Northeast Aquatic Research, LLC

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October 25, 2021

To: East Hampton Town Council Members
CC: East Hampton CT Conservation Lake Commissioners
David Cox, Town Manager
Jeremy Hall, Parks and Recreation Director
From: Hillary Kenyon, Certified Lake Manager, Northeast Aquatic Research LLC
Re: Draft Lake Pocotopaug 2021 Monitoring Summary Report

The following information serves as an overview of the data collected by Northeast Aquatic Research LLC (NEAR) at Lake Pocotopaug in 2021. The 2021 water quality results are compared to historical data.

NEAR re-entered into a contractual agreement with the Town of East Hampton on May 4, 2021, following a formal Request for Qualifications process. NEAR presently serves as the Certified Lake Manager and scientific lake and watershed consultant for the Town, and is contracted for the following services:

1. In-lake monitoring
2. Watershed improvement projects coordination
3. Environmental grant writing and assistance with contracts and reporting requirements
4. Initiation and supervision of the resident volunteer monitoring program
5. Participation in Conservation Lake Commission (CLC) and Lake Advisory Committee meetings, including professional comments on requested Inland Wetlands and Zoning permit applications that are presented to the CLC
6. Explanation of lake water quality data results
7. Scientific recommendations on lake and watershed management

The information included below will be presented to Town Council members on the October 26, 2021 regularly scheduled public meeting.

Summary of Permit Information & Monitoring Requirements

The long-term water quality monitoring program at Lake Pocotopaug has involved sampling at the two deep-hole basins in Markham and Oakwood Bays. As of 2020, the CT Department of Energy and Environmental Protection (DEEP) granted a Temporary Authorization to the Town of East Hampton to "discharge to the waters of the state at multiple locations within Lake Pocotopaug." The temporary authorization, pursuant to C.G.S. 22a-6k authorized the Town to "discharge up to 30,000 gallons per day of a consortium of aerobic bacteria identified as PureAg Simple Water Solution/Powder". Use of this product was proposed by Lake Savers LLC dba EverBlue Lakes, under the trademark BioBlast. As part of the temporary authorization special conditions, additional sampling parameters and two additional lake monitoring locations were required (Island & Outlet/South stations). At the end of the 2020 season, data spreadsheets were sent to CT DEEP Bureau of Materials Management and Compliance Assurance Water Permitting and Enforcement Division. The temporary authorization was subsequently renewed for 2021 under similar monitoring requirements and all 2021 data will be sent to CT DEEP upon completion of the 2021 monitoring season. There was no state permit process for the installation of the EverBlue Lakes destratification aeration system in 2020, nor operation in 2021.

Review of 2020 Recommendations

At the end of the 2020 monitoring season, NEAR presented the water quality monitoring results to the CLC and Town Council members. We indicated that although we were not initially supportive of the use of a circulation aeration system and BioBlast™ treatments at Lake Pocotopaug, that we are committed to scientific integrity and to the long-term management of Lake Pocotopaug through both watershed and in-lake approaches. Thus, we remained open to the prospect that the EverBlue treatment approach may improve cyanobacteria bloom conditions at Lake Pocotopaug. The 2020 monitoring results demonstrated that the circulation aeration system successfully aerated the bottom waters of the lake at the deep monitoring stations, through continuous artificial mixing using bottom-placed upwelling bubble plumes. The 2020 monitoring results pointed towards a potential reduction in cyanobacteria concentrations following each of the two 2020 treatments. Reductions did not last longer than one month each.

This finding was consistent with a limited number of scientific journal publications that have conducted research on *Bacillus* and other genera/species of bacteria, included in the PureAg microbial blend used in BioBlast™ treatments. Select publications indicate that *Bacillus* species and other types of soil bacteria may have bio-pesticide properties that cause cyanobacteria cells to rupture, thus killing the cells[1]. This research indicates that extra sampling days before and after treatments would better understand the mode of action of this product and the level of control potentially achievable though adequate dosages and treatment timing.

There are other types of registered pesticides (algaecides) like copper-based or peroxide products that are frequently used to kill cyanobacteria in recreational lakes and drinking water reservoirs, but it is known that both types of treatments provide only temporary relief from bloom conditions. This is because treatments that kill algae are not aimed at reducing nutrient concentrations, so after a certain amount of time, algae and cyanobacteria can repopulate if nutrients remain high. There are no peer-reviewed scientific publications on the use of PureAg in lakes to inform decisions regarding treatment dosages for potential cyanobacteria control. Dosages and treatment methods are decided by EverBlue lakes within the bounds of the CT DEEP temporary authorization permit. Currently, most microbial additives used in pond management are marketed as muck-reducing treatments, not bio-algaecides. That distinction may change the regulatory process on a federal level.

Please refer to the October 2020 summary report for more background information:
https://www.easthamptonct.gov/sites/g/files/vyhlif3066/f/pages/2020_provisional_near_wq_and_watershed_report.pdf

[1] Chao, P.E.N.G., Gang, W.U., Yu, X.I., Yanhua, X., Ting, Z. and Yijun, Z., 2003. Isolation and identification of three algae-lysing bacteria and their lytic effects on blue-green algae (cyanobacteria). *Research of Environmental Sciences*, *16*(1), pp.37-40.

Shunyu, S., Yongding, L., Yinwu, S., Genbao, L. and Dunhai, L., 2006. Lysis of Aphanizomenon flos-aquae (Cyanobacterium) by a bacterium Bacillus cereus. *Biological Control*, *39*(3), pp.345-351.

Wright, S.J.L., Linton, C.J., Edwards, R.A. and Drury, E., 1991. Isoamyl alcohol (3-methyl-1-butanol), a volatile anti-cyanobacterial and phytotoxic product of some Bacillus spp. *Letters in applied microbiology*, *13*(3), pp.130-132.

Wu, L., Guo, X., Liu, X. and Yang, H., 2017. NprR-NprX Quorum-sensing system Regulates the algicidal activity of Bacillus sp. strain S51107 against bloom-forming cyanobacterium Microcystis aeruginosa. *Frontiers in microbiology*, *8*, p.1968.

Yu, J., Kong, Y., Gao, S., Miao, L., Zou, P., Xu, B., Zeng, C. and Zhang, X., 2015. Bacillus amyloliquefaciens T1 as a potential control agent for cyanobacteria. *Journal of Applied Phycology*, *27*(3), pp.1213-1221.

Cyanobacteria Bloom Conditions 2021

Unfortunately, cyanobacteria blooms were persistent at Lake Pocotopaug in 2021, despite the use of both the full-season aeration and BioBlast™ treatments on the weeks of 6/24 and 7/26 [2]. Beginning in 2020, the Town and local Chatham Health Department (CHD) began to use visual criteria to determine when to post cyanobacteria swimming advisories. Cyanobacteria microscope identifications and cell counts in 2021 served to confirm the presence of certain types of cyanobacteria and to provide supplemental information following a bloom report. The first seasonal blooms were reported by residents around June 11-16th, where early-season wispy surface accumulations were visible along the middle-western lake shore. At that time the surface cyanobacteria appeared temporary and lightly wind-blown, thus a "warning advisory" was issued by CHD on 6/18/21 – equivalent to a Category 2 conditions advisory, given the CT DPH guidelines. This bloom coincided with very warm and wet June weather.

More substantial and sustained cyanobacteria blooms prompted a beach closure and Category 3 advisory from CHD on 7/15/21. CHD toxin testing revealed 2.5 ug/L microcystin cyanotoxin at that time and location (below the 8 ug/L threshold known to be a concern for human health during recreational activity). Bloom conditions did improve slightly in late July and early August, near the time of second BioBlast™ treatment, but the advisory remained in effect via CHD reports on 7/20, 8/4, and 8/20. Conditions on 8/17 were reported to be borderline Category 2/3, but the Sears beach closure remained. On 8/22-8/23 a tropical storm hit CT, brining roughly 5 inches of rainfall and heavy winds. Cyanobacteria blooms were observed on the 8/24 NEAR monitoring date and 8/26 CHD beach inspection. The cyanobacteria Category 3 advisory remained in place at that time. Cyanobacteria beach conditions reported by CHD on 9/3 had improved despite another substantial rainfall event on 9/1/21, but the advisory remained in effect because DPH guidelines require two continuous weeks of improvements before a beach closure is lifted.

CHD weekly testing officially ended following the Labor Day holiday. NEAR recorded poor water clarity (0.8 meters) and "green-throughout" water on 9/8/21, but strong winds prevented accumulation of surface cyanobacteria scums on this date. In late September to early October, there were multiple resident reports of surface cyanobacteria scums. Cyanobacteria conditions appeared to get substantially worse through 10/13. Blooms observed during NEAR monitoring on 10/13 were the worst cyanobacteria scums observed at Pocotopaug in roughly eight years. The bloom was lakewide, and there were dense surface scums on shore. A sample has been sent for toxin testing, but results have not yet been reported. The Town Recreation Department issued a late-season reminder warning for lake users. The warm autumn and several very calm days seemed to allow scum-forming types of cyanobacteria to rise to the surface, despite the artificial lake mixing by the aeration system. The October cyanobacteria bloom was dominated by toxin-producing genera *Dolichospermum*, *Microcystis*, and *Woronichinia*. Dominance of these taxa at Pocotopaug is unusual. Prior to 2020 the lake was typically dominated by smaller-celled cyanobacteria like *Planktolynbya* and *Chrysosporum*, which are less likely to form surface scums.

It is worth noting that bloom conditions were also worse than usual at several other local lakes in 2021 (observations only, no formal data comparisons), presumably in-part due to weather and increased watershed nutrient loading. Though, Pocotopaug 2021 water quality data also suggests that the destratification aeration system may have caused upwelling of internally-loaded phosphorus at the same time as increased watershed loading. Nitrogen and phosphorus data interpretation is explained further in the nutrients section of this summary report.

[2] If there were any additional BioBlast™ treatment dates, they will be added to this publication.

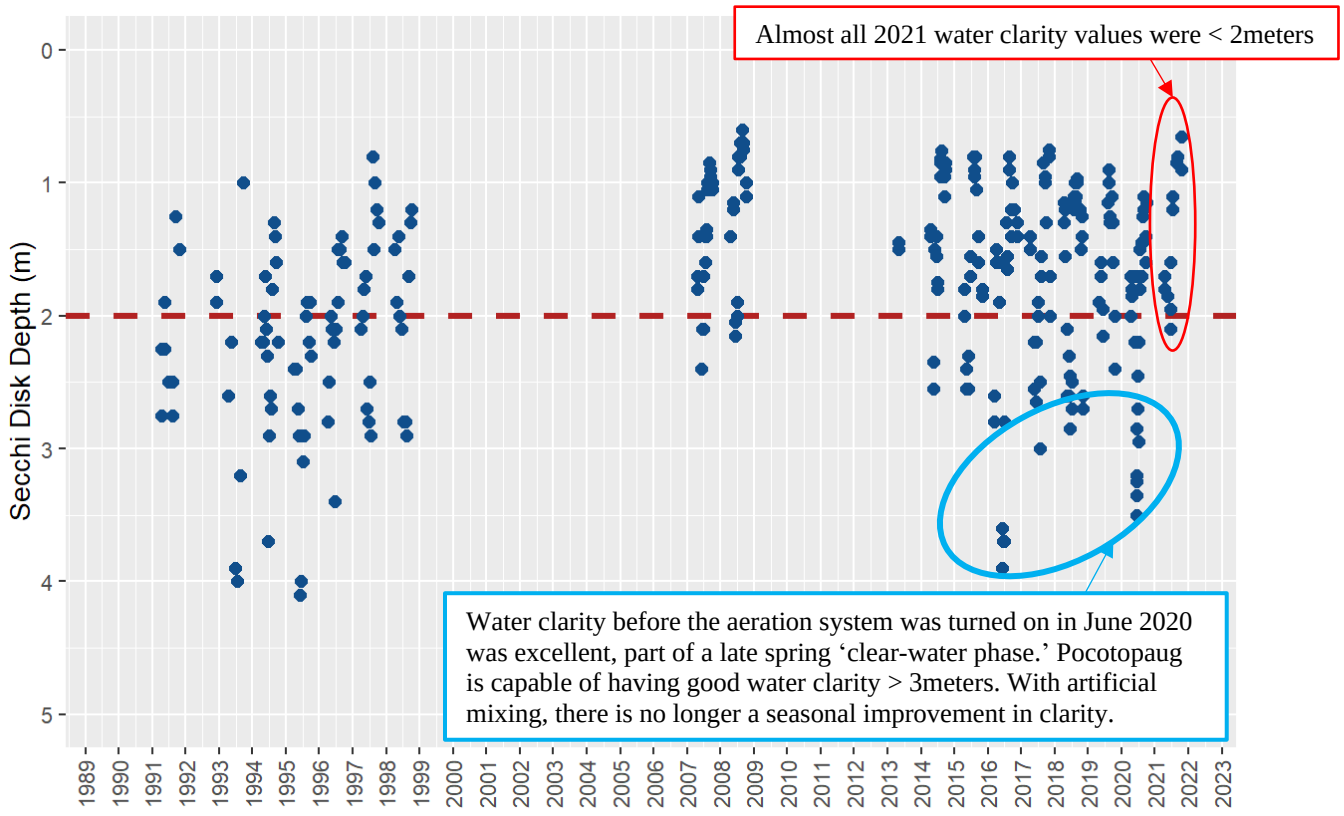
Water Clarity 2021

Water clarity readings displayed below were all measured by the same NEAR staff person. Additional water clarity readings were taken off docks and in open water by CHD and resident volunteers, all trained by NEAR and CT DEEP. Roughly six local residents were equipped with water clarity monitoring Secchi disks and view scopes to take regular readings, but limited data has been reported by volunteers so far. If any residents wish to be trained for volunteer water clarity and algae monitoring in 2022, please email: pocotopaugvolunteermonitoring@gmail.com. Residents are also encouraged to share photos of lake conditions to this email address, to keep a better record of visual conditions across seasons and years.

The Pocotopaug 2021 water clarity was lower than average across the season. As explained in the June summary report, there is no longer a pronounced improvement in water clarity in late May to mid-June, which is a partly result of artificial lake mixing from the aerators. Briefly, the late spring usually sees a natural improvement in water clarity as a lake begins to develop a thermocline, but this 'clear-water phase' is not as distinct if aerators are actively mixing a lake, because certain types of algae are no longer able to settle out of the water column when a lake would naturally begin to stratify.

Water Clarity (Secchi transparency in meters)

Station	4/19/2021	5/17/2021	6/14/2021	6/17/2021	7/16/2021	8/24/2021	9/8/2021
Oakwood	1.7	1.85	2.1	1.6	1.1	0.85	0.8
Markham	1.8	1.85	-	1.95	1.2	0.85	0.8
Island	-	-	-	1.55	1.2	0.85	0.75
South/Outlet	-	-	-	1.6	1.2	0.8	0.85



Dissolved Oxygen Results 2021

Dissolved oxygen remained present at the bottom of the Markham and Oakwood deep basins in 2021. Overall, the circulation aeration system has successfully maintained oxygen at most of the lake bottom again in 2021. Sediment oxygen demand was apparent on certain monitoring dates. Lake temperature has been uniformly distributed by the aeration system and the lake is no longer thermally stratified. The lake is well circulated in the Markham and Oakwood basins. Additional profiles were taken on each sampling visit from the Twin Island and Outlet/South stations.

Markham Station – Dissolved Oxygen mg/L

Depth(m)	4/19/2021	5/17/2021	6/17/2021	6/24/2021	7/16/2021	8/24/2021	9/8/2021
0	10.5	9.6	8.4	8.0	9.5	7.7	9.4
1	10.5	9.7	8.4	8.0	9.3	7.6	8.9
2	10.2	9.8	8.4	8.1	9.1	7.3	8.9
3	10.1	9.8	8.4	8.1	9.0	7.2	8.7
4	10.0	9.7	8.4	7.8	9.1	7.2	8.5
5	9.0	9.6	8.4	7.7	8.7	7.2	8.4
6	8.8	9.6	8.4	7.7	7.9	7.2	8.4
7	7.7	9.3	8.2	7.7	7.1	7.0	8.3
8	2.9	7.7	8.2	7.4	6.4	6.9	7.9
8.2		0.4	6.9	5.9	3.3	6.7	

Oakwood Station – Dissolved Oxygen mg/L

Depth(m)	4/19/2021	5/17/2021	6/17/2021	6/24/2021	7/16/2021	8/24/2021	10/13/2021
0	10.3	9.9	8.6	8.1	9.6	7.5	8.7
1	10.3	9.9	8.5	8	9.5	7.5	8.3
2	10.3	9.9	8.4	7.9	8.8	7.5	8.1
3	10.1	10	8.3	7.8	8.7	7.4	8
4	9.8	9.9	8.3	7.7	8.5	7.4	7.9
5	9.8	10	8.2	7.6	7.9	7.3	7.8
6	9.7	10.1	8.2	7.6	7.1	7.2	7.8
7	9.7	8.9	8.3	7.5	6.8	7.1	7.8
8	9.5	7.9	8.1	7.5	6.8	6.9	7.2
9	8.5	6.8	8.1	7.4	6.0	6.9	6.8
10	2.9	4.5	8	6.5	4.4	6.6	5.5
10.5	0.9	1.4	1.8	5.9	1.2	5	

In lake management, the main purposes of a circulation aeration system are to artificially mix the lake to disrupt cyanobacteria buoyancy enough to prevent surface scums[3] and to simultaneously replenish oxygen to the bottom, usually in order to reduce the amount of internally recycled nutrients that are capable of being released from anoxic sediments. This type of aeration is supposed to begin working immediately. However, it is widely accepted that, in practice, circulation aeration systems can only prevent a specific form of phosphorus release, primarily phosphorus bound to iron[4]. Other forms of nutrient release still occur during aeration, and increased deep-water temperatures resulting from artificial mixing also increase the rate of aerobic (oxygenated) phosphorus release from sediments. That is one reason why, in large lakes greater than 20ft deep, the circulation type of aeration tends to be less effective than deep-water oxygenation that leaves natural thermal stratification intact.

[3] Chorus, I, Welker M; eds. 2021. Toxic Cyanobacteria in Water, 2nd edition. CRC Press, Boca Raton (FL), on behalf of the World Health Organization, Geneva, CH.

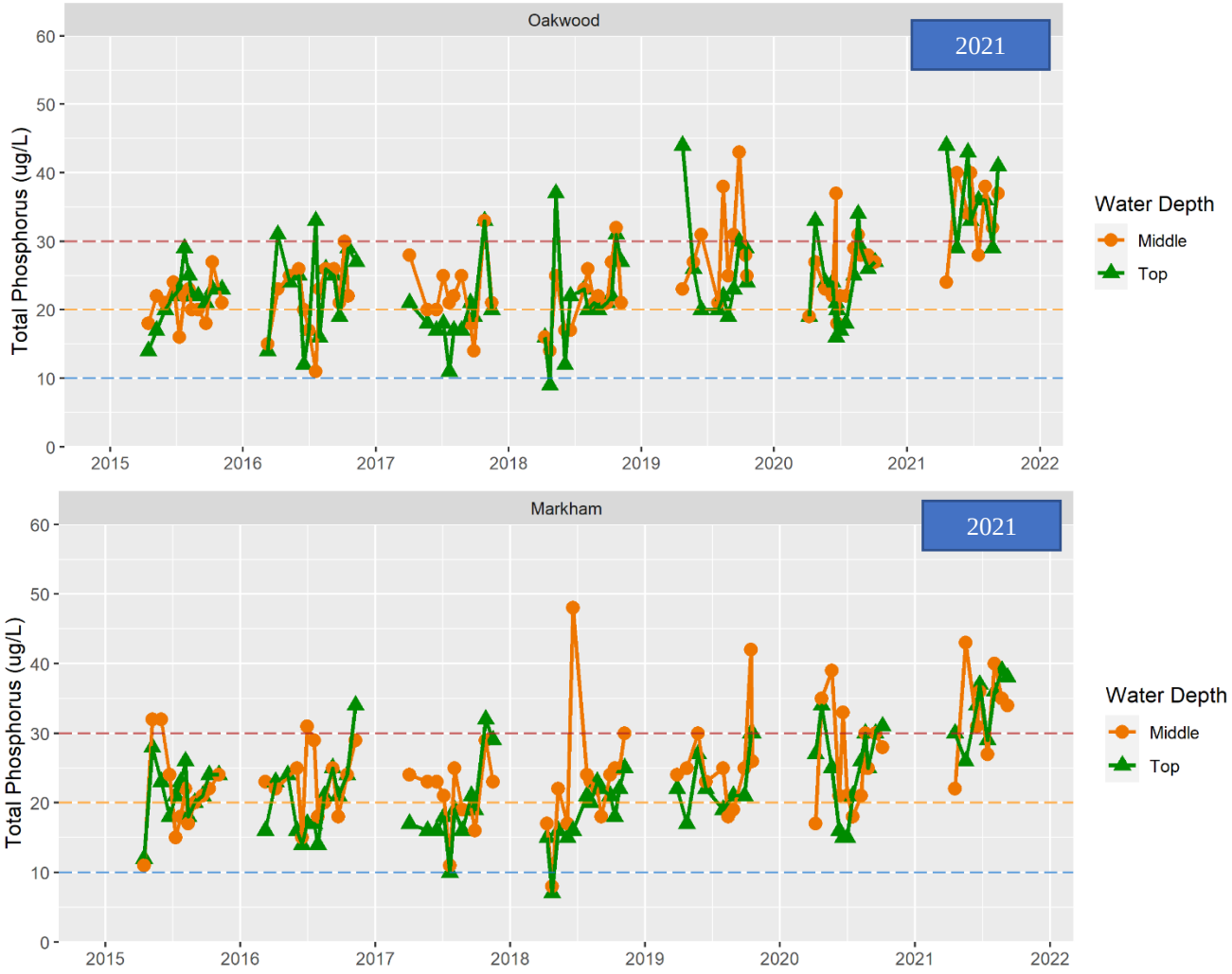
[4] Wagner, K. 2015. Oxygenation and Circulation to Aid Water Supply Reservoir Management. Water Research Foundation, Denver, CO.

Nutrients (Nitrogen & Phosphorus)

The two figures below show Total Phosphorus values in micrograms per liter (µg/L). The limit of detection for these tests is 1 µg/L (equivalent to 0.001mg/L) using the EPA Method 365.4 for lake water testing. Methods that have higher limits of detection are not appropriate for lake water testing because such tests are not sensitive enough to detect change in concentrations in lakes. Phosphorus testing on lake water samples should be performed by state-certified laboratories with good quality assurance protocols. Pocotopaug samples collected by NEAR are analyzed at UCONN. Samples are also tested against field duplicates to confirm that laboratory results are within the range of acceptable error, preferably <10% error.

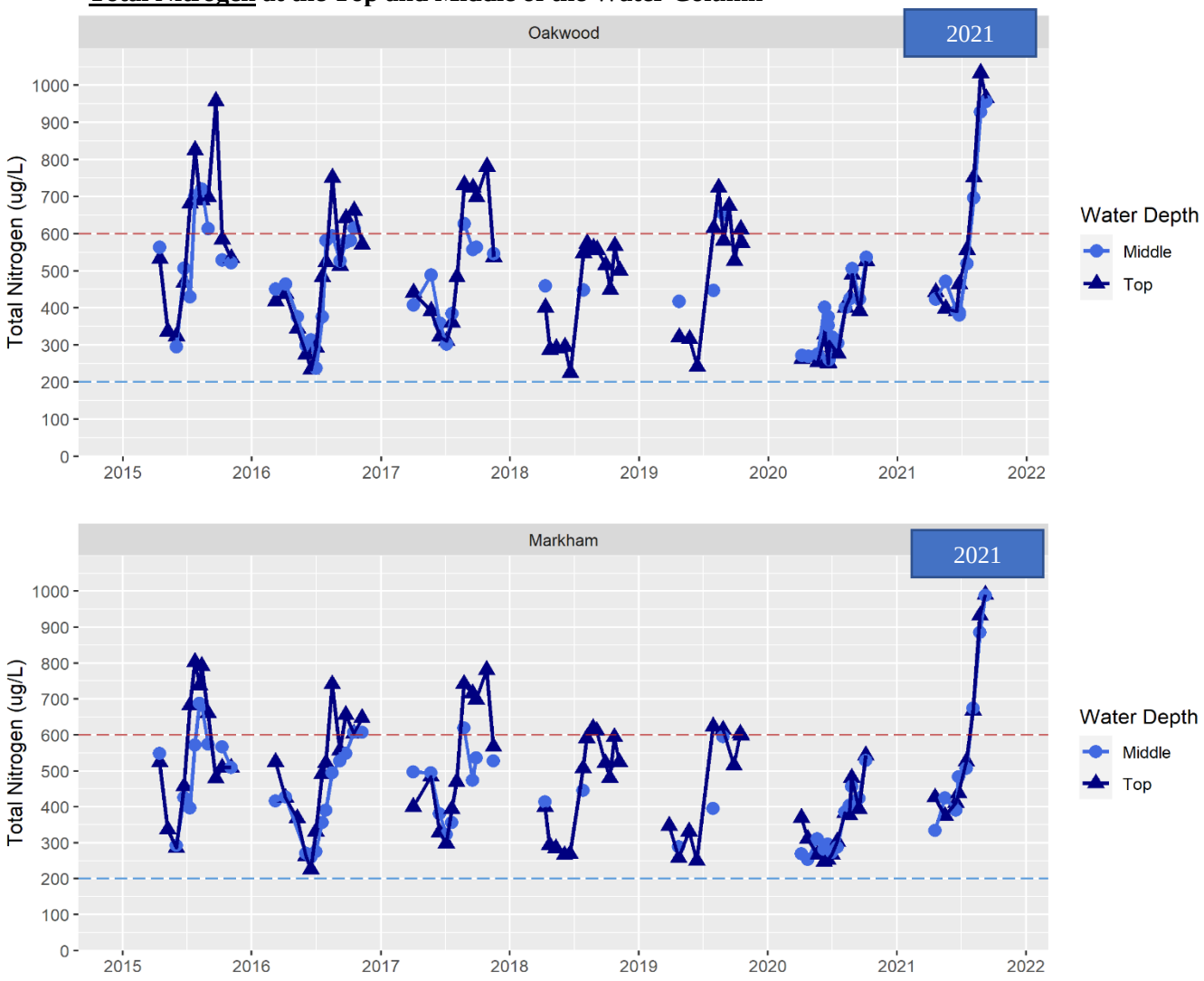
Total Phosphorus concentrations in the surface waters and in the middle of the water column at both Oakwood and Markham Stations in 2021 were above average based on data collected since 2015. Phosphorus values above the 30 µg/L upper threshold (marked by the red horizontal dashed line) indicate that phosphorus is high enough to form frequent cyanobacteria blooms and scums in the summer months. Phosphorus over 20 µg/L (orange dashed line) indicate conditions where cyanobacteria blooms can still happen, but are usually less severe. Pocotopaug unfortunately has a long history of being dominated by cyanobacteria in July and August even during the lower 20-25 µg/L phosphorus range. Cyanobacteria blooms tend to form in summer and fall, not usually in early spring when other types of algae are dominant.

Total Phosphorus at the Top and Middle of the Water Column



The extreme amount of rainfall that occurred in 2021 increases the watershed nutrient load of both phosphorus and nitrogen to the lake via stormwater runoff, which is one possible reason for the increase in surface water nutrients. Yet the surface and middle nutrient values for 2021 were very high towards the end of the season, not immediately after heavy rains. In 2020, TN concentrations remained below average, but that was not the case in 2021. Nearly all nitrogen was in organic form (actively being used by algae and cyanobacteria).

Total Nitrogen at the Top and Middle of the Water Column

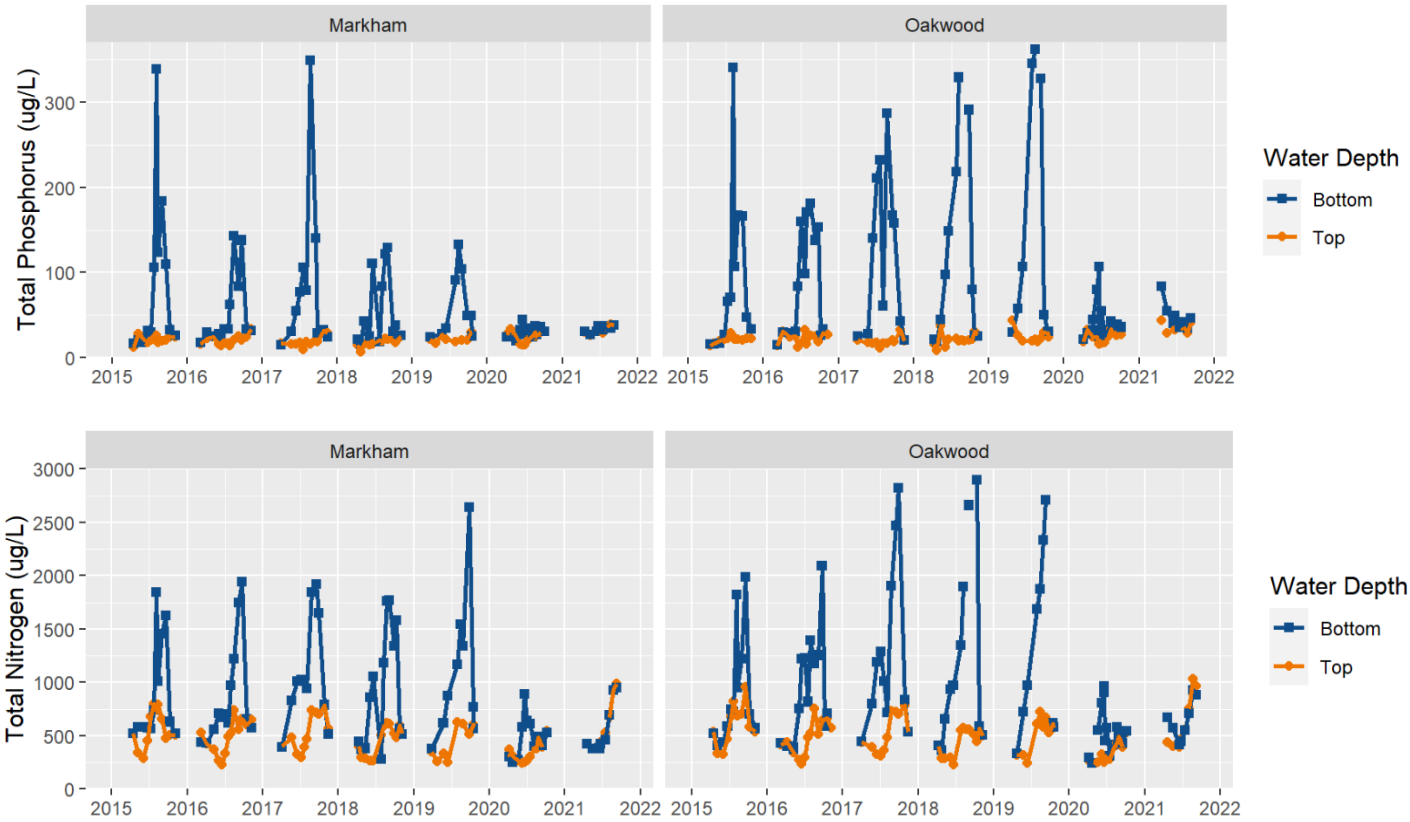


In 2020, the total nitrogen was below average, indicating that nitrogen may have been more affected by the aeration than phosphorus was. But September 2021 data show that was not the case this year. Surface nitrogen values skyrocketed at the end of the 2021 season. When there is enough phosphorus in the water column (generally > 30ug/L), certain types of cyanobacteria are capable of fixing atmospheric nitrogen, which may have further increased surface nitrogen concentrations during the fall 2021 bloom. Microscopic analysis of cyanobacteria during a dense bloom is required to identify the possible presence of nitrogen fixation specialized cells.

The bottom water concentrations of phosphorus have been dramatically reduced. Yet the reduction in bottom water concentrations cannot be entirely attributed to reduced sediment releases. Instead, some of that reduction is a result of bottom-water being mixed into surface waters through circulation aeration. It is likely a combination of the two, with at least some level of reduced sediment nutrient release, but that is very difficult to measure without laboratory sediment incubation tests. Such tests were not done prior to the installation of the aeration system.

It is a common mistake to believe that bottom water concentration reductions equate to less internal loading in an artificially circulated lake– when really there is just a dilution effect of nutrient mass being mixed evenly throughout the water column. There is a much larger surface area and water volume in surface waters than in deep-water (think a bowl shape), making it difficult to relate small increases of nutrient concentrations in surface waters to dramatic bottom-water nutrient decreases, because of full lake mixing. In short, despite bottom-water concentration reduction in both phosphorus and nitrogen, surface water phosphorus was higher than average in 2020 and 2021, and surface nitrogen was higher in 2021 – contributing to worsened cyanobacteria blooms this year.

Surface and Bottom Nutrients 2015 through 2021



Note that the concentration of bottom-water nutrients usually dwarfs the concentration of nutrients in the surface waters in non-circulated lakes, which is why it is usually graphed separately. The figures above make it difficult to see the concentrations patterns in the “top” layer of water, which is why that “top” data was first displayed in the first two nutrient figures on page 7.

In-lake Management Conclusions & Recommendations

Overall, Lake Pocotopaug is still experiencing prolific cyanobacteria blooms. The blooms appear to have shifted to the type of cyanobacteria that more readily form surface scums (*Dolichospermum*, *Microcystis*, and *Woronichinia*). This was somewhat unexpected because use of a circulation aeration system is touted as being disruptive to cyanobacteria buoyancy, thus physically preventing surface scums in the areas around aerator plumes. The cyanobacteria blooms in 2021 appear to be responding to above average summer nutrient concentrations. The mid-summer BioBlast™ treatments were unable to prevent dense surface blooms in late summer to early fall 2021. The increased nutrient surface concentrations are likely related to a combination of watershed loading and mixing of bottom nutrients into surface waters by the circulation aerators.

We have provided a number of updated in-lake management recommendations to the new CLC members. These recommendations included the pros and cons of both copper-based and peroxide algaecide treatments, as well as the feasibility of phosphorus-locking treatments such as aluminum-sulfate (Alum) and Phoslock/Eutrosorb. Phoslock is a modified clay-based product and does not have the same pH stabilization concerns that alum treatments need to approach carefully. These recommendations have been previously discussed with CLC members over the last seven years, but the community seemed unfavorable to algaecides and phosphorus-locking treatments at that time. Details regarding these types of in-lake treatments will be reiterated publicly at the Town Council meeting.

Watershed Improvement Projects

The Town of East Hampton has committed to the management of Lake Pocotopaug through three main avenues: 1. watershed control, 2. in-lake management, and 3. public education. Our work with the Town on watershed improvement projects has continued into a new round of Clean Water Act Sec. 319 grant funding. The Town is currently finalizing the contract initiation phase with the CT DEEP for multi-pronged watershed nutrient reduction projects planned for 2022. Where easements are required for construction, the Town has already begun the formal easement request processes.

These projects target nutrient reductions in the following locations:

1. Christopher Brook – upstream of the Edgemere pump house
2. Christopher Brook Pond – including Town-purchased property
3. Edgewater Circle and Town Hall stormwater runoff
4. Lake Vista/Rt66/O'Neil's Brook
5. Fawn Brook at Bay Road – downstream from large residentially developed area

Additionally, there is a list of additional Town-funded roads and drainage projects that are slated for improvements in 2021 to 2022. This list is kept by the Public Works Department, who provides periodic updates for discussion at the CLC meetings. Recent CLC and Lake Advisory Committee meetings have held discussions regarding specific watershed projects. As part of the reporting requirements for this new round of state grant funding, the CT DEEP is requiring maintenance plans for state-funded improvements. We intend to wrap these maintenance plans into an updated summary of all watershed improvement efforts to date. This list can be considered a formal update to the Nine Element Watershed Management Plan after the 2022 projects implementation.

Thank you for taking the time to review the water quality and watershed information that constitutes the wholistic Pocotopaug Lake management program.

Sincerely,

Hillary Kenyon
Certified Lake Manager
Northeast Aquatic Research LLC

Map of sampling sites for 2021.