White Pond as a Resource for All: A Vision for Water Quality, Usage and Sustainability

Prepared by
White Pond Advisory Committee
Cheryl Baggen, Josh Galper, Beth Kelly, Jeff Parker, Jim Ricker

Town of Concord, Massachusetts

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Table of Contents

Executive Overview

White Pond is a beloved natural resource enjoyed by local and out-of-town visitors. Its unique land rights management and geological features offer valued recreational opportunities. And yet, this same combination of factors is now contributing to repeated toxic algae blooms, making the pond unsafe for humans, fish and surrounding wildlife. The Town of Concord, neighboring residents and visitors have a short window of opportunity to remediate these harmful conditions and preserve White Pond for generations. Without intervention, science indicates that White Pond will be permanently closed for general purposes for most if not all of the warmer months going forward.

There are multiple factors that can contribute and/or cause toxic algae blooms. These include an over-supply of "nutrients" for algae, as they are called in the scientific literature. These unnatural contaminants to the pond water arrive in the form of runoff and leaching from septic tanks and fertilizers, and over-use including trash and refuse left behind by visitors. Each one of these contributions have solutions but each requires coordination and political will to resolve. They will not be easy to achieve, but extensive research and consultation with scientific authorities strongly suggests that they be the best and at times only way to end chronic pollution and closure of White Pond due to algae blooms.

This Vision document calls attention to the core problems and offers a call to action for solutions. As a follow up to the 2015 White Pond Vision, "A Shared Resource for White Pond," this document focuses on water quality, water testing and people management [VISION 2015]. The element of time is also considered as some items are short-term concerns or opportunities while others are identified for the longer-term.

Along with the reduction of nutrients inflows to White Pond, this Vision promotes a monitoring and testing regime led by the Town of Concord, which now owns ~30% of the shoreline surrounding the pond. The gift of the White Pond Associates beachfront and the development of that area has transformed the Town's role in the pond's management. The Town is the legal authority that has both the right and mandate to deliver a monitoring and testing program to ensure safe water conditions. Investing in White Pond now will benefit all visitors and preserve a historic treasure, while protecting the considerable investment the Town plans to make in the beach property.

The ideas presented here are generally not new; most have been advanced before in the Vision 2015 or somewhere else. What is new is the immediacy of our call to action. Frequent beach closures since 2015 due to water quality show that toxic algae blooms are now a regular feature of the pond. Without active remediation, the Town of Concord, neighborhood residents and visitors should expect that White Pond will cease to be a usable local resource. However, with Town, neighborhood and visitor engagement, White Pond can remain a treasured area for generations to come. We invite the Town of Concord, neighborhood residents and other visitors to review the recommendations in this Vision to help enact a long-term, workable plan for management of White Pond.

Introduction

White Pond is a Concord jewel. Henry Thoreau knew it and wrote about it, asserting that "perhaps the most attractive, if not most beautiful, of all our lakes" is White Pond [THOREAU]. Current Concord residents know it too, as White Pond has provided outstanding aesthetic and recreational opportunities for thousands of people. Boating, fishing, hiking, biking, skiing, skating, swimming, and wildlife viewing are just some of the pleasures of this great resource.

The White Pond Advisory Committee (WPAC) was formed by the Town of Concord in 1973. Part of its charge is to advise the Select Board and relevant Town Committees on White Pond management [TOWN OF CONCORD]. The value of the Committee is that it is comprised of frequent visitors to the pond; members see what is happening on a day-to-day basis.

The WPAC's mission is to preserve the beauty and wonder of White Pond for all visitors, respecting that there are natural capacity limits that any resource can endure. The publication of the 2015 White Pond Vision, "A Shared Resource for All," promoted the "Guiding Principles for the Development of a Long-Term Vision for White Pond". The intent of the 2015 Vision was to set a coupled water quality and people management plan for White Pond for implementation by the Town of Concord. Only three of the 33 recommendations were implemented.

The Town of Concord's acquisition of the White Pond Associates' beach property represents a turning point in the history of pond. The Town of Concord has an environmental, social and economic incentive to preserve White Pond water quality. The Town and watershed residents must now take a proactive role in reducing or eliminating toxic algae blooms for the preservation of its beach investment, with attendant benefits for the overall well-being of the pond.

This 2021 update to the White Pond Vision was requested by the Town of Concord Select Board with the aim of creating a fresh set of perspectives on water and land use management. This document is a collection of many concerns that have been previously addressed with input from neighboring residents, the Town of Concord and scientific experts on ponds and algae blooms, along with targeted solutions. The objective, consistent with the 2015 Vision, is to maintain White Pond as a long-term natural resource for Concord and the surrounding community.

Water Quality Management

Concerns

The leading concern for the health of White Pond is the state of water quality. Excess nutrients (phosphorus and nitrogen) in the water have led to a dramatic increase in the number of Cyanobacteria (commonly known as blue-green algae, toxic algae or toxic algae

blooms) that naturally exist in the water [STAGER]. Algae blooms flourish in warm weather, making the pond unsafe for any recreational use. A foul smell can also develop that negatively impacts surrounding communities and visitors. The public health concerns are potentially serious and range from dog fatalities [CLIFF] to a suspected link to ALS, also known as Lou Gehrig's Disease [SCIAM].

Other health risks related to algae blooms include [CDC]:

- Rashes or other skin irritations from direct contact. Usually, these skin irritations are not associated with toxins, but rather other non-toxic compounds produced by blooms called lipopolysaccharides (LPSs).

- Inhalation of water droplets that have toxins in them may cause allergic-like reactions, runny noses, or sore throats.

- Irritation to eyes.

- Headaches from breathing in air near toxic blooms.

- Swallowing water with high levels of cyanobacterial toxins can cause:

    - Severe stomach problems like diarrhea and vomiting.
    - Liver damage which may take hours or days to show up in people or animals. Symptoms can include abdominal pain, diarrhea, and vomiting.
    - Numb lips, tingling fingers and toes, or dizziness.

Excessive Cyanobacteria growth robs aquatic life of essential food and oxygen needed for life. The decay of the algae directly causes oxygen depletion.

When a toxin-producing bloom dies and breaks up, toxins are released into the surrounding water. This is generally the time of highest concern for public health because the lack of a visual cue (i.e., water appears clear) to avoid the water is not present. While blooms cannot be seen visually, this is when they are most dangerous. Nothing can be stated accurately about the pond's water quality without cell or concentration counts of toxins.

The root causes of toxic algae blooms are inter-related, and it is unknown whether one factor is more influential than others. However, they must all be addressed in order to ensure a successful outcome. The major human factors are:

1. Septic systems. The basic design of a septic system, including those approved under Title V, is to leach wastewater into the surrounding soil. These septic systems remove harmful bacteria but do not remove nutrients, which move into the groundwater and eventually leach into White Pond. The White Pond groundwater overlay district shows the flow of this wastewater through the soil (see Appendix B).

Other Massachusetts communities have identified sewage treatment as a primary opportunity for improving pond water quality [SNEP].

2. Chemicals and natural fertilizers. Lawn and plant fertilizers in the watershed find their way into the pond, especially when heavy rains occur after a dry spell. The dry land absorbs less rain, which runs downhill into the pond carrying fertilizers along with it. Fertilizers not taken up by plants will also leach through the soil and end up in the pond. A 2014 analysis of Cape Cod's Salt Pond found that fertilizer run off was responsible for 7% of the pond's unattenuated nitrogen load [CAPE COD COMMISSION].

3. Uncontrolled stormwater runoff. Paved surfaces provide a conduit for pollutants to enter the pond.

4. Human and dog waste. A lack of public toilets away from the beach and off-leash dogs have led to White Pond being used as a bathroom facility. Trash and suntan lotion from bathers is directly transmitted to the pond.

5. Erosion. Soil, chemical and trash runoff reach the pond after rainfalls. Erosion is cited in all studies as a contributor to excessive toxic algae in ponds.

6. Trout restocking. There are multiple results of trout restocking including an imbalance of the local ecology and overstocking that results in dead fish decaying at the bottom of the pond. White Pond historically had no fishing of interest: Thoreau wrote that "This pond has rarely been profaned by a boat, for there is little in it to tempt a fisherman" [THOREAU]. There is a causal relationship but no data showing that rainbow trout deplete zooplankton, which itself feeds on algae [HERRERA]. At White Pond, there is proof that the zooplankton population has been greatly reduced. Scientists continue to study the relationship between fish stocking and increased algae blooms.

7. Beachfront development. The development of the Town of Concord's White Pond beach property has the opportunity to help or harm pond water quality. Development could hold water quality as a foremost priority, which would lead to less runoff opportunities and maintaining tree roots that hold soil in place. Or it could encourage runoff including from further areas of the watershed district. Development designs and people management policies could also reduce opportunities for trash or nutrients left behind.

8. Water levels. Visual observation shows pond levels at highly variable levels over the last decade. A drawdown of the water table from Town Well #7 decreases the available amount of water to manage algae levels.

Solutions

Solutions are available for each contribution to toxic algae blooms:

- Sewage. The Town of Concord identified wastewater management challenges facing the White Pond neighborhood as part of its Town-wide Comprehensive Wastewater Management Plan (CWMP) finalized in 2003. As noted in this report and more recently reaffirmed by the WPAC, the reliance of conventional on-site (Title 5) septic systems is one of the single most important sources of nutrients contributing to White Pond. The CWMP said that one long-term action item that could reduce this impact would be the creation of a neighborhood wastewater collection and treatment system. Another alternative could be adoption of innovative alternative septic system technology that could reduce phosphorous and reduce nitrogen loading to the Pond. While there are few disputes to the fact that existing Title 5 approved systems result in a surplus of nutrients to the pond, more work is required to come to a Town and community consensus about the best way to move forward.

- Fertilizers. Similar to how the Town of Concord institutes lawn watering restrictions, the Town must issue guidelines to residents on how and when to apply chemical and natural lawn fertilizers. The use of chemical fertilizers in the pond watershed area should be banned. The use of natural fertilizers should be managed proactively. Other communities in Massachusetts already have fertilizer laws in place for protection of wetlands and surface waters [ORLEANS].

- Human and dog waste. An increase in Ranger supervision and trash receptacles can work together to reduce, but not eliminate, human and dog waste at the pond.

- Erosion runoff. The Town has made great progress in reducing erosion at Sachem's Cove through an extensive slope restoration project, including directed pond access points, thousands of plantings, and fencing to keep people and dogs off slopes. We encourage these efforts and look for them to continue.

- Trout restocking. At a recent WPAC meeting, UNH scientist Nancy Leland stated her belief that rainbow trout stocking decreases the amount of zooplankton in White Pond, and that zooplankton do better without fish. Zooplankton feed on the algae that produce toxic blooms. A reduction in rainbow trout should result in more zooplankton and hence less algae.[1] The Town should increase its efforts to ask the

[1] The Town of Concord has written two letters to the State of Massachusetts Department of Fish and Game to end rainbow trout restocking at White Pond. Fish and Game have not responded and again, following receipt of the first letter, stocked White Pond in March 2021 with only rainbow trout. This is counterproductive to the Fish and Game department's own mission of helping visitors enjoy recreational activities. Analysis conducted by White Pond residents show that one ton of rainbow trout decay results in as much as 10.66 kg of phosphorous, or up to four times the amount of non-stocked lakes, although research by Stager et al disagree [STAGER]. Phosphorous speeds the decline of the pond. Further, summer temperatures seem to be

State to stop restocking at least rainbow trout and preferably all trout restocking in accordance with the original ecology of White Pond.

- Beach development. The Town of Concord should prioritize White Pond water quality in the design and construction of the beach area. For example, the 1200' ramp should be paved with a permeable surface rather than an impermeable surface. Although this would require annual cleaning and hence a greater cost, the net benefit of less nutrients flowing into the pond will be worth the effort. For the entire beach project, the logic should be that if White Pond is unusable then the Town's investments will go to waste. It is a better plan to preserve water quality early in the design and build phases.

- Water levels. More study is needed to understand the impact of pumping on the pond from Town Well #7 and its impact to the ecology.

Problem	**Solutions**
Septic systems leach nutrients through soil	Neighborhood sewage treatment or implementation of alternative septic systems, using as a base the investigation completed by the White Pond Youth Conservation Group in summer 2021.
Lawn treatment run off	Issue best practice guidelines to residents on when and how much fertilizer to use on lawns. Longer-term, work to create Town bylaws for groundwater fertilizer management.
Human and dog waste	Increase Ranger supervision. Install trash receptacles with regular pick up.
Trout restocking	Engage with State Rep to review and stop rainbow trout restocking by Mass Fish and Game. Engage with MA Secretary of Energy and Environmental Affairs as necessary.
Beach development	Prioritize pond water quality in beach design and construction decisions.
Water levels	Further study needed to understand the impact of pumping.
Street / road / stormwater runoff	Improve the conditions of roads abutting the pond to reduce runoff including fertilizer, sand, dirt and asphalt. Stormwater best practice management.

The Town has been successful in stabilizing efforts of recurring erosion and in cleaning out catch basins on public roads. The Town should continue these practices to maintain existing water quality. The Town should revise and update the regulations concerning White Pond Conservation and Reservation lands to disallow swimming from those

speeding trout deaths due to poor habitats. There are also considerations about whether fish living in a pond with toxic algae blooms are safe to eat.

properties. Current temporary signs can be made permanent, and fines can be implemented for rule-breakers.

The recent test by P-POD Technologies, LLC to physically remove toxic algae from White Pond is an excellent contribution to mitigating the problem once it is apparent. The Town is encouraged to continue to engage with P-POD to continue this project into commercial application. However, removal after-the-fact does not reduce the need to mitigate the initial contributors of nutrients to the pond. P-POD will be no replacement for corrective action.

Longer-term, the Town should regularly check the condition of erosion controls and repair as necessary. This includes roads and drainage, including work on permeable vs. non-permeable surfaces and draining. Community organizers have begun the work of cataloguing maintenance and best practice efforts. A new system should recommend a maintenance program.

One area where the Town and residents have no control is climate change. It is expected that climate change will further aggravate the degradation of pond water quality as temperatures warm and more extreme weather events occur.

Water Quality Detection, Prevention and Control

The Town of Concord must establish a pond-wide testing and notification program for all residents and visitors. These tests should cover clarity, E-Coli and algae testing. The current protocol is to test and notify Beach permit holders only when toxic algae blooms are observed, and post occasional signs around the pond that are often destroyed. This process leaves most residents and visitors unaware of pond water safety. Appendix B contains our findings on water quality tests.

Algae blooms may appear or disappear from day to day, but this does not mean the water is safe for swimming or recreation. The US Environmental Protection Agency [US EPA 2019] notes that with regards to recreational bodies of water, managers and public health officials need to develop a risk based monitoring plan in place for waters that are potentially vulnerable to blooms that considers the following information:

- Existing and historical recreational water quality
- Sampling considerations
- Analytical methods
- Sampling/testing logistical considerations
- Use of predictive tools
- Frequency and number of people using the recreational water

The Town should establish a robust testing and measurements methodology. Water quality should be assessed against those goals each year. This requires reasonable goal setting along with an efficient and effective water quality monitoring plan. WPAC has shared current cost data with the Town for testing, mitigation and zooplankton regrowth efforts.

One potentially new issue to monitor is water level. Should the White Pond water level continue to fall, the effect of pumping from the nearby Town Well #7 should be studied to determine the extent to which it impacts the water level. It may be necessary to reduce the pumping if it is determined that the withdrawals from the White Pond aquifer significantly contribute to the water level decline.

People Management

Concerns

The attractiveness of White Pond has become known throughout the region, with the pond appearing on social media sites as a top place to visit [TOP7] [50SWIMS]. A warm summer day will bring hundreds of visitors to Sachem's Cove including in-town and out-of-town guests, some of whom park on neighborhood streets, some of whom reach the pond by sliding down already eroding hillsides, and some of whom reach the pond from the Bruce Freeman Rail Trail. While early morning fishermen are welcome, it is normal to find discarded beer cans, cigarette butts, plastic wrappers, plastic bags, animal feces and fishing line later in the day. Human waste goes directly in the pond and swimming in prohibited areas is common. Combined, visitors to unmanaged areas of White Pond contribute to a degradation of water quality and the surrounding land areas.

People management concerns at White Pond in 2021 are identical to what was found in 2015, including substantial traffic for small residential neighborhoods abutting the pond, speeding, loud evening noise and trash left behind including soiled diapers, drink bottles and cans, snack wrappers, Styrofoam, clothing and cigarette butts. People management has worsened since 2015: the extension of the Bruce Freeman Rail Trail (BFRT) to Powder Mill Road (BFRT Section 2C) has made and will continue to make it easier for walkers, bikers and skateboarders to access entrance points to White Ave Beach, Stone Root Beach and Sachem's Cove [RASMUSSEN].[2] The BFRT is aware of these issues and has proposed fencing to the Massachusetts Department of Transportation as part of the 75% design plan. Trespassing by and personal confrontations with swimmers crossing private property have been reported to the WPAC.

People management concerns are not limited to Concord neighborhoods. Sudbury residents at Frost Farm, near the southwest corner of the pond, have reported similar issues especially noting speeding and nighttime disturbances [MURPHY]. It is expected that the Cold Brook Crossing development on Route 117, with direct access to White Pond trails, will result in a surge of new visitors. There is no current communication plan between the Town of Concord and the Town of Sudbury on White Pond matters.

[2] The development of Gerow Park with restrooms may or may not alleviate some interest in White Pond from the rail trail.

The most effective part of people management at White Pond is the public beach now managed by the Town of Concord. The sale of beach passes ensures that capacity limits are maintained, and lifeguards employed by the Town patrol for litter and other pond abuse. However, there may be poor understanding of where swimming is allowed, and residents and out-of-town visitors are known to use abutting and alternative areas to the beach for pond access. The Town Recreation department has submitted policies for beach management, and is effective at notifying beach pass holders of pond closures due to water quality issues.

Solutions

Visitors to the pond, many of whom are well-meaning, have a cumulative impact on the negative health of White Pond's water quality and ultimately sustainability. For White Pond to thrive as a community and area resource going forward, the Town must be proactive in ensuring people management especially during weekends and evening hours. Individual people management policies will be ineffective if taken in isolation.

A holistic solution to White Pond people management begins with pinpointing the most problematic behavior areas and redirecting visitors to safer options. More Ranger patrols, especially on weekends and at night, can deter visitors from abusive behavior simply by an official presence. No parking signs on Dover, Alden and Anson Streets can prevent dangerous interactions and litter for surrounding communities. Coordination between the Town of Concord and Sudbury Police Departments can support safety at the pond especially once the Cold Brook Crossing development is complete.

The beach area may also be a target for unwelcome behavior when no lifeguards are present. This can be mitigated by closing/locking the beach gate (on the left to the parking lot) in the evenings after lifeguards leave and when the beach season is over. Most nearby recreation areas at least have a sign indicating that the area is closed from dusk to dawn; the White Pond beach could do the same.

Social media also plays a role. The Town, WPAC and neighboring residents can comment on social media sites that public access to White Pond is limited and that swimming is allowed only at the public beach. The Town's website and websites for the Bruce Freeman Rail Trail can include language that discourages visitors from taking a swimming or recreational break at the pond.

Similar to State of Massachusetts policies, the Town of Concord should implement fines for swimming outside of designated Town areas with exceptions only for private landowners. Prominent and permanent signage along with a Ranger presence can help deliver the message before fines are given.

Problem	Solutions
Public Health and Safety	Encourage use of the public beach on social media and town signs More Ranger patrols with a line item on the Town budget Fines in no parking areas and installation of additional no parking signs Fines for littering Permanent and prominent signage on rules
Uneven communication to town residents	Use social media to alert residents and interested visitors of water quality restrictions including swimming and fishing safety
Swimming in illegal areas	Permanent and prominent signage Fines for illegal swimming
Bruce Freeman Rail Trail and Sudbury Route 117 development will significantly increase public access	Effective fencing on the rail trail can deter visitors Close coordination with Sudbury police can help users understand the importance of safe behavior Communication with owners of the Cummings Building in Sudbury to install no parking signs for White Pond access

Call to Action

The WPAC calls on the Select Board and Town Manager to make the safety of White Pond water quality, water testing and people management a priority.

The Town has implemented several positive programs in the last six years, including erosion control, the hiring of a new Ranger and improved signage on trails and at Sachem's Cove. However, these efforts are small compared to the larger task of reducing nutrient flow to the pond.

Neighborhood concerns also need greater attention. For example, citizen petitions for limiting parking on Anson and Alden streets, despite following established town protocols, have yet to be acted upon. The Town has long been aware of the various concerns surrounding White Pond access, including new opportunities arising from the Bruce Freeman Rail Trail and the Cold Brook Crossing development.

Several local organizations besides WPAC are active in managing and/or advocating for White Pond including: the Friends of White Pond (FWP, an advocacy group that publishes an annual educational newsletter *Ponderings*); the Dover Street Property Association; Preserve White Pond, a community group; and the White Pond Youth Conservation Group

made up of Concord Carlisle High School students. All organizations stand ready to support the Town in delivering on the recommendations in this report. However, the Town of Concord is the only body that has the authority and resources to implement lasting change, some of which rely on coordination with the State of Massachusetts.

Clear mandates for water quality, testing and people management improvements must be made by the Select Board and Town Manager for White Pond to survive as a community and area resource. A failure to address these issues will mean the expected closure of the pond and beachfront property during warm months going forward. WPAC recommends that the town consider and implement these recommended and potential solutions in order to maintain and hopefully improve White Pond for future generations.

Appendix A: Guiding Principles

Guiding Principles for the Development of a Long-Term Vision for White Pond

White Pond Advisory Committee

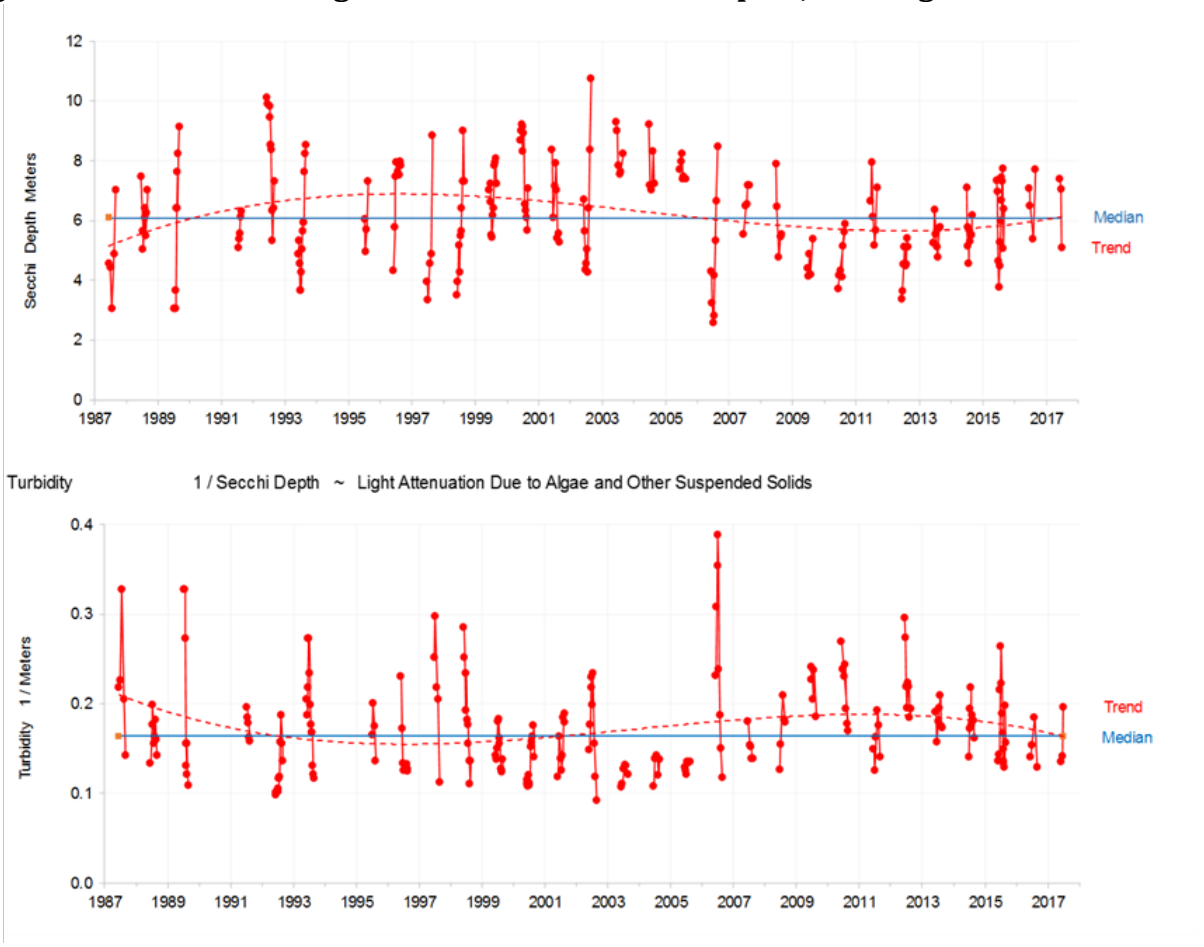
These principals were adopted in the White Pond Vision 2015 and are reconfirmed here September 29, 2021

1. Our commitment to White Pond is for today and the future.
2. We will strive to restore and maintain water quality to the highest previously measured levels.
3. We will strive to preserve and protect the watershed, its land, flora, and fauna.
4. We will seek to sustainably maintain a natural environment and a safe, clean, and enjoyable experience for all users of White Pond and its watershed.
5. We will advocate managed, public access to White Pond and its watershed.
6. We will advocate solutions to White Pond neighborhood problems.
7. We will seek to build a broad base of support for White Pond in order to ensure effective long-term advocacy.
8. We will expect the town of Concord to make ongoing formal commitments to resources, budget, and enforcement in order to affect the above principles.

Appendix B: White Pond Testing and Water Levels

White Pond's historically clear and clean water is perhaps its greatest feature, providing a wide variety of recreational opportunities for Concord residents. Thanks to a long-term monitoring effort by Concord residents Dr. Bill Walker and Judith Sprott, we have a detailed record documenting key parameters such as dissolved oxygen. These efforts have been continued by Kate Blair, Carmen Jaquier and others to the present time on temperature and transparency. Figure 1 below presents Secchi Depth measurement from 1987 to 2017 with water quality trending negatively for the last dozen years clearly indicated [WALKER]. As Walker notes, "transparency provides a practical surrogate for other water quality problems triggered by nutrient and sediment loads."

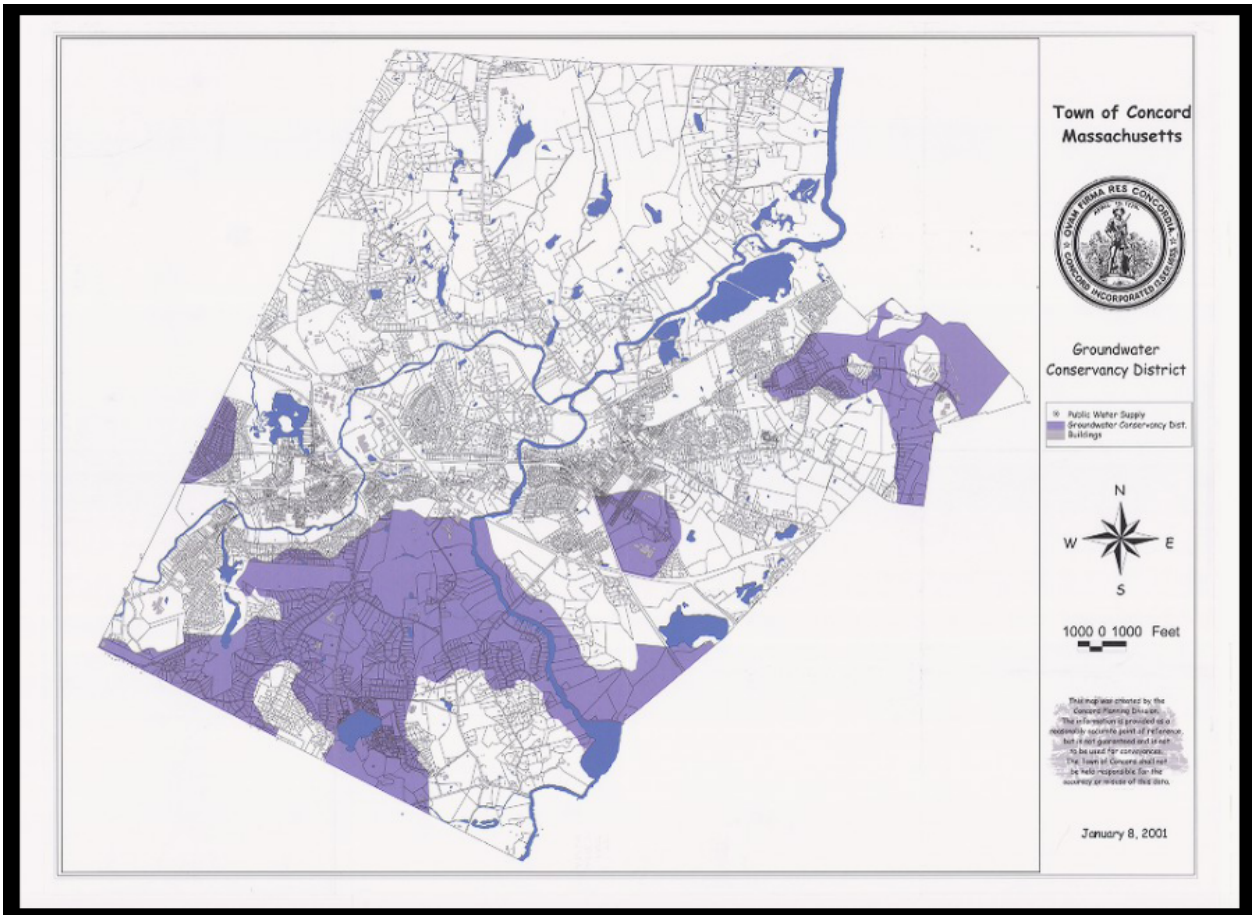
Figure 1: White Pond Long-Term Trends in Secchi Depth, June-August 1987–2017



Source: Walker

In the last six years, the frequent appearance of blue-green algae, or cyanobacteria, has forced closures of the pond. It is clear to all water scientists and public health officials consulted by WPAC that an over-provision of nutrients in the water is primarily responsible. New England kettle ponds have proven to be particularly susceptible to this type of algal bloom [CAPECOD]. The White Pond groundwater conservancy district in Figure 2 shows the area that must be elevated to priority status for nutrient contributions.

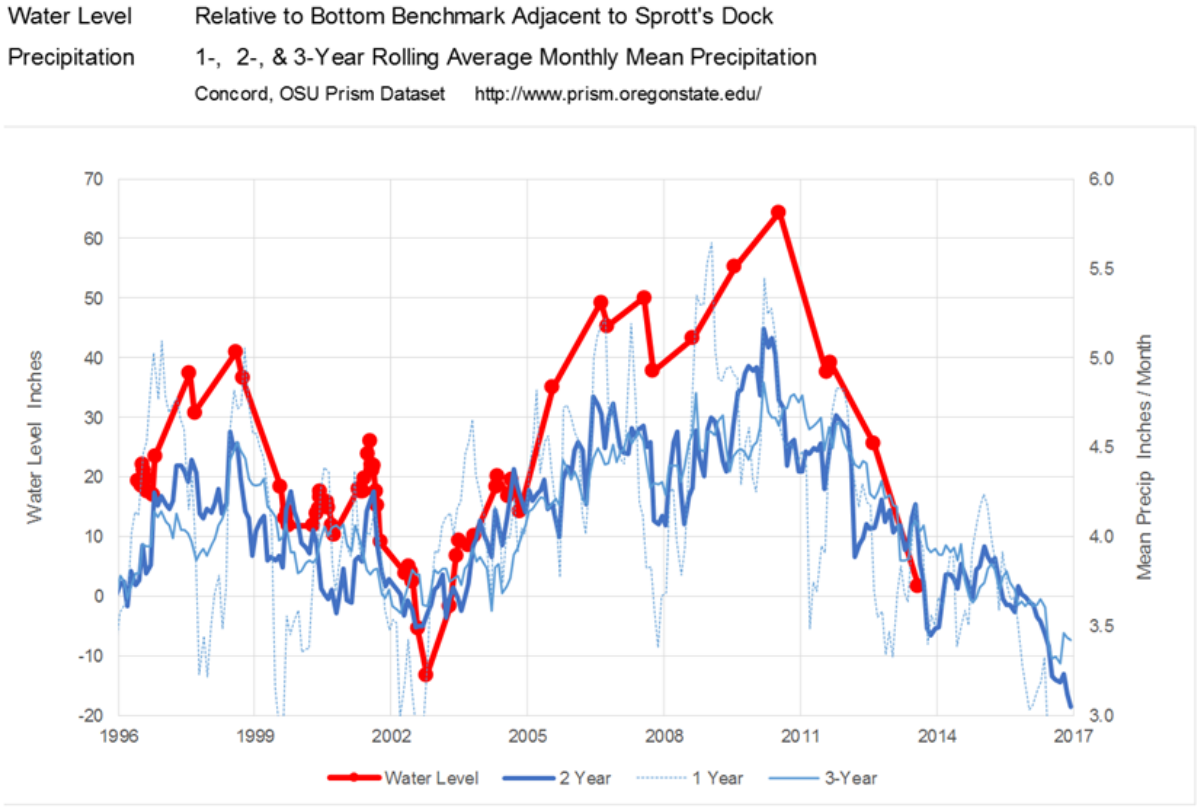
Figure 2: Town of Concord, Massachusetts ; groundwater conservancy district



Source: Harvard

White Pond's water levels have been observed to vary dramatically over the years as shown in Figure 3 [WALKER]. During periods of high rainfall and high water levels, the Pond is more susceptible to nutrient loading from erosion and runoff. Water levels strongly correlate with precipitation. However, during prolonged periods of low water levels, it is not clear whether pumping from Town Well #7, which has increased substantially over the last five years, may have an effect [ESS]. More study is needed to find the impacts of pumping, as well as its interactions with surface water evaporation and air/water temperature.

Figure 3: White Pond Water Level vs. Precipitation 1996–2016



Source: Walker

Appendix C: Causes and Effects of Cyanobacteria Blooms

Cyanobacteria blooms can have many detrimental effect on a pond's ecosystem. An overgrowth of algae consumes oxygen and blocks sunlight from underwater plants. When the algae eventually dies, the oxygen in the water is consumed. The level of dissolved oxygen in this water can fall to levels that are too low for many aquatic insects and fish to survive. This can cause extreme changes in habitat and lead to the "death" of the pond. The impacts of these algae blooms on humans and can be significant, ranging from respiratory and gastrointestinal problems in people to the death of animals including family dogs. Skin exposure alone can cause severe problems to humans.

The environmental conditions that allow toxic cyanobacteria blooms in water bodies such as White Pond are somewhat specific.

First, water quality must be poor. Excessive cyanobacteria in itself is a sign of poor water quality. The water must have high levels of contaminants like phosphorus and/or nitrogen for blooms to occur. These excess contaminants are often referred to as "nutrients" in the science literature because they nourish bacterial and algae growth.

Second, the water temperature must be high (> 10-15 deg C). Seasonally, this often occurs in the summer and early fall at White Pond.

Third, water needs a long hydraulic retention time (> 1 month). White Pond, like Walden Pond, has a very high hydraulic retention time, estimated to be 4 years. This is unusually high due to the geomorphology of kettle ponds: there is minimal substantial surface inflows and outflows into kettle ponds like White Pond.

Substantial work has been conducted on natural and cultural eutrophication at Massachusetts ponds [Bennett]. White Pond is undergoing cultural eutrophication. Cultural eutrophication is the process by which water bodies acquire high concentrates of contaminants. Eutrophication occurs naturally for all ponds but cultural factors like agricultural activities, human wastes, or industrial pollution speed up the process.

The possible sources of White Pond's cultural eutrophication include, but are not limited to, septic systems and fertilizer runoff. The subsurface infiltration of groundwater influenced by septic systems is known to carry nutrients at elevated levels. Drought conditions can also increase the likelihood of blooms where contaminant loading remains constant from septic systems into a lower volume of water of a pond for dilution. Runoff from animal feedlots and from fields containing mineral fertilizer or manure can also introduce similarly high nutrient loads.

A recent study on White Pond's eutrophication found that:

"Cyanobacterial blooms have become a frequent health hazard, and benthic anoxia has become more extreme than at Walden. The town and shoreline residents have recently increased the availability of sanitary facilities for visitors and stabilized some of the slopes and footpaths around White Pond, as was done previously at Walden (Maynard 2004). Nonetheless, anticipated long-term warming and increased runoff are likely to amplify the risk of water quality problems in both ponds. Monitoring the benthic macrophyte communities could represent an early warning system for such ecological changes in the future" [STAGER].

There are 46 septic systems are on the banks of White Pond, according to analysis conducted in summer 2021 by the White Pond Youth Conservation Group. In some limited instances, septic systems on the pond are so close to the water that they do not comply with current town standards for minimum setbacks from surface waters. In addition, it is unclear if all septic systems are being discharged correctly.

Agriculture operations have been limited recently and the agricultural fields near White Pond do not surface runoff into the pond, according to studies done by classes at CCHS. No manure or fertilizers have been applied to these fields since 2019, a fact confirmed by WPAC conversation with Verrill Farm and a statement made at a Select Board meeting in 2018. There were no agricultural activities on these lands in 2021.

Appendix D: Monitoring, Testing and Pond Closures

As an interim step, WPAC recommends continuance of Dr. Bill Walker's Water Quality Monitoring and Restoration proposal [WALKER]. We should continue the use of Secchi Depth Measurements, as this data may demonstrate trends over time. This testing is simple and low-cost. A neighborhood group has been collecting this Secchi information and plans to enter all historical data into an Excel sheet for trending purposes.

Beyond Secchi Depth testing, WPAC recommends more rigorous and consistent testing for blue green algae blooms. In addition, the state requires that E. coli testing be conducted on a weekly basis while the beach is in operation. WPAC also recommends this same test be conducted in multiple locations. Suggested locations include Sachem's Cove, and the north side of the pond past Thoreau Cove.

Further options
(1) There are multiple options for how testing can be accomplished including clarity, temperature and E-Coli levels. As a different example from Secchi Depth transparency, the Army Corps of Engineers manage Tully Lake in Athol, MA and have hired a contractor who conducts weekly Cyanobacteria Monitoring Procedures including.:

- Water Sample Location Testing sites
- Field Observation Form
- Water Sample Float Test
- Water Sample Toxin Test Strip
- Water Sample Secchi Disk Test
- Temperature, DO, pH

If cells are observed through field observation monitoring, then a Water Sample Fluorometer Analysis is conducted for Chlorophyll-a and Phycocyanin.

If trends are detected with the normal weekly monitoring, then toxicity/concentration testing by a lab is performed. This is done for a confirmation of how toxic/dangerous the water is to humans and wildlife. If an intervention is needed, a treatment of copper sulfate may be deployed to prevent the bacteria from proliferating and to keep the beaches open. Tully uses copper sulfate but many water management program treat with alum, which has a long-term effect but initial costs are more expensive.

The Town should establish clearer guidelines for beach closures and reopening's and extend these to the pond. The State of Vermont for example will close any public beach if any of the following condition are met [VERMONT]:

- Visible known blue-green algae bloom/scum or an unknown, potentially blue-green algae (i.e., not pollen), bloom/scum
- Microcystin-LR (equivalents) concentration greater than or equal to 6 ug/L (ppb)
- Anatoxin-a concentration greater than or equal to 10 ug/L (ppb)

The State will reopen beaches only if all three of these conditions are met:

- No visible blue-green algae bloom/scum
- Microcystin-LR (equivalents) concentration is less than 6 ug/L (ppb)
- Anatoxin-a concentration is less than 10 ug/L (ppb)

Testing should not be limited to the beach but should incorporate all areas that create a health risk. There should be a universal plan with designated responsible parties and consistent funding. Ultimately, WPAC recommends that the Town take over testing of White Pond and incorporate the following criteria:

- Cell counts of the cyanobacteria including number of cells/ml. water
- Individual and composite samples
- Break out counts by species of Microcystis vs. other species

(2) A still different detection testing method, and possibly preferred, is Lim-Tex cyanoCasting™. This is the characterization of cyanobacterial populations in water resources to estimate biomass and cyanotoxin concentrations and evaluate trophic interactions. The cyanoCasting™ protocol has been developed using seven years of research on cyanobacterial population dynamics and toxin production across a range of sites in New Hampshire and Massachusetts [LELAND, 2018, LELAND 2019]. The objective of the protocol is to use size-fractionated samples representing unique cyanobacterial populations to provide data documenting increased biomass leading to water quality issues including cyanobacterial accumulations in the water column (a.k.a. transparency) and at the surface (a.k.a. blooms), as well as estimation of microcystin concentrations [US EPA 2016, US EPA 2021]. The cyanoCasting™ samples have been used as leading indicators of bloom conditions and estimation of microcystin concentrations since 2018 as part of the Association to Preserve Cape Cod (APCC) Cyanobacteria Monitoring Program [LELAND 2019].

The testing provides an alert signal to increase routine monitoring and/or collection of samples for additional laboratory analysis, including cell counts. For example, water samples collected on August 24 and 26, 2021 at White Pond were size fractionated and microcystins quantified. The observed microcystin concentrations fell within the 95% confidence interval of the cyanoCasting™ model. The cyanoCasting™ protocol has also been used to evaluate aquatic trophic interactions affecting the structure of zooplankton and cyanobacterial communities [LELAND 2020].

Alternative testing includes:

Proposed Samples/Testing (Bi-weekly or Weekly)
Sample Stations: White Pond 1 “Deep Site”. Access shoreline at Boat Ramp.
White Pond 2 “Thoreau Cove”. Access shoreline at Boat Ramp

Identification of cyanobacteria: Composition and dominance of bloom-forming cyanobacteria
Documentation of fluorometer calibration and model using the Fluoroquik device (or equivalent)
Water Sample parameters: Secchi disk test, temperature, DO, pH
Water sample fluorometric analysis for cyanobacterial biomass (phycocyanin): Collection and processing of size-fractionated (<50 μm, WLW and BFC) water samples for quantification following single freeze-thaw extraction method.
Estimation of cyanotoxins (microcystins): Estimation of total microcystins using the correlations between phycocyanin and total microcystin cyanoCasting™ method. See preliminary results from August 24 and August 26 sampling events above.
Prediction of bloom condition or increase in cyanobacterial biomass: Calculation of daily growth rates of cyanobacterial biomass. When critical levels are exceeded, sampling frequency will be increased to weekly monitoring.
Water sample analysis for cyanobacterial biomass: Cyanobacterial cell counts will be conducted when surface accumulations of cyanobacteria are observed and/or whole lake water (WLW) sample exceeds critical growth rates. Cyanobacterial cell counts will be conducted when surface accumulations of cyanobacteria are observed and/or whole lake water (WLW) sample exceeds critical growth rates.

Sample Collection and Shipping for Cell counts:
1 L or 2 (500) mL amber HDPE bottles
Frozen Ice Packs
Samples immediately put on ice in cooler
Bottle sealed in zip-loc bag for shipment.
Bottles placed in Styrofoam shipping container and insulated shipping box
Include both chain-of-custody form and field observation form

The samples shall be shipped to a suitable laboratory and handled in accordance with ASTM D4638-16.

Cost of Laboratory Services

Bloom-forming Cyanobacterial population screening: $50.00
Microscopic observation is used to determine if cyanobacteria are present. Bloom-forming cyanobacteria (BFC) samples will be evaluated for composition and dominance using light microscopy. Image based report provided.
Cyanobacterial biomass and estimates of cyanotoxin concentrations: $50.00
Fluorometric size structure analysis of cyanobacterial populations and their relative biomass. Estimation of microcystin concentrations based upon most recent research of cyanobacterial populations and cyanotoxin production. Note: Estimation of cyanotoxin concentration requires cyanobacterial population screening.
Zooplankton enumeration: $125.00
Microscopic evaluation of zooplankton population to the genus level and quantification of zooplankton biomass.

Cost per sampling event at each sampling site:	
Sample collection	$150.00
Identification: Composition and Dominance	$50.00
Cyanobacterial Biomass and estimation of cyanotoxins	$50.00
Weekly data interpretation, including growth rates	$200.00
Total expense per sampling event per site	**$450.00**

Cyanobacterial biomass as cell counts (as needed)	$200.00
Zooplankton enumeration and estimate of biomass (optional)	$125.00
Final report preparation (hourly)	$100.00

Regardless of the method, WPAC recommends that testing of some sort be immediately deployed and budgeted. Relying on only visual observation is not robust enough. Both methods above will be early warnings for treatment and should be employed, including continued use of the P-POD technology.

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