Prepared for:

Town of East Hampton, Connecticut

LAKE POCOTOPAUG 2002 IN-LAKE WATER SAMPLING AND ALGAL ASSAY RESULTS

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March 2003

Document No. 8734-756-001

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1.0 RESULTS OF IN-LAKE SAMPLING

Lake Pocotopaug was sampled at two in-lake stations in 2002 (Figure 1). One station, located in the western deep basin (Oakwood Basin; LP-2), was sampled once during the months of June, July, August, and September at three depths (surface, mid-depth, and bottom). The second station, located in the southern shallow basin (unnamed basin; LP-15), was sampled once during the months of July, August, and September at one depth (surface). Samples were analyzed for nutrients (total and dissolved phosphorus, ammonium, nitrate and total Kjeldahl nitrogen), conductivity, turbidity, and pH. Secchi disk transparency (SDT) and temperature/dissolved oxygen profiles were recorded during each sampling event. One depth-integrated algal sample was collected on each date (surface to 2XSDT depth) at the Oakwood Basin (LP-2) and analyzed for algal composition and relative abundance by an ENSR taxonomist. Additional samples were collected in November and December by volunteers and analyzed by ENSR. Two zooplankton samples were collected and analyzed for composition and relative abundance by an ENSR taxonomist.

1.1 Chemical and Physical Results

The temperature profiles for Lake Pocotopaug in 2002 indicate that the lake was weakly stratified during the period of measurement (Figure 2). Profiles from previous years indicate strong thermal stratification during the months of July and August, and sometimes late June and early September. This was not the case in 2002. Dissolved oxygen concentrations followed roughly the same pattern as temperature, with values below 1.0 mg/L occurring at or below 5.0 meters during July, August, and September.

Lake Pocotopaug 2002 pH and conductivity values were comparable to previous years. The pH in 2002 ranged from 6.3 to 8.3 SU (Table 1), with higher values were reported in surface samples. Conductivity was relatively consistent throughout the water column and sampling period. Values ranged from 102 to 167 umhos/cm with a surface water average of 111 umhos/cm, slightly higher than previous years but comparable; 1991-2001 values ranged from 44 to 174 umhos/cm with an average of 81 umhos/cm.

Surface water turbidity in 2002 ranged from 1.7 to 9.8 NTU (Table 1), with the maximum recorded at the bottom of Oakwood Basin (LP-2). Surface turbidity values in previous years (1991-2001) ranged from 0.5 – 13.0, with an average of 2.6 NTU. Values above 5.0 NTU (threshold for “clean” New England lakes) were reported during August and September. Both surface samples were greater than 5.0 in August, which coincided with a reported algal bloom. The bottom sample in September was greater than 5.0 NTU. All other values were within the typical range (i.e. < 5.0 NTU).

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen and ammonium. Ammonium and nitrate nitrogen are inorganic forms which are readily available for algal uptake. The sum of TKN and nitrate is the total nitrogen content. Levels of TKN greater than 3.0 mg/L are generally considered high while levels less than 0.3 mg/L are considered low. Similarly, levels of ammonium nitrogen greater than 1.0 mg/L are generally considered high while concentrations less than 0.1 mg/L are considered low.

Lake Pocotopaug
2001-2002 Sampling Locations

Figure 1

Source:
Base Map: Scanned USGS Topographic Map from http://magic.lib.uconn.edu/
Watershed delineation: From topography, field reconnaissance and previous reports

300 0 300 600 Meters

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Figure 2. Lake Pocotopaug Temperature and Dissolved Oxygen Profiles 2002.

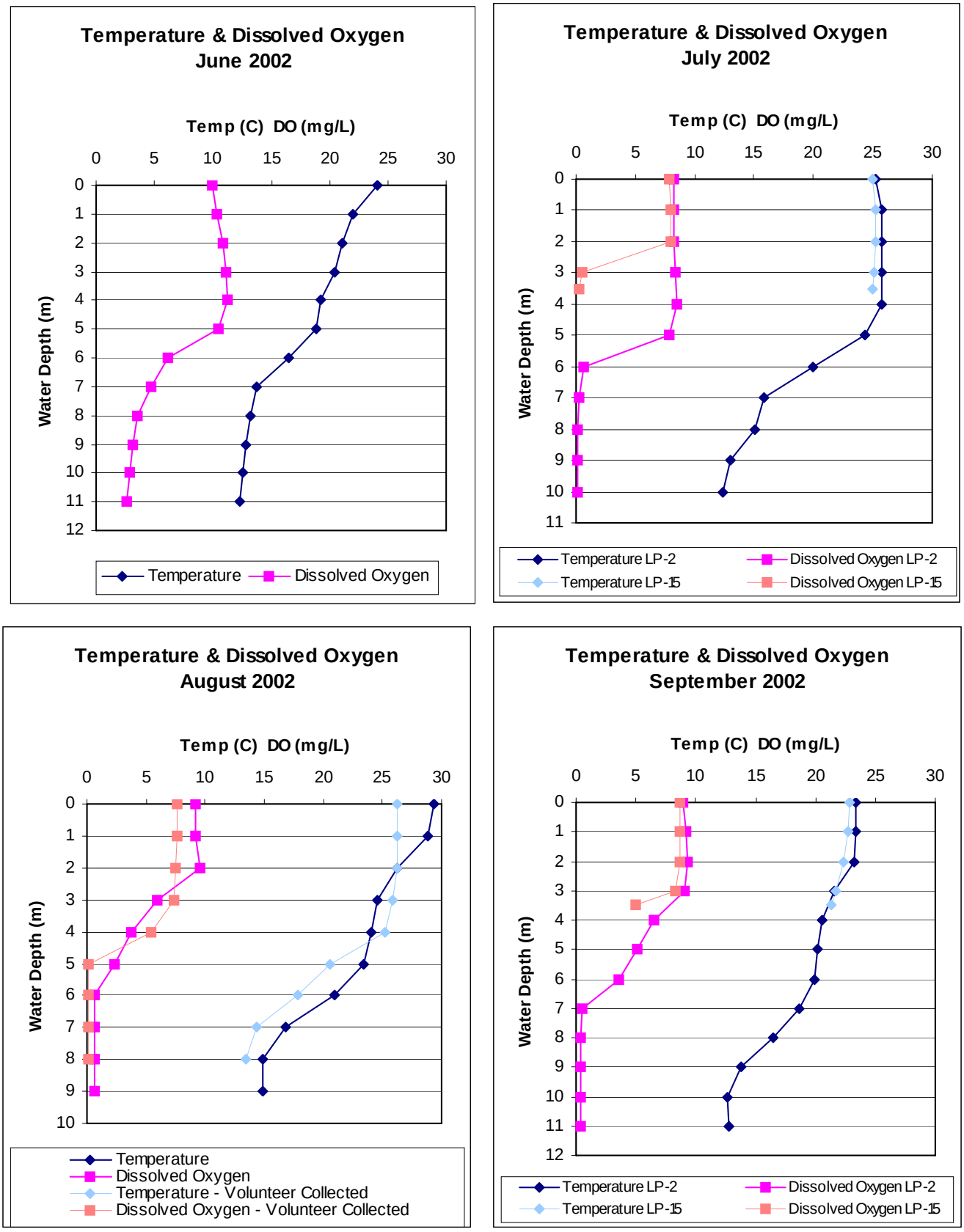


Table 1. Water Quality Sampling Results during 2002.

	Station	Date Sampled					Min	Max	Mean
		6/17/02	7/24/02	8/14/02	9/10/02				
pH (SU)	LP-2S	6.5	7.0	8.3	NS		6.5	8.3	7.3
	LP-2M	6.3	6.3	6.6	NS		6.3	6.6	6.4
	LP-2B	6.3	6.5	6.6	NS		6.3	6.6	6.5
	LP-15S	6.5	7.0	8.3	NS		6.5	8.3	7.3
Conductivity (umhos/cm)	LP-2S	111.6	109.7	103	112.4		103.0	112.4	109.2
	LP-2M	115.2	109.9	102	118.9		102.0	118.9	111.5
	LP-2B	150.3	129.1	106	166.6		106.0	166.6	138.0
	LP-15S	112.3	116.4	110	112.1		110.0	116.4	112.7
Turbidity (NTU)	LP-2S	1.7	3.2	5.6	2.4		1.7	5.6	3.2
	LP-2M	1.9	3.3	1.8	2.5		1.8	3.3	2.4
	LP-2B	2.8	2.2	3.3	9.8		2.2	9.8	4.5
	LP-15S	2.4	3.2	6.6	2.4		2.4	6.6	3.7
Ammonium (mg/L)	LP-2S	<0.01	0.02	0.01	0.09		0.01	0.09	0.03
	LP-2M	0.05	0.68	0.22	0.16		0.05	0.68	0.28
	LP-2B	0.57	0.1	0.42	2.1		0.10	2.10	0.80
	LP-15S	<0.01	0.02	<0.01	0.07		0.01	0.07	0.03
Nitrate (mg/L)	LP-2S	<0.01	<0.01	<0.01	0.02		0.01	0.02	0.01
	LP-2M	0.01	<0.01	<0.01	0.01		0.01	0.01	0.01
	LP-2B	<0.01	<0.01	<0.01	<0.01		0.01	0.01	0.01
	LP-15S	<0.01	<0.01	<0.01	0.02		0.01	0.02	0.01
TKN (mg/L)	LP-2S	0.5	0.5	0.9	0.8		0.5	0.9	0.7
	LP-2M	1.0	0.8	0.7	0.9		0.7	1.0	0.9
	LP-2B	1.0	1.4	0.9	2.6		0.9	2.6	1.5
	LP-15S	0.4	0.6	0.7	0.8		0.4	0.8	0.6
Total Nitrogen (mg/L)	LP-2S	0.5	0.5	0.9	0.8		0.5	0.9	0.7
	LP-2M	1.0	0.8	0.7	0.9		0.7	1.0	0.9
	LP-2B	1.0	1.4	0.9	2.6		0.9	2.6	1.5
	LP-15S	0.4	0.6	0.7	0.8		0.4	0.8	0.6
Total Phosphorus (mg/L)	LP-2S	0.02	<0.01	0.03	0.031		0.01	0.03	0.02
	LP-2M	0.04	<0.01	0.03	0.036		0.01	0.04	0.03
	LP-2B	0.44	0.04	0.08	0.196		0.04	0.44	0.19
	LP-15S	0.02	0.02	0.03	0.034		0.02	0.03	0.03
Dissolved Phosphorus (mg/L)	LP-2S	0.01	<0.01	0.01	0.014		0.01	0.01	0.01
	LP-2M	0.01	<0.01	0.02	0.020		0.01	0.02	0.01
	LP-2B	0.03	0.01	0.05	0.059		0.01	0.06	0.04
	LP-15S	0.01	<0.01	0.02	0.020		0.01	0.02	0.01
Secchi Disk Transparency (ft)									
	LP-1	6.5	3.5	3.0	5.3		3.0	6.5	4.6
	LP-15	6.0	3.5	NS	4.8		3.5	6.0	4.8
NS = Not Sampled									

TKN at the surface water stations ranged from 0.4 to 0.9 mg/L, with an average of 0.7 mg/L in the moderate range (Table 1). Bottom water samples ranged from 0.9 to 2.6 mg/L, with an average of 1.5 mg/L. Surface water values in 1991-2001 ranged from 0.3 to 0.7 mg/L, with an average of 0.5 mg/L, lower than in 2002 but comparable. Nitrate concentrations were low; 75% of the samples were below the 0.01 mg/L detection limit. Nitrate levels in 2002 were lower on average than in previous years (average in 2002 was <0.01 vs. average of 1991-2001 was 0.04 mg/L). Ammonium nitrogen was low to moderate and generally increased with water depth, except in July when the mid-depth sample contained higher concentrations than the bottom sample. Surface water samples ranged from less than the 0.01 mg/L detection limit to 0.09 mg/L, with an average of 0.03 mg/L; average surface water ammonium was higher in previous years (0.10 mg/L).

Surface water phosphorus values at the Oakwood Basin were comparable to previous years. Although average surface water total phosphorus is higher in 2002 than in 2001 (Figure 3), this difference was not statistically significant (P = 0.11). Average surface water phosphorus at the Oakwood Basin in 2002 was 0.02 mg/L, average in 2001 was 0.01 mg/L. As blooms are rare at 0.01 mg/L and start to become more common above 0.02 mg/L, this is a concern. However, the values of 0.02 or greater (0.03 mg/L in August and September) occurred after the bloom started in July. This suggests that higher surface water P did not trigger the bloom, and is consistent with the hypothesis that algae are rising from the bottom with high levels of P already in the cells. As surface water samples assessed for total P include these algae, the surface P concentration in August and September may be a function of the transport of P from sediments to surface waters by the buoyant *Anabaena*. Note that dissolved P remains low throughout the summer in the surface waters.

Surface water dissolved phosphorus in the Oakwood Basin was less than 50% of the total phosphorus available when concentrations were above the detection limit. The shallow basin (LP-3) had a higher portion of dissolved phosphorus (> 50% in three of the four samplings).

Total phosphorus in bottom water exhibited a distinct increase over the summer (Figure 4), rising from 0.04 mg/L in July to almost 0.20 mg/L in September. The even higher value in June (0.44 mg/L) is not believed to be a consequence of stirred up bottom material. Rather, it is suggested that the high total P near the bottom is actually an indication of the *Anabaena* accumulation that later rose to the surface. This is speculative at this point, but fits the observations of 2002.

The dissolved phosphorus in the bottom samples from the Oakwood Basin exhibited a more mild increase over the summer, but was higher than in 2001. The average in 2002 was 0.04 mg/L (range of 0.01 to 0.06 mg/L) vs < 0.01 mg/L in 2001 (Figure 5). The higher total P levels appear to be a consequence of settling of particulates into the bottom waters, carrying associated P with them as they settle. The increase in dissolved P in bottom waters could be either a function of decay of those particulates or release from bottom sediment, but P levels were not high enough to be a major concern for P transport to the upper waters. The alum treatment should maintain bottom water P levels below 0.10 mg/L, with very little of this reaching the upper waters during summer.

Secchi disk transparancy (SDT) ranged from 3.0 to 6.5 feet. The shallow basin (LP-15) had lower SDT values, but the average value was higher due to sample size and timing of collection. This difference is likely due to resuspension of previously settled sediment. The lowest value occurred in August during a reported algal bloom that began in late July.

Figure 3. Surface (Epilimnetic) Water Total Phosphorus at Oakwood Basin (LP-2).

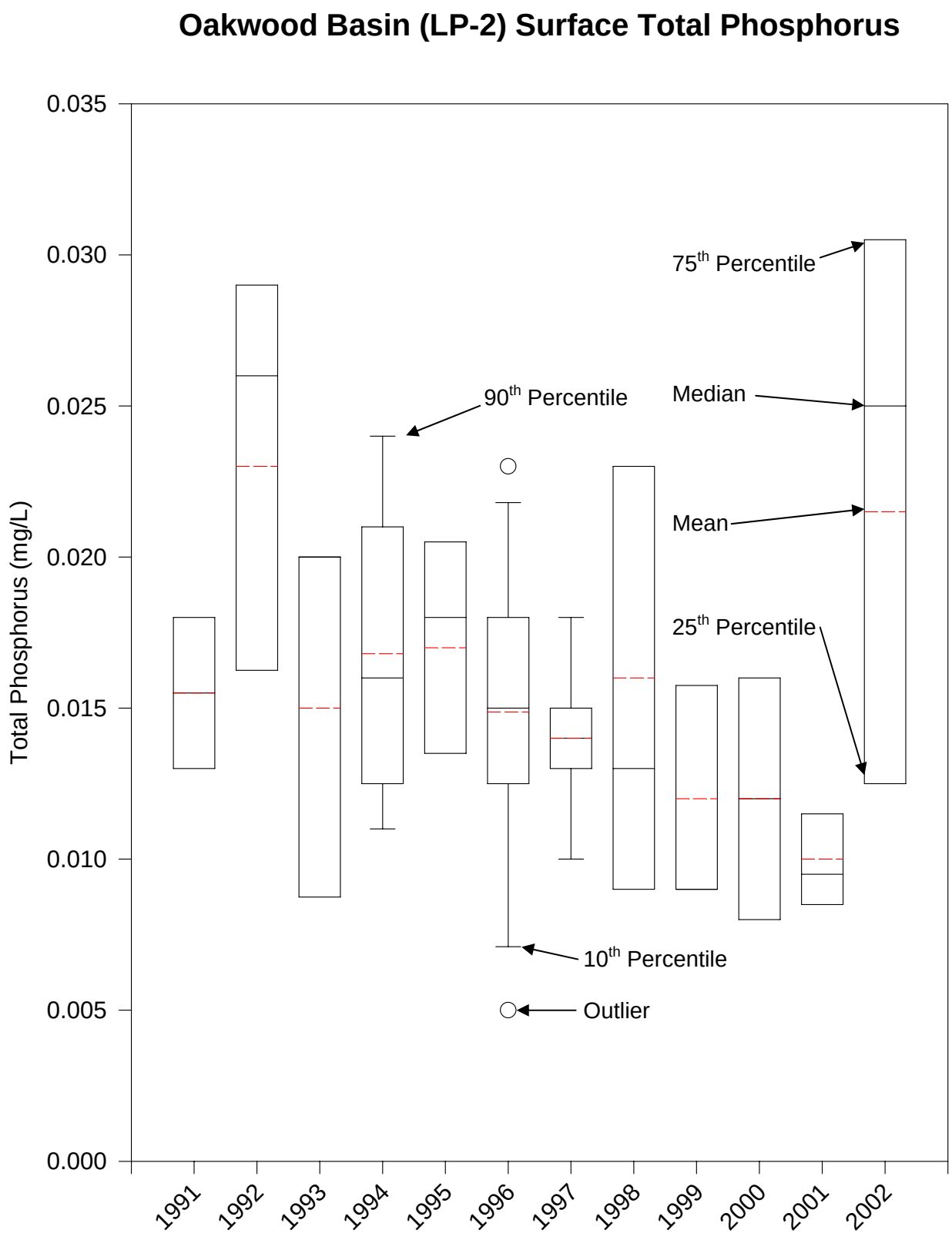


Figure 4. Bottom (Hypolimnetic) Water Total Phosphorus at Oakwood Basin (LP-2).

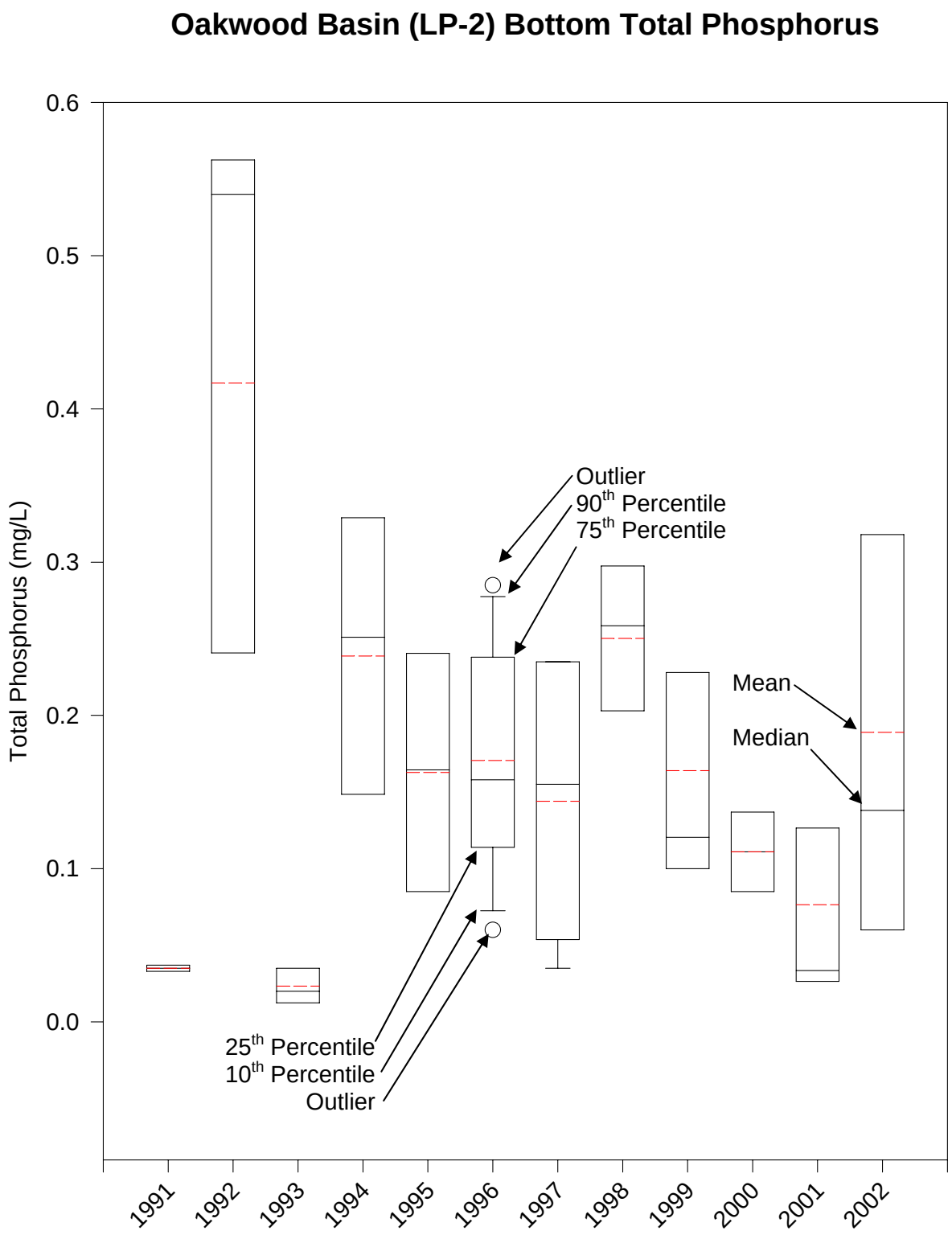
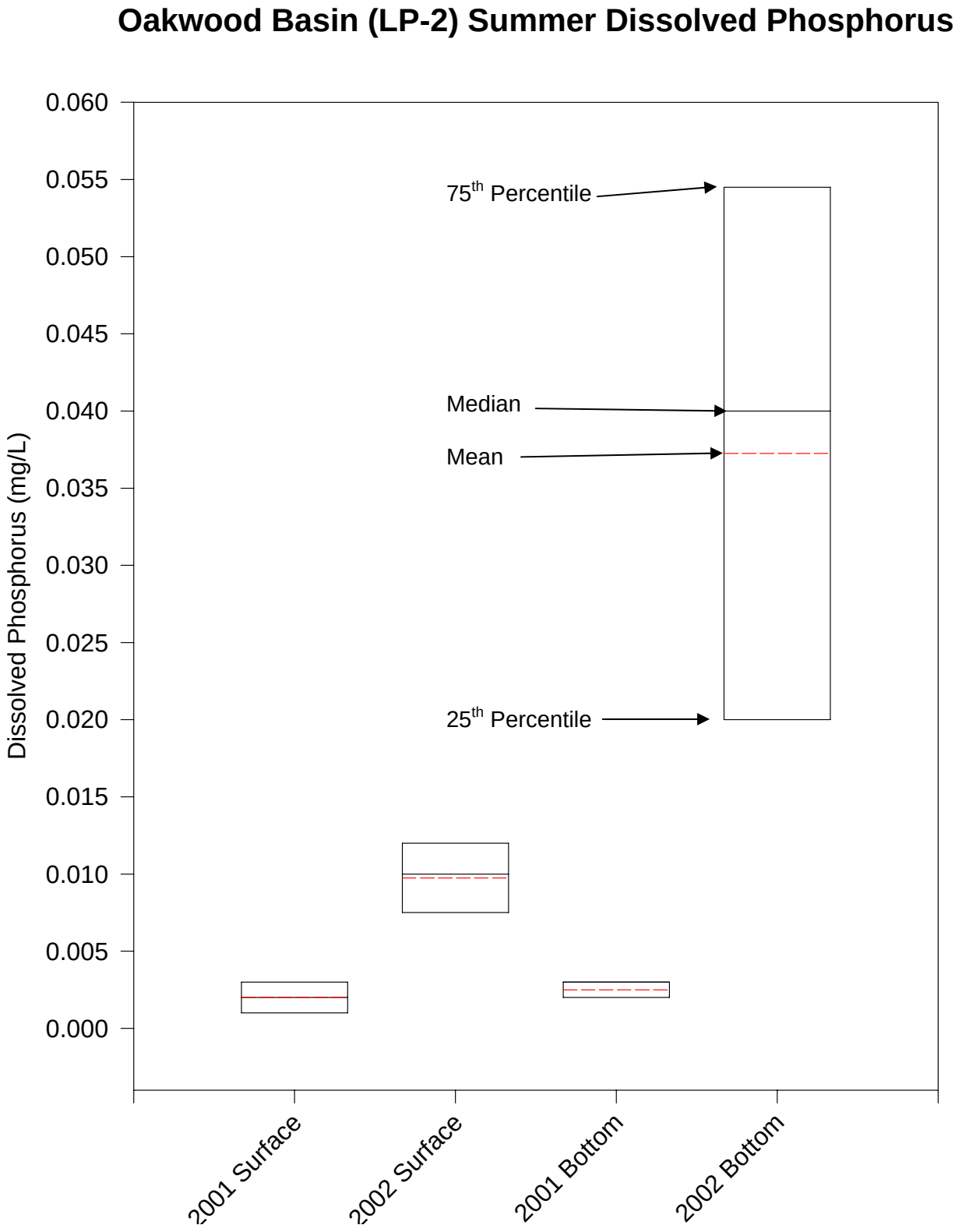


Figure 5. Lake Pocotopaug Dissolved Phosphorus 2001-2002.



1.2 Biological Results

Phytoplankton samples were taken by ENSR on one date in each of June, July, August, and September in 2002. Integrated samples were taken to a depth of two times the Secchi disk transparency depth, and represent a composite sample of the photic zone. Additional samples were taken by volunteers once in November and twice in December and sent to ENSR for analysis. Additional late 2002 sampling was impeded by thin ice cover on the lake. Algal samples were preserved in gluteraldehyde (0.3% final solution), concentrated by settling, and analyzed under phase contrast microscopy at 400X.

Cell counts (Table 2) and biomass (Table 3) generally varied together, although there were a few shifts in composition that lead to deviation of counts and biomass. Diatoms (mostly *Stephanodiscus* and *Tabellaria*) and chrysophytes (mainly *Dinobryon*) were the dominant phytoplankton component in June and after mid-September. The blue-green *Anabaena (*believed to be *A. aphanizomenoides)* was reported in the highest numbers and biomass in July, August and September. Taxonomic richness (the number of algal types present) and diversity (the distribution of cells among taxa) were not high in 2002, and diversity was lowest when *Anabaena* dominated.

While water clarity was not high during any sampling, lowest clarity matched the blue-green bloom period. Visual observation indicated that *Anabaena* was concentrated in the upper 7 ft of the lake, with very clear water present at depths greater than 10 ft. This alga appears to have "hatched" from resting cells in the bottom sediments, grown into short chains of cells near the sediment-water interface, then rose to the surface as gas vesicles were formed. This highly buoyant alga has minimal cell contents, a high biomass:chlorophyll ratio, and may be getting most of its necessary phosphorus from the sediments during the overwinter incubation period. Abundance was maximum shortly after the bloom formed at the surface and declined over time, consistent with limited nutrient availability in the surface waters.

Late fall/early winter samples provided no indication of toxic algae. *Dinobryon* was abundant in both late spring and late fall and can be a nuisance alga, imparting color and odor to the water. However, spring/fall levels of algae were generally not high enough to impair lake uses. Only the summer bloom of *Anabaena* appears to represent a threat to recreation and ecological health in this system.

Zooplankton samples were collected from the Oakwood Basin in June, August, and September. The zooplankton of Lake Pocotopaug was sampled by towing a net with a mesh aperture of 53 micrometers through 30 meters of water, resulting in a concentrated sample representing 948 liters of lake water. Samples were collected at LP-2 on three dates, and examined at 40X to 100X magnification under brightfield optics to determine types, abundance and size of zooplankters present (Table 4). Composition included three species of rotifers, three types of copepods, and seven genera of cladocerans, all forms commonly found in this region and fairly similar to the composition in 2001. The presence of large-bodied forms of *Daphnia*, a cladoceran that provides substantial grazing pressure on algae, is of particular interest and is being encouraged by the stocking of walleye (which eat the perch that otherwise decimate the *Daphnia* population).

Density as number of individuals was low and biomass per liter values were low to moderate, with an obvious decline in late summer. The same pattern was evident in 2001, although the late summer decline was more distinct in 2002. Average size was moderate to large early in summer, but declined to a low level by late summer. Again, the same pattern was noted in

Table 2. Lake Pocotopaug 2002 Phytoplankton Density.

	PHYTOPLANKTON DENSITY (CELLS/ML)							
	LP-2	LP-2	LP-2	LP-2	Outlet	LP-SP	LP-SP	LP-SP
TAXON	6/17/02	7/24/02	8/14/02	9/10/02	9/24/02	11/25/02	12/20/02	12/23/02
BACILLARIOPHYTA								
Achnanthes	0	0	0	0	0	20	7	12
Asterionella	16	0	0	28	0	360	28	48
Cyclotella	8	0	0	28	0	0	0	0
Cymbella	0	0	0	0	0	10	0	0
Diploneis	4	0	0	0	0	0	0	0
Eunotia	0	0	0	0	0	0	0	12
Melosira	32	50	0	140	84	150	0	0
Navicula	0	10	0	0	0	10	0	12
Nitzschia	0	0	0	0	0	10	7	12
Rhizosolenia	0	0	0	14	56	0	0	0
Stephanodiscus	152	20	0	126	14	30	0	0
Synedra	0	0	0	0	0	0	7	12
Tabellaria	32	70	0	56	56	1270	56	492
CHLOROPHYTA								
Actinastrum	0	0	0	84	0	0	0	0
Ankistrodesmus	0	10	0	308	112	0	0	0
Closteriopsis	0	0	0	42	28	0	0	0
Coelastrum	128	0	0	0	0	0	0	0
Cosmarium	0	0	0	0	0	0	0	12
Crucigenia	0	0	0	0	0	240	0	192
Dictyosphaerium	0	240	0	0	448	160	28	96
Elakatothrix	0	20	0	56	0	20	0	0
Golenkinia	0	0	0	14	0	0	0	0
Mougeotia	0	0	0	84	0	0	0	0
Oocystis	16	0	0	56	0	0	0	0
Paulschultzia	0	20	0	0	0	0	0	0
Pediastrum	128	0	0	0	0	0	0	0
Quadrigula	0	0	0	0	56	0	0	0
Scenedesmus	16	0	8	0	0	40	0	0
Sphaerocystis	0	0	64	336	224	0	0	0
Staurastrum	8	0	0	0	28	0	0	0
Staurodesmus	0	0	0	112	56	0	0	0
CHRYSOPHYTA								
Dinobryon	1760	40	0	84	714	10	7	12
Mallomonas	8	20	0	98	28	0	7	36
Ochromonas	0	0	0	0	0	0	14	0
CRYPTOPHYTA								
Cryptomonas	0	0	12	0	0	0	0	0

Table 2 (continued). Lake Pocotopaug 2002 Phytoplankton Density.

	PHYTOPLANKTON DENSITY (CELLS/ML)							
	LP-2	LP-2	LP-2	LP-2	Outlet	LP-SP	LP-SP	LP-SP
TAXON	6/17/02	7/24/02	8/14/02	9/10/02	9/24/02	11/25/02	12/20/02	12/23/02
CYANOPHYTA								
Anabaena spp.	440	43800	21540	13440	2520	120	0	0
Aphanocapsa	0	3400	0	0	1680	0	0	0
Chroococcus	0	0	32	0	0	0	0	0
Lyngbya	80	22700	3620	25480	53340	0	0	0
Microcystis	0	0	60	420	0	0	0	0
Oscillatoria	0	0	0	8400	24780	1200	0	0
EUGLENOPHYTA								
Trachelomonas	8	20	16	28	14	10	0	12
PYRRHOPHYTA								
Gymnodinium	0	0	0	0	0	0	7	0
RHODOPHYTA								
SUMMARY STATISTICS								
DENSITY (#/ML)								
BACILLARIOPHYTA	244	150	0	392	210	1860	105	600
CHLOROPHYTA	296	290	72	1092	952	460	28	300
CHRYSOPHYTA	1768	60	0	182	742	10	28	48
CRYPTOPHYTA	0	0	12	0	0	0	0	0
CYANOPHYTA	520	69900	25252	47740	82320	1320	0	0
EUGLENOPHYTA	8	20	16	28	14	10	0	12
PYRRHOPHYTA	0	0	0	0	0	0	7	0
RHODOPHYTA	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	2836	70420	25352	49434	84238	3660	168	960
TAXONOMIC RICHNESS								
BACILLARIOPHYTA	6	4	0	6	4	8	5	7
CHLOROPHYTA	5	4	2	9	7	4	1	3
CHRYSOPHYTA	2	2	0	2	2	1	3	2
CRYPTOPHYTA	0	0	1	0	0	0	0	0
CYANOPHYTA	2	3	4	4	4	2	0	0
EUGLENOPHYTA	1	1	1	1	1	1	0	1
PYRRHOPHYTA	0	0	0	0	0	0	1	0
RHODOPHYTA	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	16	14	8	22	18	16	10	13
S-W DIVERSITY INDEX	0.60	0.37	0.20	0.54	0.42	0.76	0.85	0.70
EVENNESS INDEX	0.50	0.32	0.22	0.40	0.33	0.63	0.85	0.63

Table 3. Lake Pocotopaug 2002 Phytoplankton Biomass.

	PHYTOPLANKTON BIOMASS (UG/L)							
	LP-2	LP-2	LP-2	LP-2	Outlet	LP-SP	LP-SP	LP-SP
TAXON	6/17/02	7/24/02	8/14/02	9/10/02	9/24/02	11/25/02	12/20/02	12/23/02
BACILLARIOPHYTA								
Achnanthes	0	0	0	0	0	2	1	1
Asterionella	3	0	0	6	0	72	6	10
Cyclotella	1	0	0	3	0	0	0	0
Cymbella	0	0	0	0	0	10	0	0
Diploneis	12	0	0	0	0	0	0	0
Eunotia	0	0	0	0	0	0	0	12
Melosira	10	15	0	42	25	45	0	0
Navicula	0	5	0	0	0	5	0	6
Nitzschia	0	0	0	0	0	8	6	10
Rhizosolenia	0	0	0	17	67	0	0	0
Stephanodiscus	1064	140	0	882	98	210	0	0
Synedra	0	0	0	0	0	0	6	10
Tabellaria	26	56	0	45	45	1016	45	394
CHLOROPHYTA								
Actinastrum	0	0	0	8	0	0	0	0
Ankistrodesmus	0	1	0	154	56	0	0	0
Closteriopsis	0	0	0	21	14	0	0	0
Coelastrum	90	0	0	0	0	0	0	0
Cosmarium	0	0	0	0	0	0	0	10
Crucigenia	0	0	0	0	0	24	0	19
Dictyosphaerium	0	24	0	0	45	16	3	10
Elakatothrix	0	2	0	6	0	2	0	0
Golenkinia	0	0	0	3	0	0	0	0
Mougeotia	0	0	0	84	0	0	0	0
Oocystis	6	0	0	22	0	0	0	0
Paulschultzia	0	8	0	0	0	0	0	0
Pediastrum	26	0	0	0	0	0	0	0
Quadrigula	0	0	0	0	11.2	0	0	0
Scenedesmus	1.6	0	0.8	0	0	4	0	0
Sphaerocystis	0	0	12.8	67.2	44.8	0	0	0
Staurastrum	51.2	0	0	0	22.4	0	0	0
Staurodesmus	0	0	0	67.2	33.6	0	0	0
CHRYSOPHYTA								
Dinobryon	5280	120	0	252	2142	30	21	36
Mallomonas	4	10	0	49	14	0	3.5	60
Ochromonas	0	0	0	0	0	0	1.4	0

Table 3 (continued). Lake Pocotopaug 2002 Phytoplankton Biomass.

	PHYTOPLANKTON BIOMASS (UG/L)							
	LP-2	LP-2	LP-2	LP-2	Outlet	LP-SP	LP-SP	LP-SP
TAXON	6/17/02	7/24/02	8/14/02	9/10/02	9/24/02	11/25/02	12/20/02	12/23/02
CRYPTOPHYTA								
Cryptomonas	0	0	2.4	0	0	0	0	0
CYANOPHYTA								
Anabaena spp.	88	8760	4308	2688	504	24	0	0
Aphanocapsa	0	34	0	0	16.8	0	0	0
Chroococcus	0	0	0.3	0	0	0	0	0
Lyngbya	1.6	454	72.4	509.6	1066.8	0	0	0
Microcystis	0	0	1.8	12.6	0	0	0	0
Oscillatoria	0	0	0	84	247.8	12	0	0
EUGLENOPHYTA								
Trachelomonas	8	20	16	28	14	10	0	12
PYRRHOPHYTA								
Gymnodinium	0	0	0	0	0	0	14.7	0
RHODOPHYTA								
SUMMARY STATISTICS								
DENSITY (#/ML)								
BACILLARIOPHYTA	1115.6	216	0	994	235.2	1368	62.3	441.6
CHLOROPHYTA	174.4	35	13.6	432.6	226.8	46	2.8	38.4
CHRYSOPHYTA	5284	130	0	301	2156	30	25.9	96
CRYPTOPHYTA	0	0	2.4	0	0	0	0	0
CYANOPHYTA	89.6	9248	4382.5	3294.2	1835.4	36	0	0
EUGLENOPHYTA	8	20	16	28	14	10	0	12
PYRRHOPHYTA	0	0	0	0	0	0	14.7	0
RHODOPHYTA	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	6671.6	9649	4414.5	5049.8	4467.4	1490	105.7	588

Table 4. Lake Pocotopaug 2002 Zooplankton Density and Biomass.

	DENSITY (#/L)			BIOMASS (ug/L)		
TAXON	**6/17/02**	**8/14/02**	**9/10/02**	**6/17/02**	**8/14/02**	**9/10/02**
PROTOZOA						
Ciliophora	0.0	0.0	0.4	0.0	0.0	0.0
ROTIFERA						
Conochilus	0.0	17.4	0.0	0.0	0.7	0.0
Kellicottia	0.0	0.6	0.0	0.0	0.0	0.0
Keratella	0.0	0.0	0.2	0.0	0.0	0.0
COPEPODA						
Copepoda-Cyclopoida						
Cyclops	0.0	0.0	0.2	0.0	0.0	0.4
Mesocyclops	1.1	2.2	0.1	3.9	2.8	0.2
Copepoda-Calanoida						
Diaptomus	3.7	3.7	0.2	13.8	8.5	0.1
Other Copepoda-Nauplii	1.0	0.6	0.5	3.2	1.7	1.4
CLADOCERA						
Bosmina	0.0	1.0	0.0	0.0	0.9	0.0
Ceriodaphnia	0.0	1.6	0.1	0.0	11.0	0.2
Chydorus	0.0	19.2	0.9	0.0	18.8	0.9
Daphnia galeata	0.2	0.2	0.0	3.8	2.5	0.0
Daphnia retrocurva	0.2	0.3	0.0	2.7	1.1	0.0
Diaphanosoma	1.9	1.8	0.1	5.7	3.6	0.1
Leptodora	0.0	0.0	0.0	10.1	13.4	0.0
SUMMARY STATISTICS						
DENSITY						
PROTOZOA	0.0	0.0	0.4	0.0	0.0	0.0
ROTIFERA	0.0	18.1	0.2	0.0	0.7	0.0
COPEPODA	5.8	6.6	1.0	20.8	13.0	2.1
CLADOCERA	2.4	24.0	1.0	22.3	51.4	1.1
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	8.2	48.7	2.6	43.1	65.1	3.2
TAXONOMIC RICHNESS						
PROTOZOA	0	0	1			
ROTIFERA	0	2	1			
COPEPODA	3	3	4			
CLADOCERA	4	7	3			
OTHER ZOOPLANKTON	0	0	0			
TOTAL ZOOPLANKTON	7	12	9			
S-W DIVERSITY INDEX	0.62	0.67	0.80			
EVENNESS INDEX	0.74	0.62	0.84			
MEAN LENGTH: ALL FORMS (MM)	0.91	0.33	0.33			
MEAN LENGTH: CRUSTACEANS	0.91	0.46	0.40			

2001. Limited grazing pressure on algae is provided by this assemblage, which is still apparently subject to significant predation by perch and other planktivores. Stocked walleye would not yet be expected to exert a major impact on the perch population; at least three years of stocking, high survival, and growth will be needed.

Diversity and evenness were moderate to high, suggesting that no one genus of zooplankter was strongly dominant. Early season values were lower than late season values, with fish predation apparently removing the more abundant large forms and limiting desirable dominance by those zooplankters.

Continued monitoring of zooplankton is an excellent way to assess the success of the walleye stocking and overall fish management program. It is not surprising that 2002 results show little change from 2001 data, as the walleye stocked in 2001 were juveniles at a low to moderate density. Observed growth of those walleye has been substantial over the last year, but continued stocking and growth will be necessary before sufficient pressure is exerted on planktivore populations to relieve the predation pressure on the zooplankton. As the walleye population increases, an increase in *Daphnia* densities and mean zooplankter length should be detected, and will signal a decline in planktivore densities.

2.0 ALGAL ASSAY

2.1 Methods

An algal assay was performed using water collected from Lake Pocotopaug to determine if algal growth could be minimized by reducing phosphorus concentrations through dilution. Two treatments were tested, one using epilimnetic water (water collected at the surface of the lake), and one using hypolimnetic water (water collected near the bottom of the lake). There were five dilution sets tested in each treatment with four replicates in each dilution. Each treatment and set was inoculated with 50 mL of epilimnetic water to serve as a phytoplankton source. Treatments, sets, and replicates were set up as follows:

Treatment 1: Epilimnetic (epi) Water

Set A Reps 1-4 = 950mL filtered epi water; 50mL unfiltered epi water (no dilution)
Set B Reps 1-4 = 500mL filtered epi water; 450mL distilled water; 50mL unfiltered epi water (47% dilution)
Set C Reps 1-4 = 100mL filtered epi water; 850mL distilled water; 50mL unfiltered epi water (89% dilution)
Set D Reps 1-4 = 20mL filtered epi water; 930mL distilled water; 50mL unfiltered epi water (98% dilution)
Set E Reps 1-4 = 950mL distilled water; 50mL unfiltered epi water (control)

Treatment 2: Hypolimnetic (hypo) Water

Set A Reps 1-4 = 950mL filtered hypo water; 50mL unfiltered epi water (no dilution)
Set B Reps 1-4 = 500mL filtered hypo water; 450mL distilled water; 50mL unfiltered epi water (47% dilution)
Set C Reps 1-4 = 100mL filtered hypo water; 850mL distilled water; 50mL unfiltered epi water (89% dilution)
Set D Reps 1-4 = 20mL filtered hypo water; 930mL distilled water; 50mL unfiltered epi water (98% dilution)
Set E Reps 1-4 = 950mL distilled water; 50mL unfiltered epi water (control)

Each replicate was fitted with one air diffuser. The treatments were set up under ultraviolet (UV) grow lights on a table sectioned into 40 different “stations”. The air diffusers were attached to air pumps and turned on.

Treatment 1 was started on August 16, 2003. Treatment 2 began on August 17, 2003. Treatments were randomly moved and sampled. Final sampling occurred on August 26, 2003; 10 days after Treatment 1 began and 9 days after Treatment 2 began. Treatments were set up and moved as shown below.

Stations:

1	2	3	4	21	22	23	24
5	6	7	8	25	26	27	28
9	10	11	12	29	30	31	32
13	14	15	16	33	34	35	36
17	18	19	20	37	38	39	40

Treatment 1 was set up on August 16, 2002, and an initial sample of 8mL was taken from each repetition.

1B-1		1A-4			1D-3		1B-2
			1E-1			1D-4	1E-2
	1A-2	1A-3			1D-2		1C-2
1B-3		1E-2	1C-3	1D-1		1A-1	
			1E-4	1B-4	1C-4	1C-1	

Treatment 2 was set up on August 17, 2002, and an initial sample of 8mL was taken from each repetition.

1B-1	2A-2	1A-4	2E-2	2E-3	1D-3	2B-3	1B-2
2A-1	2A-4	2D-3	1E-1	2C-1	2C-3	1D-4	1E-2
2C-4	1A-2	1A-3	2B-4	2E-4	1D-2	2B-2	1C-2
1B-3	2D-1	1E-2	1C-3	1D-1	2E-1	1A-1	2C-2
2D-2	2D-4	2A-3	1E-4	1B-4	1C-4	1C-1	2B-1

The treatments were then randomly moved on August 19, 2002. Each replicate was shaken and 8mL of sample was taken from each repetition.

1A-3	2D-1	2C-1	1B-2	1E-4	1B-4	1A-1	1D-4
2D-2	1A-4	2C-2	1A-2	1D-2	1D-1	2A-1	2B-1
1B-3	2B-2	1C-1	2E-4	2E-3	2A-2	2E-2	2A-4
2A-3	2B-3	1B-1	2B-4	2C-4	2E-1	1E-2	1D-3
2D-4	2D-3	1E-3	2C-3	1E-1	1C-3	1C-4	1C-2

Treatments were then randomly moved on August 20, 2002.

1A-1	2D-2	1E-1	2E-3	1D-4	1B-3	2A-2	2C-4
1D-1	1E-4	1C-3	2C-1	2E-4	2D-3	2A-4	1B-2
2B-3	1E-3	1C-1	1E-2	1A-4	1A-2	2A-3	2A-1
2C-3	1C-2	2D-4	1B-1	2C-2	2E-1	1D-2	2B-4
1B-4	1D-3	2D-1	1C-4	1A-3	2B-A	2E-2	2B-2

Treatments were then randomly moved on August 21, 2002. Each repetition was shaken and 8mL of sample was taken from each replicate.

2E-1	2E-3	1C-2	2C-2	1B-2	1E-4	1A-4	2B-3
1A-3	2B-4	2D-1	1D-4	1E-2	2E-2	2B-2	1B-3
2D-2	1D-1	2C-3	1E-3	2A-2	1C-1	1B-1	2A-4
1E-1	1A-1	2C-4	2D-4	2D-3	2A-1	1A-2	1B-4
2B-1	2E-4	2C-1	1C-4	1D-3	2A-3	1D-2	1C-3

Treatments were then randomly moved on August 22, 2002.

2C-1	2E-3	2A-4	2D-4	1B-3	1E-2	1C-4	2C-4
2B-3	2C-3	2B-1	1D-4	1C-2	1D-2	2D-2	1A-4
1C-1	2A-2	2A-1	2E-1	2C-2	2B-2	1B-1	2D-3
1E-4	1A-3	1B-4	2D-1	1A-2	2A-3	1D-1	1D-3
2E-4	2E-2	2B-4	1E-3	1C-3	1E-1	1B-2	1A-1

Treatments were then randomly moved on August 23, 2002. Each replicate was shaken and 8mL of sample was taken from each replicate.

2D-3	2C-2	1A-2	2C-4	1A-4	1D-4	2B-4	1C-3
1E-4	2C-3	1B-3	2A-2	2B-1	2B-3	1D-2	1A-1
1D-3	2D-2	2C-1	2E-3	2A-3	1B-1	2A-4	2D-4
1E-1	1C-2	2D-1	1B-4	1B-2	1E-2	1C-1	1E-3
2E-1	1C-4	1D-1	1A-3	2B-2	2E-4	2E-2	2A-1

Treatments were then randomly moved on August 24, 2002.

1A-4	2D-1	1E-4	2A-4	1A-2	1C-2	1C-1	2C-2
2B-3	2E-2	1D-3	2A-2	2E-3	1C-3	2A-1	1D-1
2D-2	1B-3	2B-2	2C-3	2E-4	1D-2	2B-4	1E-3
2C-4	1D-4	2E-1	2D-3	2B-1	1B-2	1B-4	1C-4
1A-3	2D-4	1E-1	2C-1	1B-1	2A-3	1E-2	1A-1

Treatments were then randomly moved on August 25, 2002.

1C-3	2B-4	1A-4	2C-3	2D-2	2D-4	1B-2	2A-4
2E-1	1D-3	1E-4	2B-2	2E-4	2E-3	1A-1	1D-4
1E-3	1B-4	2E-2	1B-3	1D-1	1A-3	1E-2	1C-1
2C-4	2B-3	2D-3	1C-4	1D-2	1C-2	1B-1	2A-2
2A-1	1A-2	2C-1	1E-1	2A-3	2C-2	2D-1	2B-1

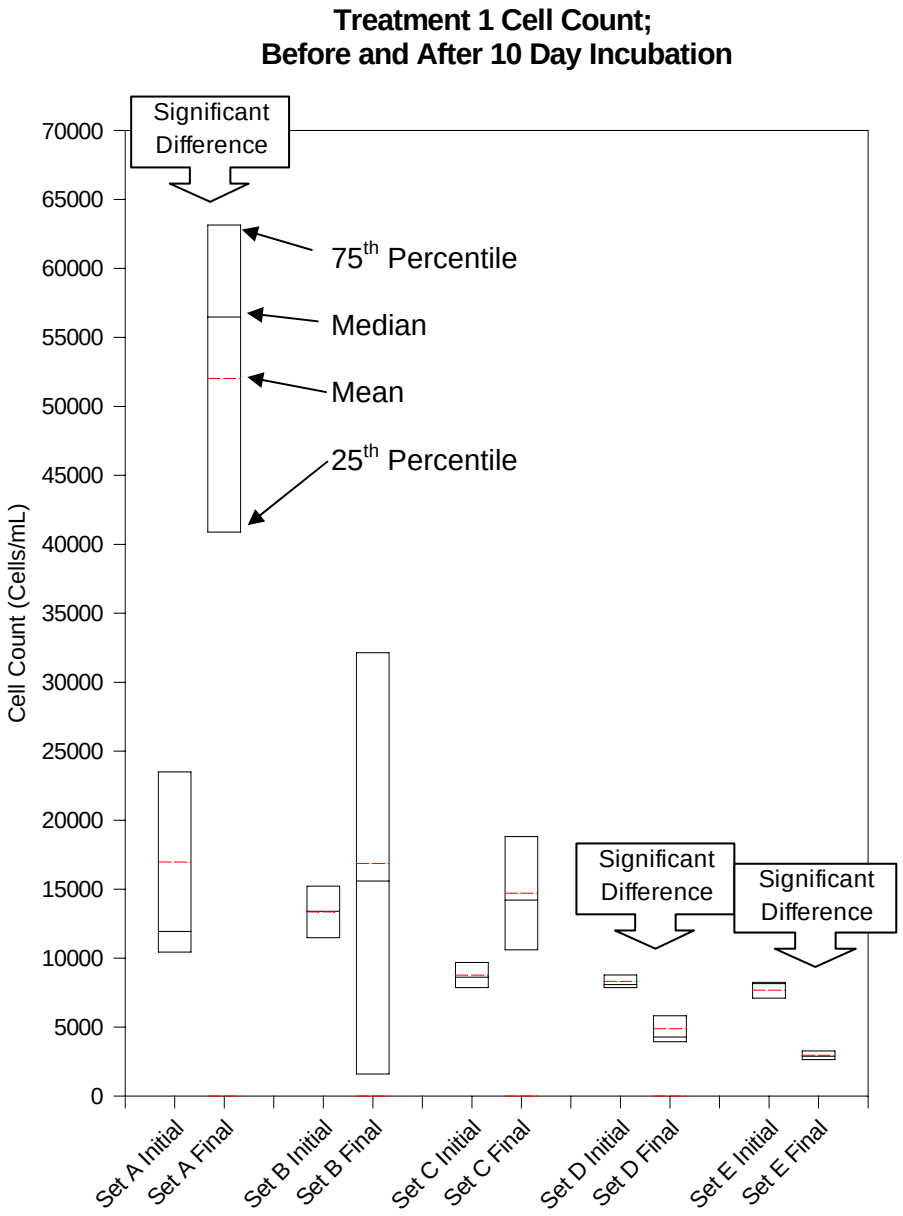
Treatments were then randomly moved on August 26, 2002. Each replicate was shaken and 250mL of sample was taken from each replicate.

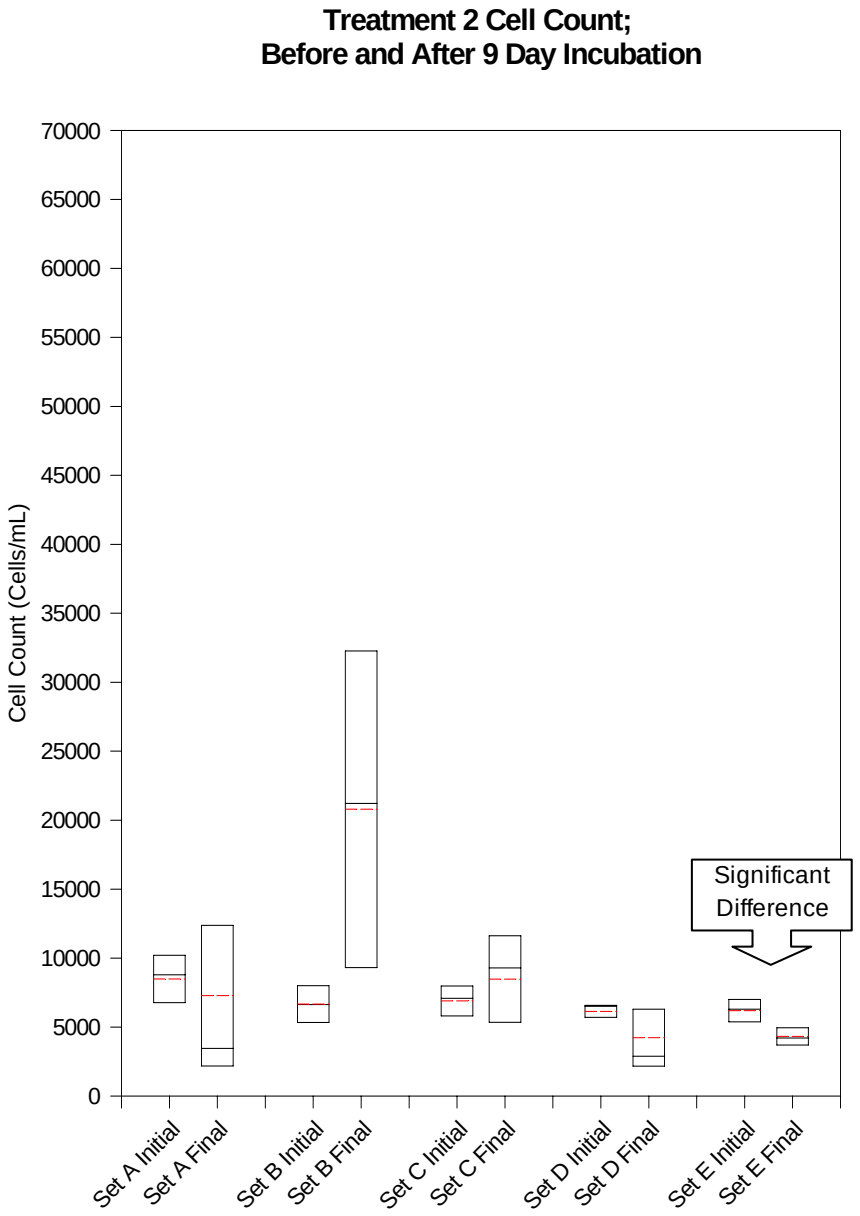
1A-3	2B-2	1B-3	1D-3	2A-1	2C-4	2E-3	1A-4
1A-2	1C-4	1C-2	2E-2	1D-1	2A-4	1E-2	1B-2
2D-2	2B-3	1E-4	1E-1	1A-1	1D-4	2B-4	1C-4
2E-1	2A-3	1E-3	2D-3	2C-2	1B-1	2D-1	2D-4
1D-2	2C-3	1B-4	2A-2	1C-3	2E-4	2C-1	2B-1

2.2 Assay Results

There were significant changes ($P < 0.05$) in cell counts within Treatment 1, using epilimnetic water, before and after incubation in three of the five treatment sets (A, D, and E; Figure 6). Average cell count significantly increased in Set A, and decreased in Sets D & E. Average cell count increased in Sets B and C, but not significantly. What this means is that the whole lake water from the surface allowed growth by the inoculated assemblage (dominated by *Anabaena*), while moderate dilution yielded no growth and severe dilution caused a die-off. As the background P concentration in the undiluted lake water is not high, this species of *Anabaena* is either adapted to growing under low P levels or comes with its own supply (internal reserves). The former is possible but the latter is suspected. Under extreme dilution,

Figure 6. Cell Count before and after Incubation.





nutrient levels are insufficient to support the assemblage. This could mean that P in the cells is inadequate to allow continued growth over 10 days, but could also be a function of inadequate levels of other nutrients.

Treatment 2, using hypolimnetic water, resulted in only one significant change, Set E (distilled water), where there was a significant decrease in cell count (P=0.04). Average cell counts also decreased in Sets A and D, but were not significant. Average cell counts in Sets B and C increased, but the change was not significant. These results suggest that even with intracellular reserves of P, the algae do not grow with hypolimnetic water as a medium over a 10-day period. While we do not know what specifically prevents growth, it can be concluded that the observed bloom conditions are not a function of bottom water conditions.

Comparison of algal cell counts for Sets (dilutions) and Treatments (epi vs. hypo water) reveals that while growth declines with dilution in surface (epi) water (Figure 7), growth is essentially static (no statistically significant change) in bottom (hypo) water. The relative changes are such that the growth is significantly greater in undiluted surface water than undiluted bottom water (epi vs. hypo).

The algal community was dominated by blue-greens (Cyanophyta) before and after incubation in both treatments and in all dilution sets (Figures 8 and 9). Percent composition of green algae (Chlorophyta) increased in four of the five dilution sets in Treatment 1; there was a decrease in percent composition in dilution Set C. Percent composition of Chlorophyta increased in all dilution sets in Treatment 2. There was a decrease in Cyanophyta percent composition in all dilution sets within both treatments. The degree of change in percent composition of Chlorophyta is inversely proportional to the change in Cyanophyta (Figure 10). The most striking aspect of these data is that the nuisance assemblage that bloomed in Lake Pocotopaug and was injected into these treatments was maintained in composition by the surface water but was altered drastically by the bottom water. Again, the bottom water does not appear responsible for what was observed in the lake in 2002.

The management significance of these assays is twofold: 1) bottom water conditions do not support the bloom observed in Lake Pocotopaug in 2002 (and other years by extension), and 2) nutrient levels would have to be reduced almost 100-fold in the surface water to get a die-off of the problem algae. As P concentrations are already low in surface water (10-30 ug/L) and background levels for this ecoregion are not much less (perhaps 5 ug/L), this is not a realistic goal for nutrient management. Unless one is willing to concede that the observed blooms are natural and should be tolerated, an alternative approach to control is needed. The alum treatment inactivated phosphorus to the extent that it is not released into overlying waters during summer stratification and associated anoxia, but may not prevent the uptake of phosphorus by either resting cells of the algae or young filaments (before they rise to the surface). It is also possible that blooms are being fueled by resting cells deposited long before alum treatment, and that this supply will eventually be exhausted, but this seems unlikely.

Figure 7. Change in Cell Count after Incubation.

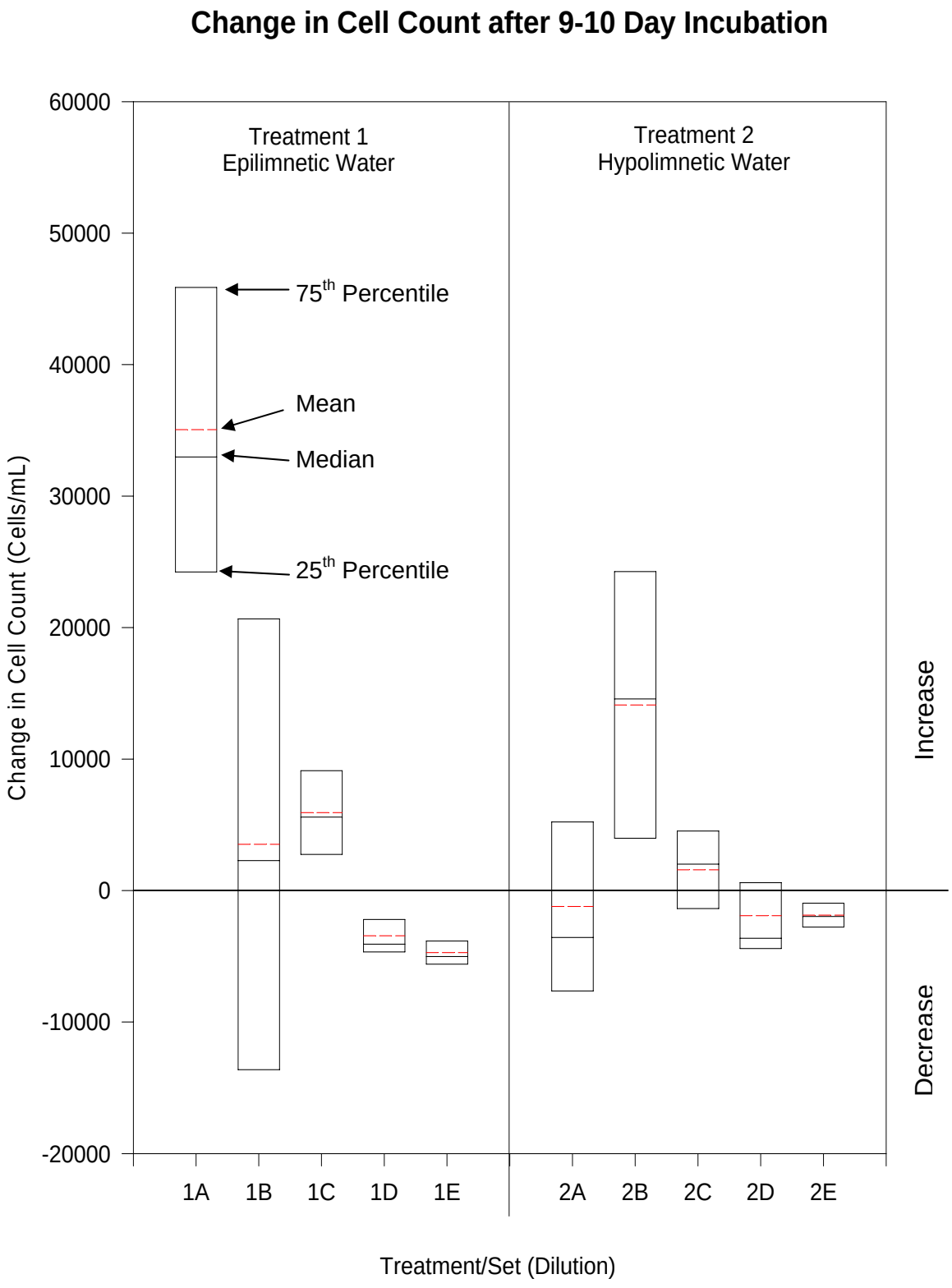
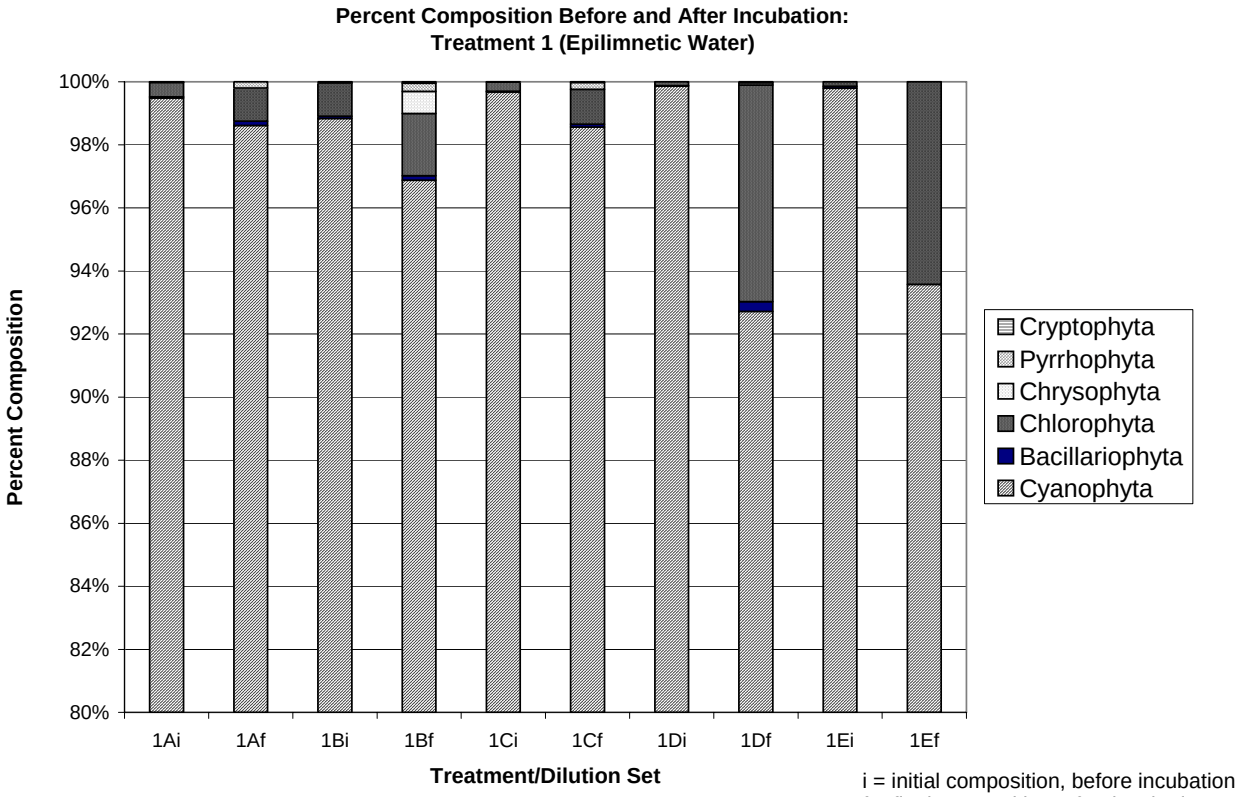
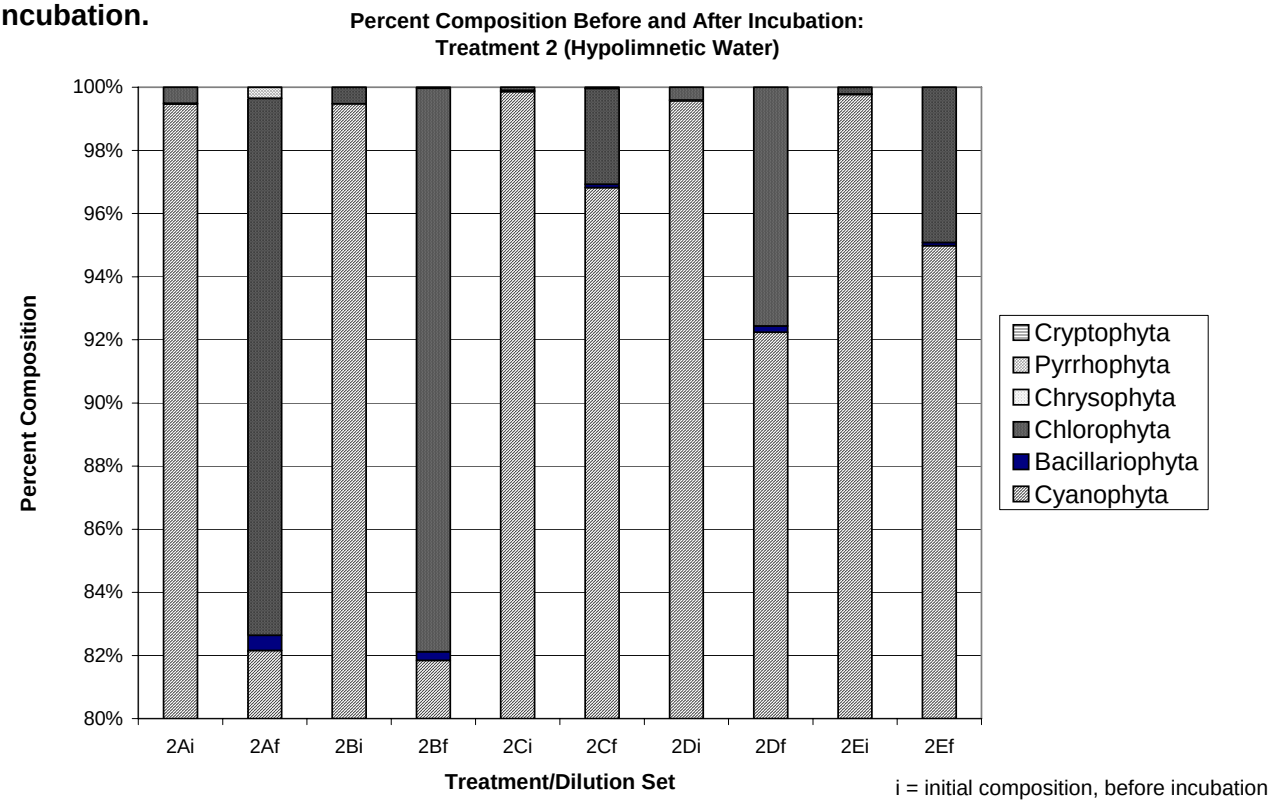


Figure 8. Treatment 1: Algal Community Percent Composition before and after Incubation.



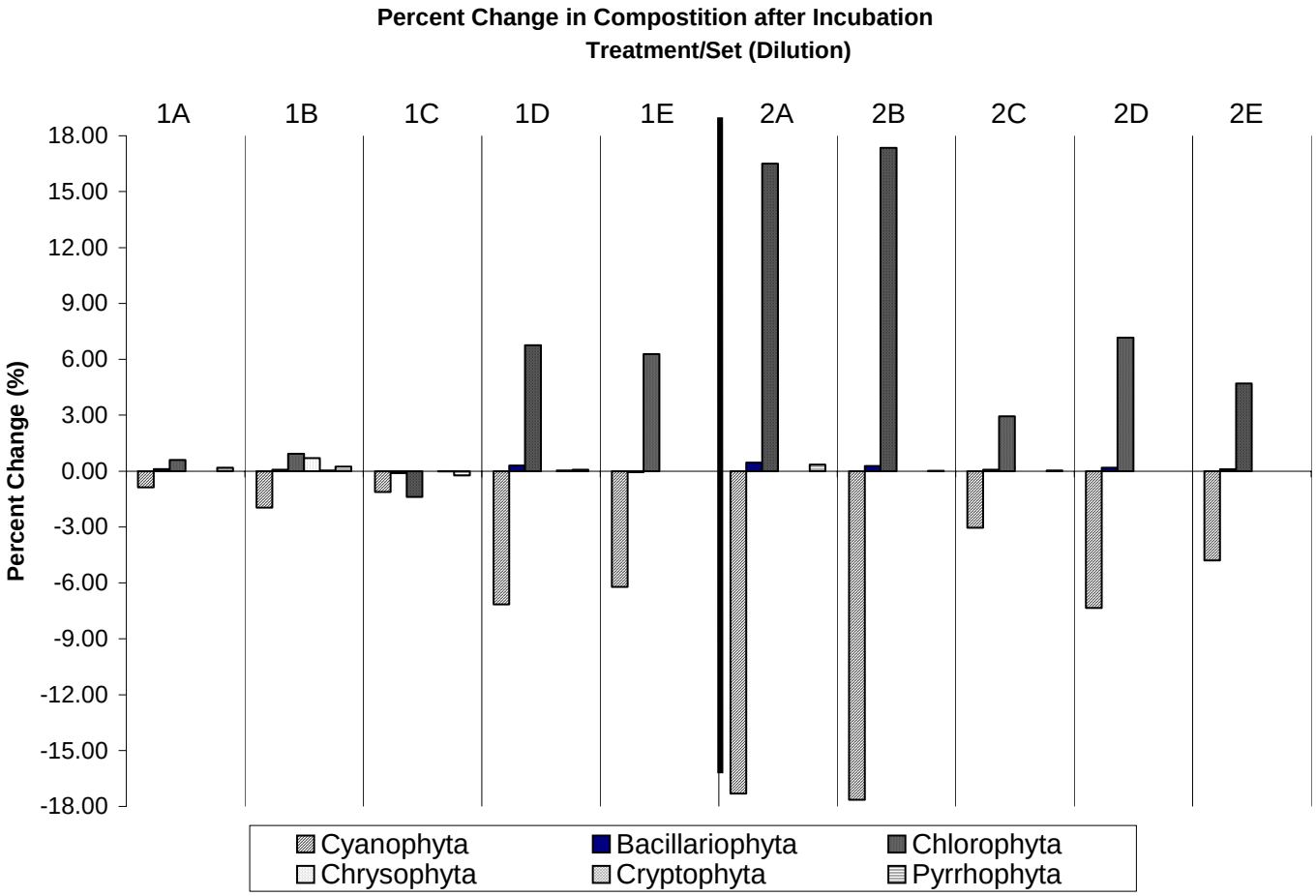
i = initial composition, before incubation
f = final composition, after incubation

Figure 9. Treatment 2: Algal Community Percent Composition before and after Incubation.



i = initial composition, before incubation
f = final composition, after incubation

Figure 10. Percent Change in Composition after Incubation.



3.0 RECOMMENDATIONS

2003 sampling of the watershed and lake should proceed as scheduled. Sampling of phytoplankton should be modified to include sampling within the hypolimnion, beginning in June and extending until any bloom develops. This would provide data regarding algae near the sediment water interface, presumably where the *Anabaena* gets its start. Algae that lay dormant in the hypolimnetic sediments could be responsible for the summer blooms. Luxury uptake of phosphorus in those sediments with migration of phytoplankton to the photic zone could be causing the blooms observed at Lake Pocotopaug during periods of low phosphorus concentration in the epilimnion.

The hypolimnion of the lake could be treated with an algaecide, specifically a form of copper. Copper algaecides disrupts photosynthesis, nitrogen metabolism, and membrane transport. It can be applied in liquid or granular form. In Lake Pocotopaug, the liquid form would be applied with an injection system, like those used to apply alum at depth, concentrating the algaecide in the hypolimnion, or a pelletized form could potentially be applied to yield similar results. Copper compounds can be toxic to aquatic fauna. However, concentrating the algaecide in the hypolimnion during anoxia would mitigate toxicity since nearly all organisms of concern reside in metalimnetic and epilimnetic layers where oxygen is plentiful. In addition, hypolimnetic injection would reduce the impact of any toxicity or nutrient recycling from lysing cells since cell material would likely be contained in this stratified layer where few biota are found.

It is envisioned that a late spring or early summer treatment in both deep basins (Oakwood and Markham) would occur before algal migration to the photic zone. Hypolimnetic water should be sampled for phytoplankton on a weekly basis starting in June. Application of the algaecide is to commence as soon as a substantial increase in phytoplankton numbers is observed. State permits would be necessary, so a permit application should be completed and submitted no later than April 30, 2003. Hypolimnetic monitoring should occur on a monthly basis after treatment to assess the effectiveness and any secondary release of algae from the bottom sediments. ACT has supplied the Town with a memorandum outlining how such a treatment could be conducted, with associated costs. This is a relatively inexpensive experiment that could disrupt the life cycle of the problem alga. The best case scenario would be that no resting stages are laid down in 2003 and the population disappears thereafter. It is possible that the relief will be only temporary, but this approach is worth pursuing.

Alternatives are limited at this time. Additional alum treatment may further inactivate P in the sediment such that extraction by algal resting cells is not possible, but this is highly speculative and would require considerable additional testing. Aeration of the bottom waters would greatly enhance deep water habitat and typically disrupts blue-green algal growth, but would be very expensive on capital (about $300,000) and operational (about $10,000/yr) bases. The continuing biomanipulative approach using walleye to control panfish, encourage zooplankton, and potentially control algal biomass has merit, but is not likely to provide consistent and strong control of this algal species. The copper treatment is therefore recommended.