	2.8
ANNUAL				**0.046**	**0.021**	**0.07**	**0.20**	**0.67**	**0.47**	**0.75**	**6.6**	**3.8**
				0.013	**0.001**	**0.01**	**0.10**	**0.38**	**0.28**	**0.53**	**5.7**	**1.0**
				0.185	**0.136**	**0.16**	**0.55**	**1.52**	**0.97**	**1.53**	**6.9**	**10.4**
GROWING SEASON				**0.060**	**0.030**	**0.05**	**0.25**	**0.72**	**0.47**	**0.77**	**6.6**	**4.1**
				0.018	**0.001**	**0.01**	**0.11**	**0.40**	**0.28**	**0.53**	**6.3**	**1.0**
				0.185	**0.136**	**0.13**	**0.55**	**1.52**	**0.97**	**1.53**	**6.8**	**10.4**
24-May-06	5	B	8.5	0.027	0.011	0.130	0.12	0.43	0.31	0.56	6.3	4.0
11-Jul-06	5	B	7.5	0.043	0.006	0.080	0.20	0.73	0.53	0.81	6.6	4.4
3-Aug-06	5	B	7.0	0.041	0.004	0.020	0.25	0.72	0.47	0.74	6.4	6.8
31-Aug-06	5	B	6.5	0.042	0.006	0.140	< 0.10	0.80	0.70	0.94	6.3	7.2
18-Sep-06	5	B	7.0	0.013	0.012	< 0.010	< 0.10	0.64	0.54	0.65	6.9	4.0
19-Oct-06	5	B	5.5	0.020	0.002	0.100	< 0.10	0.45	0.35	0.55	6.6	9.6
ANNUAL & GROWING SEASON				**0.031**	**0.007**	**0.08**	**0.15**	**0.63**	**0.48**	**0.71**	**6.5**	**6.0**
				0.013	**0.002**	**0.01**	**0.10**	**0.43**	**0.31**	**0.55**	**6.3**	**4.0**
				0.043	**0.012**	**0.14**	**0.25**	**0.80**	**0.70**	**0.94**	**6.9**	**9.6**

TP = Total phosphorus
DRP = Dissolved reactive phosphorus (filtered)
NO2/NO3 = Nitrate/Nitrite nitrogen
NH3 = Ammonia nitrogen
TN = Total Nitrogen
ON = Organic Nitrogen
TKN = Total Kjeldahl nitrogen
ALK = Alkalinity
pH = pH
TSS = Total suspended solids

Lake Wallenpaupack Watershed Management District

2006 Lake Wallenpaupack Water Quality Summary

2006 Phytoplankton Pigments and Transparency

FXB Project No. PA1012-66

	Date	Station	Secchi Depth (m)	Chlorophyll a (ug/L)		Pheophytin (ug/L)
	25-Jan-06	3	2.4	8.3		0.5
	16-Feb-06	3	2.3	12.0	<	0.1
	22-Mar-06	3	2.4	9.9	<	0.1
	19-Apr-06	3	2.3	10.4		0.2
	10-May-06	3	2.2	16.0	<	0.1
	24-May-06	3	2.7	8.0		0.9
	14-Jun-06	3	3.0	6.1		1.0
	11-Jul-06	3	2.4	12.0		1.3
	26-Jul-06	3	2.0	13.2		1.8
	3-Aug-06	3	2.2	15.5		0.3
	16-Aug-06	3	1.6	21.7		1.8
	31-Aug-06	3	1.7	23.7	<	0.1
	18-Sep-06	3	1.8	25.0		1.8
	2-Oct-06	3	1.5	17.2		2.4
	19-Oct-06	3	1.9	15.0		3.9
	31-Oct-06	3	2.0	19.0		2.1
	15-Nov-06	3	1.6	20.0		2.8
	11-Dec-06	3	2.0	12.0		1.3
Annual	**Annual Avg**		**2.11**	**14.72**		**1.25**
	MINIMUM		**1.50**	**6.10**		**0.10**
	MAXIMUM		**3.00**	**25.00**		**3.90**
Growing Season	**GS AVERAGE**		**2.08**	**16.03**		**1.46**
	GS MINIMUM		**1.50**	**6.10**		**0.10**
	GS MAXIMUM		**3.00**	**25.00**		**3.90**
	24-May-06	5	2.2	5.0		0.3
	11-Jul-06	5	1.5	8.0		3.5
	3-Aug-06	5	1.9	10.0		0.7
	31-Aug-06	5	1.6	17.7		0.5
	18-Sep-06	5	1.1	35.0	<	0.1
	19-Oct-06	5	1.5	8.3		1.7
Annual and Growing Season	**MEAN**		**1.63**	**14.00**		**1.13**
	MINIMUM		**1.10**	**5.00**		**0.10**
	MAXIMUM		**2.20**	**35.00**		**3.50**

APPENDIX D

2006 DISSOLVED OXYGEN AND TEMPERATURE DATA

Lake Wallenpaupack Watershed Management District
2006 Lake Wallenpaupack Water Quality Management Study
2006 Dissolved Oxygen & Temperature Profiles - Station #3
FXB Project No. PA1012-66

Date M/D/Y	Temperature ºC	Dissolved Oxygen mg/L	Depth m
1/25/2006	1.64	11.19	0
1/25/2006	1.63	11.03	1
1/25/2006	1.62	10.96	2
1/25/2006	1.63	10.96	3
1/25/2006	1.62	11.03	4
1/25/2006	1.64	10.92	5
1/25/2006	1.63	10.9	6
1/25/2006	1.63	10.83	7
1/25/2006	1.63	10.98	8
1/25/2006	1.63	10.89	9
1/25/2006	1.64	10.88	10
1/25/2006	1.64	10.83	11
1/25/2006	1.65	10.8	12
2/16/2006	1.2	11.43	0
2/16/2006	1.23	11.42	1
2/16/2006	1.22	11.46	2
2/16/2006	1.22	11.41	3
2/16/2006	1.23	11.39	4
2/16/2006	1.25	11.39	5
2/16/2006	1.25	11.36	6
2/16/2006	1.25	11.27	7
2/16/2006	1.25	11.22	8
2/16/2006	1.31	11.26	9
2/16/2006	1.35	11.28	10
2/16/2006	1.37	11.29	11
3/22/2006	2.11	11.62	0
3/22/2006	2.12	11.59	1
3/22/2006	2.12	11.69	2
3/22/2006	2.08	11.62	3
3/22/2006	2.09	11.69	4
3/22/2006	2.09	11.65	5
3/22/2006	2.07	11.61	6
3/22/2006	2.08	11.58	7
3/22/2006	2.07	11.68	8
3/22/2006	2.08	11.58	9
3/22/2006	2.21	11.58	10
3/22/2006	2.24	11.58	11
4/19/2006	9.41	11.64	0
4/19/2006	9.37	11.64	1
4/19/2006	9.24	11.67	2
4/19/2006	9.12	11.7	3
4/19/2006	8.88	11.67	4
4/19/2006	8.62	11.67	5
4/19/2006	8.44	11.59	6
4/19/2006	7.75	11.68	7
4/19/2006	7.02	11.67	8
4/19/2006	6.72	11.69	9
4/19/2006	6.33	11.03	10
4/19/2006	6.26	11.01	11
4/19/2006	6.18	10.8	12
5/10/2006	15.61	8.32	0
5/10/2006	15.14	8.25	1
5/10/2006	14.78	8.24	2
5/10/2006	14.63	8.23	3
5/10/2006	14.59	8.26	4
5/10/2006	13.32	8.18	5
5/10/2006	12.49	7.99	6
5/10/2006	11.06	7.6	7
5/10/2006	9.8	6.48	8
5/10/2006	9.27	6.39	9
5/10/2006	8.57	6.71	10
5/10/2006	7.72	6.24	11
5/10/2006	7.65	6.04	12
5/24/2006	13.84	8.93	0
5/24/2006	13.75	8.82	1
5/24/2006	13.48	8.86	2
5/24/2006	13.31	8.83	3
5/24/2006	13.27	8.77	4
5/24/2006	13.24	8.76	5
5/24/2006	13.22	8.68	6
5/24/2006	13.19	8.69	7
5/24/2006	12.51	8.44	8
5/24/2006	11.83	7.97	9
5/24/2006	9.13	6.55	10
5/24/2006	8.77	6.02	11
5/24/2006	8.75	5.65	12

Date M/D/Y	Temperature ºC	Dissolved Oxygen mg/L	Depth m
6/14/2006	18.75	8.78	0
6/14/2006	18.1	8.77	1
6/14/2006	17.81	8.65	2
6/14/2006	17.27	8.7	3
6/14/2006	16.96	8.21	4
6/14/2006	16.5	7.97	5
6/14/2006	15.98	7.78	6
6/14/2006	14.74	7.35	7
6/14/2006	13.04	6.2	8
6/14/2006	11.85	5.62	9
6/14/2006	11.51	4.9	10
6/14/2006	10.19	3.79	11
6/14/2006	9.61	2.62	12
7/11/2006	23.44	7.97	0
7/11/2006	23.3	7.97	1
7/11/2006	23.11	7.89	2
7/11/2006	23.01	7.85	3
7/11/2006	22.94	7.77	4
7/11/2006	22.83	7.58	5
7/11/2006	22.63	7.41	6
7/11/2006	18.85	5.71	7
7/11/2006	17.24	4.58	8
7/11/2006	14.63	3.42	9
7/11/2006	11.85	1.57	10
7/11/2006	10.94	0.91	11
7/11/2006	10.76	0.51	12
7/26/2006	26.81	8.07	0
7/26/2006	26.06	8.07	1
7/26/2006	25.58	7.93	2
7/26/2006	25.46	7.66	3
7/26/2006	25.35	7.47	4
7/26/2006	25.28	7.27	5
7/26/2006	22.51	3.33	6
7/26/2006	19.87	2.5	7
7/26/2006	17.17	1.69	8
7/26/2006	14.85	0.9	9
7/26/2006	12.87	0.51	10
7/26/2006	12.05	0.38	11
7/26/2006	11.36	0.33	12
8/3/2006	27.49	7.53	0
8/3/2006	27.36	7.53	1
8/3/2006	27.22	7.49	2
8/3/2006	27.19	7.44	3
8/3/2006	27.11	7.35	4
8/3/2006	25.9	5.76	5
8/3/2006	22.86	2.01	6
8/3/2006	20.05	0.8	7
8/3/2006	17.7	0.41	8
8/3/2006	14.56	0.21	9
8/3/2006	12.63	0.21	10
8/3/2006	12.03	0.19	11
8/16/2006	24.7	7.81	0
8/16/2006	24.48	7.91	1
8/16/2006	24.12	7.62	2
8/16/2006	23.98	7.4	3
8/16/2006	23.92	7.21	4
8/16/2006	23.8	6.75	5
8/16/2006	23.5	6.18	6
8/16/2006	22.46	4.38	7
8/16/2006	18.17	1.52	8
8/16/2006	15.67	0.57	9
8/16/2006	13.34	0.27	10
8/16/2006	12.8	0.23	11
8/16/2006	12.54	0.21	12

Date M/D/Y	Temperature ºC	Dissolved Oxygen mg/L	Depth m
9/18/2006	21.33	9.53	0
9/18/2006	20.76	9.66	1
9/18/2006	20.3	9.78	2
9/18/2006	19.22	9.95	3
9/18/2006	18.93	8.51	4
9/18/2006	18.88	7.8	5
9/18/2006	18.85	7.62	6
9/18/2006	18.82	7.47	7
9/18/2006	18.55	5.7	8
9/18/2006	17.61	1.34	9
9/18/2006	15.21	0.56	10
9/18/2006	14.73	0.36	11
10/2/2006	16.79	7.45	0
10/2/2006	16.75	7.42	1
10/2/2006	16.64	7.32	2
10/2/2006	16.63	7.25	3
10/2/2006	16.62	7.19	4
10/2/2006	16.61	7.14	5
10/2/2006	16.61	7.12	6
10/2/2006	16.59	7.06	7
10/2/2006	16.56	7.04	8
10/2/2006	16.52	6.95	9
10/2/2006	16.49	5.64	10
10/19/2006	14.22	9.12	0
10/19/2006	14.08	9.13	1
10/19/2006	13.93	9.14	2
10/19/2006	13.85	8.95	3
10/19/2006	13.8	8.86	4
10/19/2006	13.7	8.7	5
10/19/2006	13.67	8.59	6
10/19/2006	13.6	8.46	7
10/19/2006	13.55	7.8	8
10/19/2006	13.55	7.77	9
10/19/2006	13.55	7.59	10
10/31/2006	9.89	10.36	0
10/31/2006	9.87	10.35	1
10/31/2006	9.75	10.36	2
10/31/2006	9.66	10.31	3
10/31/2006	9.64	10.21	4
10/31/2006	9.6	10.15	5
10/31/2006	9.59	10.08	6
10/31/2006	9.59	10.02	7
10/31/2006	9.58	9.97	8
10/31/2006	9.56	9.92	9
10/31/2006	9.47	9.4	10
11/15/2006	9.52	10.99	0
11/15/2006	9.26	11.06	1
11/15/2006	9.23	11.01	2
11/15/2006	9.18	10.94	3
11/15/2006	9.14	10.85	4
11/15/2006	9.13	10.72	5
11/15/2006	9.13	10.66	6
11/15/2006	8.85	9.86	7
11/15/2006	8.68	9.5	8
11/15/2006	8.59	9.15	9
11/15/2006	8.47	8.65	10
11/15/2006	8.47	8.54	11
12/11/2006	5.18	12.49	0
12/11/2006	5.13	12.44	1
12/11/2006	5.09	12.43	2
12/11/2006	5.09	12.41	3
12/11/2006	5.07	12.4	4
12/11/2006	5.04	12.36	5
12/11/2006	5.04	12.34	6
12/11/2006	5.01	12.34	7
12/11/2006	5.01	12.31	8
12/11/2006	5	12.3	9
12/11/2006	4.99	12.29	10
12/11/2006	4.98	12.29	11
12/11/2006	4.99	12.2	12

Lake Wallenpaupack Watershed Management District
2006 Lake Wallenpaupack Water Quality Management Study
2006 Dissolved Oxygen & Temperature Profiles - Station #5
FXB Project No. PA1012-66

Date M/D/Y	Temperature ºC	Dissolved Oxygen mg/L	Depth m
5/24/2006	12.09	7.63	-0.009
5/24/2006	11.95	7.6	1.019
5/24/2006	11.66	7.58	2.073
5/24/2006	11.57	7.48	3.11
5/24/2006	11.51	7.32	4.036
5/24/2006	11.3	7.18	5.033
5/24/2006	11.02	6.87	6.094
5/24/2006	10.67	6.34	7.084
5/24/2006	10.45	5.49	8.058
5/24/2006	10.35	5.13	9.062
7/11/2006	24.02	8.24	-0.004
7/11/2006	23.32	8.18	1.027
7/11/2006	21.14	6.81	2.046
7/11/2006	20.42	6.66	3.066
7/11/2006	19.94	6.55	4.049
7/11/2006	19.49	6.27	5.057
7/11/2006	18.97	4.73	6.072
7/11/2006	17.77	3.07	7.093
7/11/2006	16.81	1.49	8.069
8/3/2006	27.3	7.71	-0.031
8/3/2006	26.97	7.56	0.997
8/3/2006	26.21	6.78	2.004
8/3/2006	24.63	4.91	3.039
8/3/2006	24.24	4.58	4.023
8/3/2006	23.59	3.83	5.027
8/3/2006	21.75	0.59	6.039
8/3/2006	19.54	0.31	7.019

Date M/D/Y	Temperature ºC	Dissolved Oxygen mg/L	Depth m
9/18/2006	20.47	11.04	0.072
9/18/2006	19.28	11.28	1.085
9/18/2006	18.93	11.24	2.045
9/18/2006	17.51	9.53	3.044
9/18/2006	17.06	9.27	4.045
9/18/2006	16.72	9.1	5.052
9/18/2006	16.53	8.91	6.038
9/18/2006	16.13	6.81	7.058
10/19/2006	13.24	10.78	0.056
10/19/2006	12.3	10.86	1.058
10/19/2006	11.82	10.81	2.076
10/19/2006	11.43	10.58	3.028
10/19/2006	10.96	10.55	4.018
10/19/2006	10.35	10.42	5.01
10/19/2006	9.49	7.52	6.061

APPENDIX E

2006 LAKE WALLENPAUPACK PHYTOPLANKTON DATA

Lake Wallenpaupack Watershed Management District
2006 Lake Wallenpaupack Water Quality Summary
Phytoplankton Density Data - 2006 Station 3
FXB Project No. PA1012-66

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	LWWMD 3 01/25/06	LWWMD 3 02/16/06	LWWMD 3 03/22/06	LWWMD 3 04/19/06	LWWMD 3 05/10/06	LWWMD 3 05/24/06	LWWMD 3 06/14/06	LWWMD 3 07/11/06	LWWMD 3 07/26/06	LWWMD 3 08/03/06	LWWMD 3 08/16/06	LWWMD 3 08/31/06	LWWMD 3 09/18/06	LWWMD 3 10/02/06	LWWMD 3 10/19/06	LWWMD 3 10/31/06	LWWMD 3 11/15/06	LWWMD 3 12/11/06
BACILLARIOPHYTA																		
Centric Diatoms																		
Aulacoseira	30	0	36	120	0	144	0	0	0	0	0	0	80	180	209	0	462	1020
Cyclotella	0	0	0	0	0	0	0	0	40	18	0	0	0	0	0	51	0	0
Stephanodiscus	0	0	0	40	88	90	0	0	0	0	0	32	0	0	0	0	21	0
Urosolenia	90	140	72	120	0	0	0	0	0	0	0	0	0	0	95	34	42	48
Araphid Pennate Diatoms																		
Asterionella	1095	1560	2736	4040	4554	1116	72	19	0	0	32	32	0	108	38	51	294	216
Fragilaria/related taxa	75	0	90	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synedra	240	580	378	260	616	72	0	0	20	0	64	16	60	54	38	34	42	24
Tabellaria	120	300	306	240	352	378	144	152	800	828	1328	320	620	180	152	0	84	312
Monoraphid Pennate Diatoms																		
Achnanthidium/related taxa	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biraphid Pennate Diatoms																		
Nitzschia	0	0	0	20	0	0	0	0	0	0	0	0	20	108	0	0	0	12
Surirella	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0
CHLOROPHYTA																		
Flagellated Chlorophytes																		
Chlamydomonas	0	0	0	0	0	0	0	0	20	18	0	0	0	0	0	0	0	0
Coccoid/Colonial Chlorophytes																		
Ankistrodesmus	15	20	18	40	0	0	0	38	40	54	32	16	40	0	38	17	42	24
Botryococcus	0	0	0	0	0	0	0	0	0	360	0	0	80	0	0	0	0	0
Closteriopsis	0	0	0	0	0	18	0	0	0	0	0	16	0	0	0	0	0	0
Coelastrum	0	0	0	0	0	0	0	0	0	0	0	0	0	216	0	0	0	0
Crucigenia	0	0	0	0	88	0	0	0	0	72	0	64	0	0	0	0	0	0
Elakatothrix	15	0	0	0	22	0	0	19	0	36	0	0	0	0	0	0	0	0
Golenkinia	0	0	0	20	0	0	0	0	0	18	16	0	0	18	0	0	0	0
Paulschulzia	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0
Pediastrum	0	0	0	0	0	0	0	0	80	0	0	0	0	0	304	0	0	96
Quadrigula	0	0	0	0	0	0	0	0	0	0	0	64	0	0	0	0	0	0
Scenedesmus	0	0	0	0	0	0	0	0	0	0	96	64	200	0	152	68	0	48
Schroederia	0	0	0	0	0	0	0	0	40	18	16	16	0	0	0	0	0	0
Sphaerocystis	0	0	0	160	0	144	0	456	160	18	128	0	0	0	0	0	0	0
Desmids																		
Cosmarium	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0
Mougeotia/Debarya	0	0	0	0	0	0	36	0	0	0	0	0	280	288	95	0	0	0
Staurastrum	0	0	0	0	0	0	0	0	0	0	16	16	0	0	0	0	0	0
Staurodesmus	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0
CHRYSOPHYTA																		
Flagellated Classic Chrysophytes																		
Dinobryon	30	0	36	320	220	54	1116	38	20	36	48	0	0	0	152	867	21	12
Ochromonas	30	40	0	0	0	0	0	0	400	0	128	0	0	0	0	0	0	0
Synura	0	40	36	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA																		
Cryptomonas	75	40	36	120	88	90	288	532	740	90	96	176	160	180	342	187	1176	300
CYANOPHYTA																		
Unicellular and Colonial Forms																		
Aphanocapsa	0	0	0	0	0	0	0	570	0	0	640	0	800	0	0	0	0	720
Coelosphaerium	0	0	1800	0	0	0	0	0	0	1080	0	0	0	0	3420	0	0	0
Microcystis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1900	0	0	0
Filamentous Nitrogen Fixers																		
Anabaena	0	0	0	0	0	0	180	570	0	3780	9120	14400	9600	2700	2280	510	420	240
Aphanizomenon	600	0	0	600	880	2160	540	190	3600	15120	17760	7680	27000	5400	9500	10710	13860	8640
Limnothrix	0	0	0	0	0	0	0	0	0	0	0	0	0	0	380	2040	0	0
Filamentous Non-Nitrogen Fixers																		
Oscillatoria	0	0	0	0	0	0	0	380	0	0	0	0	0	0	1140	3060	2520	1800
Planktolyngbya	0	0	0	0	0	1800	180	380	0	0	0	0	0	0	0	0	0	0
Pseudanabaena	2700	0	2160	16000	11000	11700	1440	5700	400	360	0	0	0	0	0	0	0	0
EUGLENOPHYTA																		
Trachelomonas	15	20	18	40	22	0	36	19	0	18	64	64	20	36	38	17	21	12
PYRRHOPHYTA																		
Peridinium	15	20	18	60	22	0	18	38	20	18	16	16	0	0				
DENSITY (CELLS/ML) SUMMARY																		
BACILLARIOPHYTA	**1650**	**2600**	**3618**	**4960**	**5610**	**1800**	**216**	**171**	**860**	**846**	**1424**	**400**	**780**	**648**	**532**	**170**	**945**	**1632**
Centric Diatoms	120	140	108	280	88	234	0	0	40	18	0	32	80	180	304	85	525	1068
Araphid Pennate Diatoms	1530	2440	3510	4660	5522	1566	216	171	820	828	1424	368	680	342	228	85	420	552
Monoraphid Pennate Diatoms	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biraphid Pennate Diatoms	0	0	0	20	0	0	0	0	0	0	0	0	20	126	0	0	0	12
CHLOROPHYTA	**30**	**20**	**18**	**220**	**110**	**162**	**36**	**513**	**420**	**594**	**352**	**256**	**600**	**522**	**589**	**85**	**42**	**168**
Flagellated Chlorophytes	0	0	0	0	0	0	0	0	20	18	0	0	0	0	0	0	0	0
Coccoid/Colonial Chlorophytes	30	20	18	220	110	162	0	513	400	576	288	240	320	234	494	85	42	168
Desmids	0	0	0	0	0	0	36	0	0	0	64	16	280	288	95	0	0	0
CHRYSOPHYTA	**60**	**80**	**72**	**320**	**220**	**54**	**1116**	**38**	**440**	**36**	**176**	**0**	**0**	**0**	**152**	**867**	**21**	**12**
Flagellated Classic Chrysophytes	60	80	72	320	220	54	1116	38	440	36	176	0	0	0	152	867	21	12
CRYPTOPHYTA	**75**	**40**	**36**	**120**	**88**	**90**	**288**	**532**	**740**	**90**	**96**	**176**	**160**	**180**	**342**	**187**	**1176**	**300**
CYANOPHYTA	**3300**	**0**	**3960**	**16600**	**11880**	**15660**	**2340**	**7790**	**4000**	**20340**	**27520**	**22080**	**37400**	**8100**	**18620**	**16320**	**16800**	**11400**
Unicellular and Colonial Forms	0	0	1800	0	0	0	0	570	0	1080	640	0	800	0	5320	0	0	720
Filamentous Nitrogen Fixers	600	0	0	600	880	2160	720	760	3600	18900	26880	22080	36600	8100	12160	13260	14280	8880
Filamentous Non-Nitrogen Fixers	2700	0	2160	16000	11000	13500	1620	6460	400	360	0	0	0	0	1140	3060	2520	1800
EUGLENOPHYTA	**15**	**20**	**18**	**40**	**22**	**0**	**36**	**19**	**0**	**18**	**64**	**64**	**20**	**36**	**38**	**17**	**21**	**12**
PYRRHOPHYTA	**15**	**20**	**18**	**60**	**22**	**0**	**18**	**38**	**20**	**18**	**16**	**16**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL	**5145**	**2780**	**7740**	**22320**	**17952**	**17766**	**4050**	**9101**	**6480**	**21942**	**29648**	**22992**	**38960**	**9486**	**20273**	**17646**	**19005**	**13524**
CELL DIVERSITY	**0.65**	**0.59**	**0.68**	**0.44**	**0.50**	**0.52**	**0.76**	**0.64**	**0.68**	**0.47**	**0.46**	**0.38**	**0.38**	**0.55**	**0.76**	**0.54**	**0.43**	**0.58**
CELL EVENNESS	**0.55**	**0.57**	**0.60**	**0.36**	**0.46**	**0.48**	**0.73**	**0.55**	**0.56**	**0.38**	**0.36**	**0.31**	**0.34**	**0.50**	**0.60**	**0.49**	**0.39**	**0.48**

Lake Wallenpaupack Watershed Management District
2006 Lake Wallenpaupack Water Quality Summary
Phytoplankton Biomass Data - 2006 Station 3
FXB Project No. PA1012-66

PHYTOPLANKTON BIOMASS (UG/L)

TAXON	LWWMD 3 01/25/06	LWWMD 3 02/16/06	LWWMD 3 03/22/06	LWWMD 3 04/19/06	LWWMD 3 05/10/06	LWWMD 3 05/24/06	LWWMD 3 06/14/06	LWWMD 3 07/11/06	LWWMD 3 07/26/06	LWWMD 3 08/03/06	LWWMD 3 08/16/06	LWWMD 3 08/31/06	LWWMD 3 09/18/06	LWWMD 3 10/02/06	LWWMD 3 10/19/06	LWWMD 3 10/31/06	LWWMD 3 11/15/06	LWWMD 3 12/11/06
BACILLARIOPHYTA																		
Centric Diatoms																		
Aulacoseira	9.0	0.0	10.8	36.0	0.0	43.2	0.0	0.0	0.0	0.0	0.0	0.0	24.0	54.0	62.7	0.0	138.6	306.0
Cyclotella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	45.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
Stephanodiscus	0.0	0.0	0.0	4.0	114.4	95.4	0.0	0.0	0.0	0.0	0.0	41.6	0.0	0.0	0.0	0.0	52.5	0.0
Urosolenia	108.0	168.0	86.4	144.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	114.0	40.8	50.4	57.6
Araphid Pennate Diatoms																		
Asterionella	219.0	312.0	547.2	808.0	910.8	223.2	14.4	3.8	0.0	0.0	6.4	6.4	0.0	21.6	7.6	10.2	58.8	43.2
Fragilaria/related taxa	22.5	0.0	27.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Synedra	192.0	464.0	302.4	208.0	492.8	57.6	0.0	0.0	16.0	0.0	51.2	12.8	48.0	43.2	167.2	27.2	33.6	105.6
Tabellaria	96.0	240.0	244.8	192.0	281.6	302.4	115.2	121.6	640.0	662.4	1062.4	256.0	496.0	144.0	121.6	0.0	67.2	249.6
Monoraphid Pennate Diatoms																		
Achnanthidium/related taxa	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms																		
Nitzschia	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	86.4	0.0	0.0	0.0	9.6
Surirella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.0	0.0	0.0	0.0	0.0
CHLOROPHYTA																		
Flagellated Chlorophytes																		
Chlamydomonas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes																		
Ankistrodesmus	1.5	2.0	1.8	4.0	0.0	0.0	0.0	3.8	4.0	27.0	16.0	8.0	4.0	0.0	3.8	1.7	4.2	2.4
Botryococcus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0
Closteriopsis	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0
Coelastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.2	0.0	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0	0.0	8.8	0.0	0.0	0.0	0.0	7.2	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0
Elakatothrix	1.5	0.0	0.0	0.0	2.2	0.0	0.0	1.9	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Golenkinia	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	3.6	3.2	0.0	0.0	3.6	0.0	0.0	0.0	0.0
Paulschulzia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pediastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	60.8	0.0	0.0	19.2
Quadrigula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0
Scenedesmus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	6.4	20.0	0.0	15.2	6.8	0.0	4.8
Schroederia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	45.0	40.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	0.0	32.0	0.0	28.8	0.0	91.2	32.0	3.6	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Desmids																		
Cosmarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mougeotia/Debarya	0.0	0.0	0.0	0.0	0.0	0.0	36.0	0.0	0.0	0.0	0.0	0.0	280.0	288.0	95.0	0.0	0.0	0.0
Staurastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8	12.8	0.0	0.0	0.0	0.0	0.0	0.0
Staurodesmus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHRYSOPHYTA																		
Flagellated Classic Chrysophytes																		
Dinobryon	90.0	0.0	108.0	960.0	660.0	162.0	3348.0	114.0	60.0	108.0	144.0	0.0	0.0	0.0	456.0	2601.0	63.0	36.0
Ochromonas	3.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Synura	0.0	32.0	28.8	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA																		
Cryptomonas	15.0	8.0	7.2	24.0	17.6	68.4	259.2	319.2	428.0	144.0	64.0	624.0	920.0	486.0	516.8	309.4	705.6	252.0
CYANOPHYTA																		
Unicellular and Colonial Forms																		
Aphanocapsa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	6.4	0.0	8.0	0.0	0.0	0.0	0.0	7.2
Coelosphaerium	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	0.0	34.2	0.0	0.0	0.0
Microcystis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0	0.0	0.0
Filamentous Nitrogen Fixers																		
Anabaena	0.0	0.0	0.0	0.0	0.0	0.0	36.0	114.0	0.0	756.0	1824.0	2880.0	1920.0	540.0	456.0	102.0	84.0	48.0
Aphanizomenon	78.0	0.0	0.0	78.0	114.4	280.8	70.2	24.7	468.0	1965.6	2308.8	998.4	3510.0	702.0	1235.0	1392.3	1801.8	1123.2
Limnothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	20.4	0.0	0.0
Filamentous Non-Nitrogen Fixers																		
Oscillatoria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	11.4	30.6	25.2	18.0
Planktolyngbya	0.0	0.0	0.0	0.0	0.0	18.0	1.8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudanabaena	27.0	0.0	21.6	160.0	110.0	117.0	14.4	57.0	4.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA																		
Trachelomonas	15.0	20.0	18.0	40.0	22.0	0.0	36.0	19.0	0.0	18.0	64.0	64.0	20.0	36.0	38.0	17.0	21.0	12.0
PYRRHOPHYTA																		
Peridinium	31.5	42.0	37.8	126.0	46.2	0.0	37.8	79.8	42.0	37.8	33.6	33.6	0.0	0.0	0.0	0.0	0.0	0.0
BIOMASS (UG/ML) SUMMARY																		
BACILLARIOPHYTA	**646.5**	**1186.0**	**1218.6**	**1444.0**	**1799.6**	**721.8**	**129.6**	**125.4**	**660.0**	**707.4**	**1120.0**	**316.8**	**584.0**	**421.2**	**473.1**	**83.3**	**401.1**	**771.6**
Centric Diatoms	117.0	168.0	97.2	184.0	114.4	138.6	0.0	0.0	4.0	45.0	0.0	41.6	24.0	54.0	176.7	45.9	241.5	363.6
Araphid Pennate Diatoms	529.5	1016.0	1121.4	1244.0	1685.2	583.2	129.6	125.4	656.0	662.4	1120.0	275.2	544.0	208.8	296.4	37.4	159.6	398.4
Monoraphid Pennate Diatoms	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	158.4	0.0	0.0	0.0	9.6
CHLOROPHYTA	**3.0**	**2.0**	**1.8**	**40.0**	**11.0**	**37.8**	**36.0**	**96.9**	**192.0**	**169.2**	**142.4**	**94.4**	**320.0**	**334.8**	**174.8**	**8.5**	**4.2**	**26.4**
Flagellated Chlorophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	3.0	2.0	1.8	40.0	11.0	37.8	0.0	96.9	184.0	162.0	94.4	81.6	40.0	46.8	79.8	8.5	4.2	26.4
Desmids	0.0	0.0	0.0	0.0	0.0	0.0	36.0	0.0	0.0	0.0	48.0	12.8	280.0	288.0	95.0	0.0	0.0	0.0
CHRYSOPHYTA	**93.0**	**36.0**	**136.8**	**960.0**	**660.0**	**162.0**	**3348.0**	**114.0**	**116.0**	**108.0**	**156.8**	**0.0**	**0.0**	**0.0**	**456.0**	**2601.0**	**63.0**	**36.0**
Flagellated Classic Chrysophytes	93.0	36.0	136.8	960.0	660.0	162.0	3348.0	114.0	116.0	108.0	156.8	0.0	0.0	0.0	456.0	2601.0	63.0	36.0
CRYPTOPHYTA	**15.0**	**8.0**	**7.2**	**24.0**	**17.6**	**68.4**	**259.2**	**319.2**	**428.0**	**144.0**	**64.0**	**624.0**	**920.0**	**486.0**	**516.8**	**309.4**	**705.6**	**252.0**
CYANOPHYTA	**105.0**	**0.0**	**39.6**	**238.0**	**224.4**	**415.8**	**122.4**	**209.0**	**472.0**	**2736.0**	**4139.2**	**3878.4**	**5438.0**	**1242.0**	**1759.4**	**1545.3**	**1911.0**	**1196.4**
Unicellular and Colonial Forms	0.0	0.0	18.0	0.0	0.0	0.0	0.0	5.7	0.0	10.8	6.4	0.0	8.0	0.0	53.2	0.0	0.0	7.2
Filamentous Nitrogen Fixers	78.0	0.0	0.0	78.0	114.4	280.8	106.2	138.7	468.0	2721.6	4132.8	3878.4	5430.0	1242.0	1694.8	1514.7	1885.8	1171.2
Filamentous Non-Nitrogen Fixers	27.0	0.0	21.6	160.0	110.0	135.0	16.2	64.6	4.0	3.6	0.0	0.0	0.0	0.0	11.4	30.6	25.2	18.0
EUGLENOPHYTA	**15.0**	**20.0**	**18.0**	**40.0**	**22.0**	**0.0**	**36.0**	**19.0**	**0.0**	**18.0**	**64.0**	**64.0**	**20.0**	**36.0**	**38.0**	**17.0**	**21.0**	**12.0**
PYRRHOPHYTA	**31.5**	**42.0**	**37.8**	**126.0**	**46.2**	**0.0**	**37.8**	**79.8**	**42.0**	**37.8**	**33.6**	**33.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
TOTAL	**909.0**	**1294.0**	**1459.8**	**2872.0**	**2780.8**	**1405.8**	**3969.0**	**963.3**	**1910.0**	**3920.4**	**5720.0**	**5011.2**	**7282.0**	**2520.0**	**3418.1**	**4564.5**	**3105.9**	**2294.4**
BIOMASS DIVERSITY	**0.93**	**0.71**	**0.80**	**0.85**	**0.78**	**0.93**	**0.31**	**0.88**	**0.78**	**0.66**	**0.64**	**0.57**	**0.61**	**0.85**	**0.87**	**0.49**	**0.60**	**0.75**
BIOMASS EVENNESS	**0.79**	**0.68**	**0.70**	**0.69**	**0.72**	**0.86**	**0.30**	**0.75**	**0.65**	**0.53**	**0.50**	**0.47**	**0.54**	**0.77**	**0.70**	**0.44**	**0.54**	**0.62**

Lake Wallenpaupack Watershed Management District
2006 Lake Wallenpaupack Water Quality Summary
Phytoplankton Density & Biomass Data - 2006 Stations 5
FXB Project No. PA1012-66

	PHYTOPLANKTON DENSITY (CELLS/ML)						**PHYTOPLANKTON BIOMASS (UG/L)**					
TAXON	**LWWMD 5 05/24/06**	**LWWMD 5 07/11/06**	**LWWMD 5 08/03/06**	**LWWMD 5 08/31/06**	**LWWMD 5 09/18/06**	**LWWMD 5 10/19/06**	**LWWMD 5 05/24/06**	**LWWMD 5 07/11/06**	**LWWMD 5 08/03/06**	**LWWMD 5 08/31/06**	**LWWMD 5 09/18/06**	**LWWMD 5 10/19/06**
BACILLARIOPHYTA												
Centric Diatoms												
Acanthoceras	0	0	136	0	0	0	0.0	0.0	353.6	0.0	0.0	0.0
Aulacoseira	0	0	102	0	40	84	0.0	0.0	30.6	0.0	12.0	25.2
Cyclotella	0	0	51	0	0	0	0.0	0.0	45.9	0.0	0.0	0.0
Melosira	24	0	0	0	0	0	7.2	0.0	0.0	0.0	0.0	0.0
Stephanodiscus	72	0	0	0	0	0	7.2	0.0	0.0	0.0	0.0	0.0
Urosolenia	0	60	578	0	0	112	0.0	72.0	1502.8	0.0	0.0	134.4
Araphid Pennate Diatoms												
Asterionella	432	0	68	66	0	56	86.4	0.0	13.6	13.2	0.0	11.2
Fragilaria/related taxa	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Synedra	48	20	34	22	60	28	38.4	16.0	27.2	17.6	192.0	123.2
Tabellaria	192	0	799	528	280	42	153.6	0.0	639.2	422.4	224.0	33.6
Monoraphid Pennate Diatoms												
Achnanthidium/related taxa	24	0	0	0	0	0	2.4	0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms												
Cymbella/related taxa	24	0	0	0	0	14	24.0	0.0	0.0	0.0	0.0	14.0
Navicula/related taxa	24	0	0	0	0	28	12.0	0.0	0.0	0.0	0.0	14.0
Nitzschia	24	0	34	0	20	0	19.2	0.0	27.2	0.0	16.0	0.0
Surirella	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
CHLOROPHYTA												
Flagellated Chlorophytes												
Chlamydomonas	0	60	0	0	0	0	0.0	24.0	0.0	0.0	0.0	0.0
Coccomonas	0	0	17	0	0	0	0.0	0.0	6.8	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes												
Ankistrodesmus	0	0	34	88	40	28	0.0	0.0	17.0	8.8	4.0	2.8
Botryococcus	0	0	0	176	0	0	0.0	0.0	0.0	35.2	0.0	0.0
Closteriopsis	24	0	0	22	0	0	12.0	0.0	0.0	11.0	0.0	0.0
Crucigenia	0	0	0	88	0	0	0.0	0.0	0.0	8.8	0.0	0.0
Dictyosphaerium	0	0	272	0	0	0	0.0	0.0	27.2	0.0	0.0	0.0
Elakatothrix	0	20	0	0	0	0	0.0	2.0	0.0	0.0	0.0	0.0
Golenkinia	0	0	17	0	0	0	0.0	0.0	3.4	0.0	0.0	0.0
Oocystis	0	0	68	0	0	0	0.0	0.0	27.2	0.0	0.0	0.0
Pediastrum	0	0	68	0	0	0	0.0	0.0	13.6	0.0	0.0	0.0
Quadrigula	24	0	0	22	0	0	4.8	0.0	0.0	4.4	0.0	0.0
Scenedesmus	0	0	68	176	200	112	0.0	0.0	6.8	17.6	20.0	11.2
Schroederia	0	60	34	0	0	0	0.0	150.0	85.0	0.0	0.0	0.0
Sphaerocystis	0	0	17	0	20	0	0.0	0.0	3.4	0.0	4.0	0.0
Tetrallantos	0	0	17	0	0	0	0.0	0.0	3.4	0.0	0.0	0.0
CHRYSOPHYTA												
Flagellated Classic Chrysophytes												
Chromulina	0	20	0	0	0	0	0.0	4.0	0.0	0.0	0.0	0.0
Dinobryon	48	120	187	0	20	1050	144.0	360.0	561.0	0.0	60.0	3150.0
Ochromonas	0	20	0	0	0	0	0.0	4.0	0.0	0.0	0.0	0.0
Synura	0	20	0	0	0	0	0.0	16.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA												
Cryptomonas	144	300	136	198	120	280	163.2	200.0	122.4	818.4	496.0	504.0
CYANOPHYTA												
Filamentous Nitrogen Fixers												
Anabaena	0	0	0	8360	6000	840	0.0	0.0	0.0	1672.0	1200.0	168.0
Aphanizomenon	480	1800	3570	9240	58200	8400	62.4	234.0	464.1	1201.2	7566.0	1092.0
Limnothrix	0	0	0	0	0	2240	0.0	0.0	0.0	0.0	0.0	22.4
Filamentous Non-Nitrogen Fixers												
Oscillatoria	0	0	0	0	0	6300	0.0	0.0	0.0	0.0	0.0	63.0
Planktolyngbya	480	0	0	0	0	0	4.8	0.0	0.0	0.0	0.0	0.0
Pseudanabaena	3120	0	0	0	0	0	31.2	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA												
Trachelomonas	0	60	34	66	20	14	0.0	60.0	34.0	66.0	20.0	14.0
PYRRHOPHYTA												
Peridinium	0	80	34	22	0	0	0.0	1026.0	71.4	46.2	0.0	0.0
DENSITY (CELLS/ML) SUMMARY												
BACILLARIOPHYTA	**864**	**80**	**1802**	**616**	**400**	**364**	**350.4**	**88.0**	**2640.1**	**453.2**	**444.0**	**355.6**
Centric Diatoms	96	60	867	0	40	196	14.4	72.0	1932.9	0.0	12.0	159.6
Araphid Pennate Diatoms	672	20	901	616	340	126	278.4	16.0	680.0	453.2	416.0	168.0
Monoraphid Pennate Diatoms	24	0	0	0	0	0	2.4	0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms	72	0	34	0	20	42	55.2	0.0	27.2	0.0	16.0	28.0
CHLOROPHYTA	**48**	**140**	**612**	**572**	**260**	**140**	**16.8**	**176.0**	**193.8**	**85.8**	**28.0**	**14.0**
Flagellated Chlorophytes	0	60	17	0	0	0	0.0	24.0	6.8	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	48	80	595	572	260	140	16.8	152.0	187.0	85.8	28.0	14.0
Filamentous Chlorophytes	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Desmids	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
CHRYSOPHYTA	**48**	**180**	**187**	**0**	**20**	**1050**	**144.0**	**384.0**	**561.0**	**0.0**	**60.0**	**3150.0**
Flagellated Classic Chrysophytes	48	180	187	0	20	1050	144.0	384.0	561.0	0.0	60.0	3150.0
CRYPTOPHYTA	**144**	**300**	**136**	**198**	**120**	**280**	**163.2**	**200.0**	**122.4**	**818.4**	**496.0**	**504.0**
CYANOPHYTA	**4080**	**1800**	**3570**	**17600**	**64200**	**17780**	**98.4**	**234.0**	**464.1**	**2873.2**	**8766.0**	**1345.4**
Filamentous Nitrogen Fixers	480	1800	3570	17600	64200	11480	62.4	234.0	464.1	2873.2	8766.0	1282.4
Filamentous Non-Nitrogen Fixers	3600	0	0	0	0	6300	36.0	0.0	0.0	0.0	0.0	63.0
EUGLENOPHYTA	**0**	**60**	**34**	**66**	**20**	**14**	**0.0**	**60.0**	**34.0**	**66.0**	**20.0**	**14.0**
PYRRHOPHYTA	**0**	**80**	**34**	**22**	**0**	**0**	**0.0**	**1026.0**	**71.4**	**46.2**	**0.0**	**0.0**
TOTAL	**5184**	**2640**	**6375**	**19074**	**65020**	**19628**	**772.8**	**2168.0**	**4086.8**	**4342.8**	**9814.0**	**5383.0**
CELL DIVERSITY	**0.65**	**0.56**	**0.75**	**0.46**	**0.17**	**0.64**	**0.95**	**0.72**	**0.87**	**0.66**	**0.37**	**0.59**
CELL EVENNESS	**0.54**	**0.50**	**0.55**	**0.40**	**0.16**	**0.53**	**0.79**	**0.65**	**0.64**	**0.58**	**0.34**	**0.49**

APPENDIX F

2006 LAKE WALLENPAUPACK ZOOPLANKTON DATA

Lake Wallenpaupack Watershed Management District
2006 Lake Wallenpaupack Water Quality Summary
Zooplankton Biomass Data - 2006 All Stations
FXB Project No. PA1012-66

	ZOOPLANKTON DENSITY (#/L)						ZOOPLANKTON BIOMASS (UG/L)				
TAXON	LWWMD 5/24/06	LWWMD 7/11/06	LWWMD 8/3/06	LWWMD 8/31/06	LWWMD 9/18/06	LWWMD 10/19/06	LWWMD 5/24/06	LWWMD 7/11/06	LWWMD 8/3/06	LWWMD 8/31/06	LWWMD 9/18/06
PROTOZOA											
Ciliophora	4.0	0.0	0.0	0.0	35.1	0.0	0.1	0.0	0.0	0.0	0.7
Mastigophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sarcodina	3.6	14.3	12.8	3.7	0.0	0.0	0.1	0.3	0.3	0.1	0.0
ROTIFERA											
Asplanchna	0.8	5.3	0.6	0.4	0.4	0.4	0.8	10.6	1.3	0.7	0.8
Brachionus	1.6	0.6	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Conochilus	1.2	6.7	17.3	3.7	7.0	0.0	0.0	0.3	0.7	0.1	0.3
Filinia	0.4	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Kellicottia	1.6	1.4	1.9	0.7	0.0	9.7	0.1	0.1	0.1	0.0	0.0
Keratella	17.4	6.7	8.3	18.9	2.0	0.0	1.6	0.6	0.7	1.7	0.2
Lepadella	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Ploesoma	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Polyarthra	22.6	15.1	2.6	15.5	9.0	21.1	2.0	1.4	0.2	1.4	0.8
Synchaeta	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Trichocerca	0.6	1.7	2.6	2.2	0.8	2.2	0.0	0.1	0.1	0.1	0.0
COPEPODA											
Copepoda-Cyclopoida											
Cyclops	2.4	0.6	1.3	0.0	0.0	0.2	5.9	1.4	3.1	0.0	0.0
Mesocyclops	0.0	0.0	2.9	1.5	0.8	0.0	0.0	0.0	3.6	1.9	1.0
Copepoda-Calanoida											
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	2.0	1.7	2.9	1.1	1.2	0.7	5.3	4.5	7.6	2.9	3.1
CLADOCERA											
Bosmina	4.4	7.3	2.6	4.4	1.2	1.1	4.3	7.1	2.5	4.4	1.1
Ceriodaphnia	0.0	1.4	1.6	0.4	0.4	0.0	0.0	3.6	4.2	1.0	1.0
Chydorus	0.0	0.0	0.0	1.5	0.4	0.0	0.0	0.0	0.0	1.5	0.4
Daphnia ambigua	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.9	1.0	0.0	0.0
Daphnia galeata	0.0	1.4	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.0
Diaphanosoma	0.2	0.3	0.0	0.0	0.4	0.0	0.2	0.3	0.0	0.0	0.4
OTHER ZOOPLANKTON											
Ostracoda	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.9
SUMMARY STATISTICS											
DENSITY											
PROTOZOA	7.6	14.3	12.8	3.7	35.1	0.0	0.2	0.3	0.3	0.1	0.7
ROTIFERA	46.2	37.5	33.3	47.7	19.1	35.2	4.7	13.0	3.1	4.4	2.1
COPEPODA	4.4	2.2	7.0	2.6	2.0	0.9	11.2	5.8	14.4	4.8	4.1
CLADOCERA	4.6	10.9	4.8	6.3	2.3	1.1	4.5	20.1	7.7	6.8	2.9
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.9
TOTAL ZOOPLANKTON	62.8	65.0	57.9	60.3	58.9	37.2	20.5	39.2	25.4	16.0	13.7