PART C: Examination of Lake Water Quality

Effective lake and watershed management is based on understanding how lakes work and how they change, particularly with respect to the changes that result from human activities.

Since every lake is unique, ongoing monitoring and assessments are necessary to provide sufficient information to understand the most important causes/sources of changes. The information can help identify management targets and goals—realistic actions that can provide long-term, cost-effective resource protection.

White Lake has now had five consecutive years of lake monitoring and annual aquatic vegetation surveys, with three years of lake level monitoring, facilitated by the installation of two easily accessed lake level gauges. Rainfall records have been kept for many years at the Town's wastewater treatment plant and are now reported in conjunction with lake levels and other monitoring data. In addition, several special projects have been conducted in recent years (development of a groundwater model, sediment nutrient sampling, assessment of stormwater outfalls to the lake, rainfall nutrient monitoring, winter waterfowl counts), adding significantly to what we know about White Lake.

Old files, reports, and publications have been reviewed to determine what historical lake conditions were, both in White Lake and other nearby Bay Lakes. A great deal of information about the lake has been shared through public presentations, Town of White Lake board reports, and the White Lake Watch website (www.whitelakewatch.com). Extensive supporting information for this study, including recent lake monitoring data and historical data, is provided in a series of attachments.

General Characteristics of White Lake

The following fundamental attributes about the lake body are important to help set the stage for the following sections.

- White Lake is a small and very shallow Carolina Bay Lake. The average depth is 6.2 feet and the maximum depth is 9.6 feet. These depths are often a foot lower in the summer.

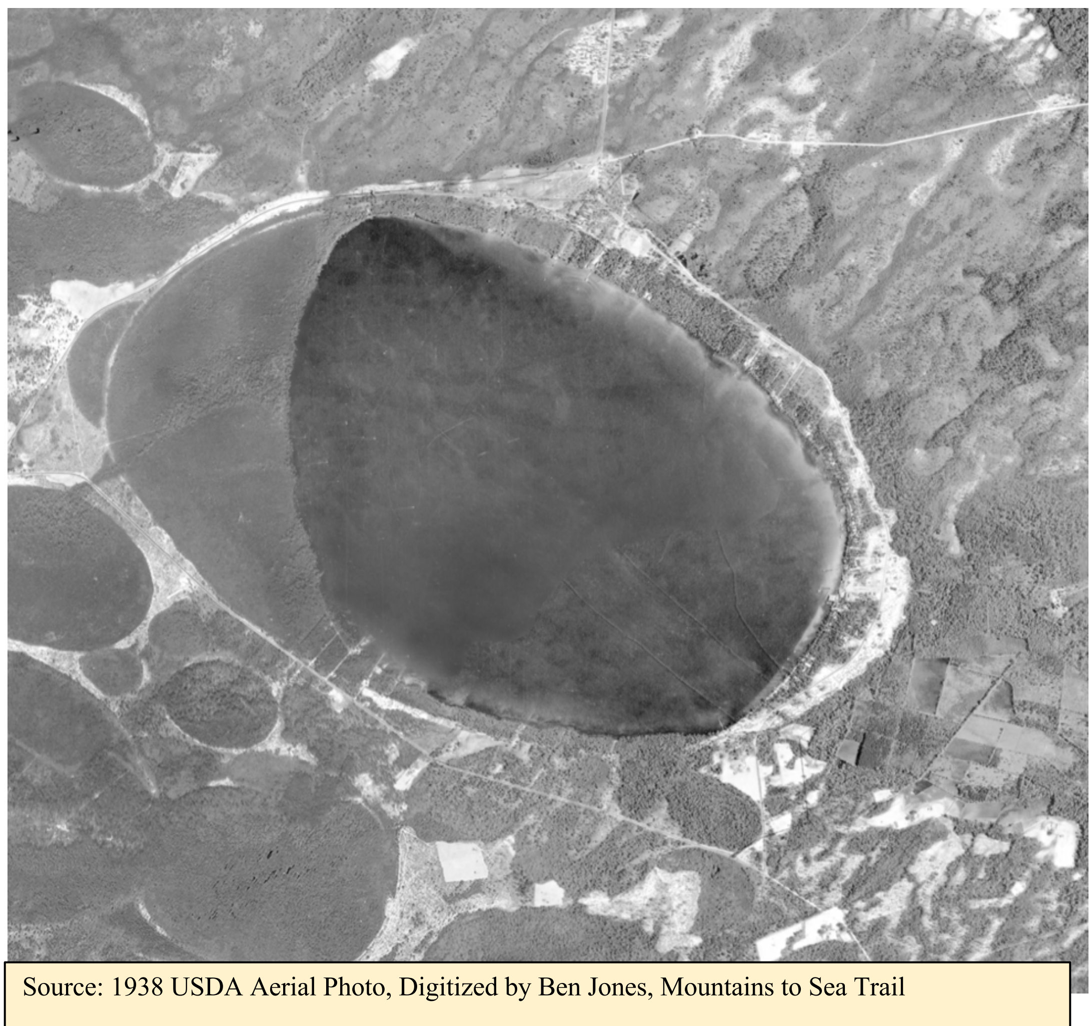
- There is no surface water inlet to the lake. Rainfall on the lake surface is the main source of water with groundwater being a secondary source.

- Due to its shallow depth and sediment-rich bottom in the main portion of the lake, motorized watercraft can easily disturb the lake bottom. This affects the lake aesthetics and contributes to the clarity problem.

- Wetlands have no significant influence on the lake. The other Bay Lakes are tea colored and acidic due to the organic acids from the wetlands that surround these lakes. This condition does not exist in White Lake.

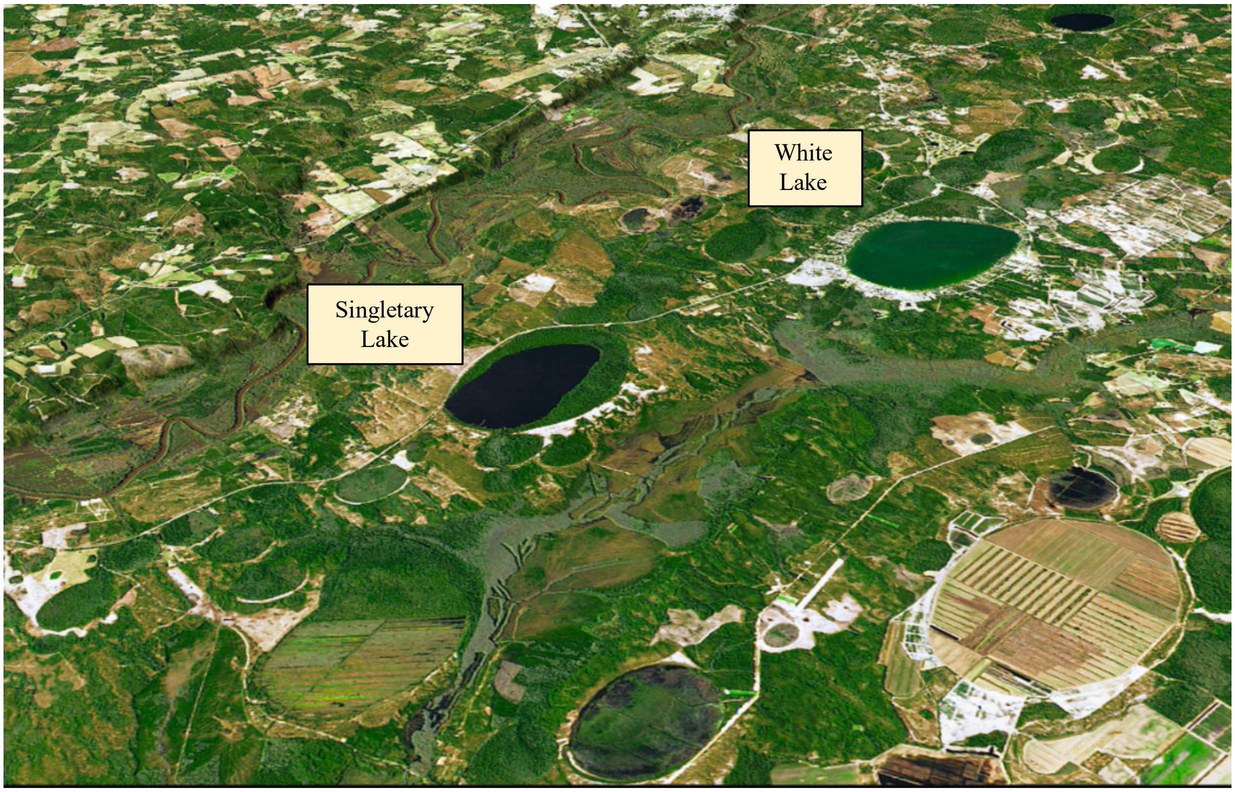
The first aerial views of the Bay Lakes here in eastern North Carolina were provided by US Department of Agriculture photography in 1938. Some of these photographs have been digitized and stitched together to provide clear views of what the lakes looked like 80+ years ago. ***Figure 1*** below is a photo from this collection. It shows the Carolina Bay characteristics—elliptical shape, NW-SE orientation, a sand rim—that are evident when viewed from the air. ***Figure 2*** is a current satellite view of White Lake and the immediate vicinity.

Figure 1. Visual characteristics of Carolina Bays - 1938 Aerial View of White Lake.



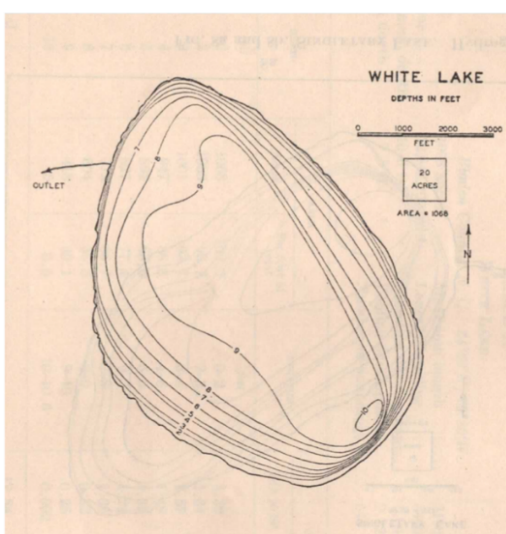
Source: 1938 USDA Aerial Photo, Digitized by Ben Jones, Mountains to Sea Trail

Figure 2. NASA Landsat 8 Satellite Image of White Lake and neighboring Bay Lakes, 2021.



Dr. David Frey, a University of North Carolina-Chapel Hill researcher, conducted extensive studies of the Bay Lakes of Bladen and Columbus counties in the late 1940s and early 1950s, describing their similarities and differences in a series of scientific publications and articles. Below is a map of depth intervals, showing that the nearly all of the lake was less than 10 feet deep, from one of Frey's publications.

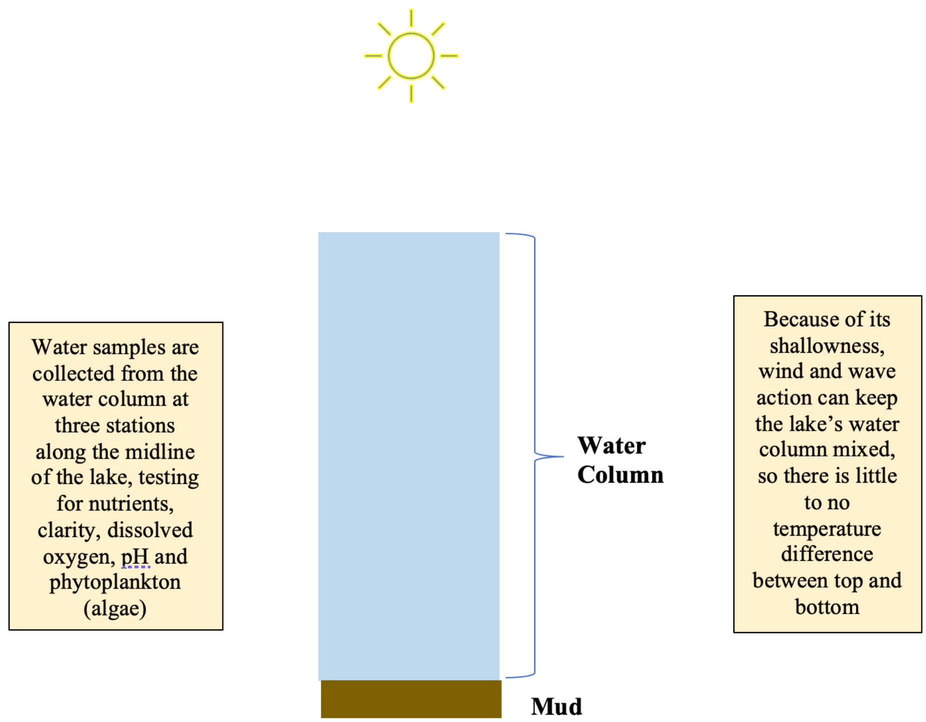
Figure 3. Frey image - 1947



Frey's hand-drawn map of depth contours in White Lake, based on depth soundings taken in 1947, and tracings made from the 1938 USDA aerial photos

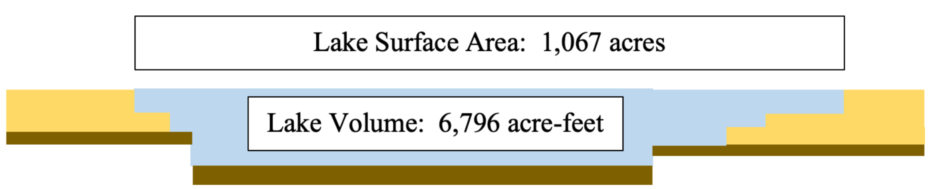
Because White Lake is so shallow, wind and wave action keep it well-mixed. The shallowness of the lake allows sunlight to penetrate to the lake bottom, where low-growing plants and filamentous algae (which often grow attached to the plants) can be abundant, as they are able to take advantage of the nutrients in the lake sediments.

Figure 4. A vertical section (surface to bottom) view of the lake***.***



Muddy sediments comprise about half of the lake bottom area, while sand is found in the shallow perimeter of the lake (tan color in ***Figure 5***). The shallowness of the lake means that the lake volume to lake surface area ratio is relatively low, which underscores the importance of rainfall and evaporation in the water budget of the lake.

Figure 5. A horizontal cross-section of the lake***,*** with surface area and volume.



Lake Level and Rainfall Monitoring

The water level in White Lake varies with rainfall amounts, as both historical monitoring and recent monitoring has demonstrated. Groundwater flow rates vary with water table levels, which are largely dependent on rainfall and infiltration. Land development that increases the amount of impervious surface reduces infiltration and increases stormwater runoff, which can quickly enter the lake ditches and pipes.

Summary of Lake Level and Rainfall Monitoring

White Lake now has four consecutive years of lake water level monitoring. These data tell us the following:

- The four-year mean high-water level is 64.85 feet NAVD 88 (North American Vertical Data 1988). Extended periods of high rainfall are needed to sustain lake levels at or above 65 feet.

- Lake levels can drop 4-5 inches in a month when the monthly rainfall amounts are very low, and during severe drought periods lake levels can drop 2+ feet.

- Annual lake level variations ranged from 10-16 inches.

- The total variation in lake level (highest to lowest) over a four-year period, 2019-2022, was 21.1 inches.

- Monthly rainfall amounts over the four-year period, 2019-2022, ranged from a low of 0.4 inches to a high of 12.25 inches. Total rainfall in 2020 was 1.4 times the annual average for the region, providing a volume of water equivalent to 97% of the volume of the lake.

Atmospheric Monitoring 1974-2020: No More Acid Rain

Many studies were done in the U.S. in the 1970s and 1980s documenting the wide-spread occurrence of acid rain as well as its effects on freshwater ecosystems in the Northeastern US and Canada. In North Carolina, acid rain and fog greatly impacted terrestrial ecosystems in the mountains, where dead trees were commonly seen at higher elevations.

Acid rain is caused by a chemical reaction that begins when compounds like sulfur dioxide and nitrogen oxides are released into the air. These acidic pollutants can rise very high into the atmosphere, where they mix and react with water, oxygen, and other chemicals to form more acidic precipitation.

The National Atmospheric Deposition Program (NADP) developed a National Trends Network (NTN) for measurements of wet deposition of acidic pollutants and nitrogen pollutants. The nearest monitoring station to White Lake is found in Clinton, NC (NTN NC35).

A graph of rainfall pH over time at this monitoring station ***(Figure 6)*** shows that rainfall was quite acidic (meeting the definition of acid rain, at around 4.5 standard units (SU)) before the year 1990. There was a relatively rapid increase in the pH over the period 2008-2013, with average annual values since 2013 hovering around 5.8 SU.

What is pH?

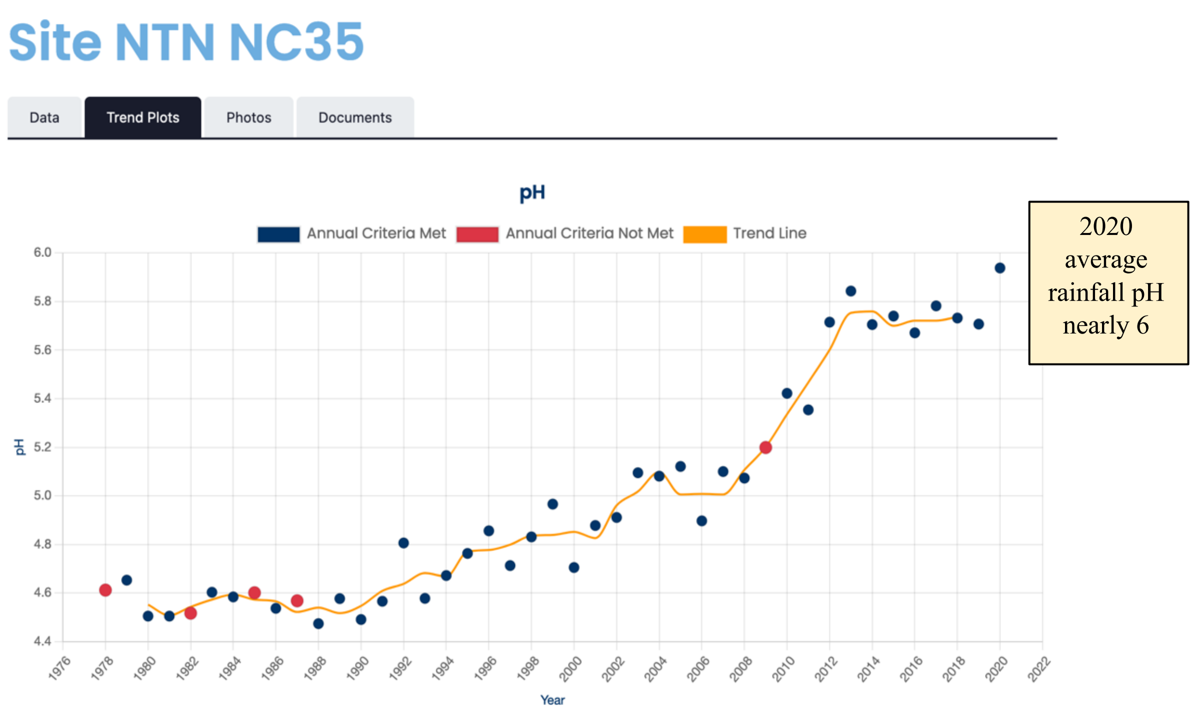
It can be an important indicator of water that is changing chemically.

The pH scale ranges from 0 (the acidity of hydrochloric acid).

to 14 (very basic, such as a caustic liquid drain cleaner).

Each one-unit change represents a ten-fold difference in acidity/basicness, so water with a pH of 5 is ten times more acidic than water with a pH of 6.

Figure 6. Annual average pH of rainfall measured at the Clinton, NC NADP monitoring station through 2020. https://nadp.slh.wisc.edu (Accessed 1/4/22).



North Carolina passed the Clean Smokestacks Act in 2002, that resulted in two state electric utilities making substantial reductions in emissions of the acidic pollutant sulfur dioxide, by 85% over a ten-year period (2002-2011), with an equivalent reduction projected by the largest "upwind" utility, the Tennessee Valley Authority (TVA), by 2015 (Andrews, 2013). Therefore, the pH change of rainfall was relatively rapid.

Summary of Observations from Atmospheric/Rainfall Monitoring

- The pH of rainfall has changed considerably in a relatively short period of time, with the most rapid change taking place in the five-year period 2008 – 2013.

- The pH change is primarily due to the reductions in acidic emissions from utilities, which has occurred nationwide, and as a result, there is no longer acid rain found anywhere in the U.S.

- The continuing increase in rainfall pH in the Coastal Plain region is due to increased emissions of a strongly basic substance, ammonia.

White Lake's pH Also Changed Relatively Quickly

Every five years, NC DEQ conducts lake monitoring for White Lake, and that schedule happened to bookend the period of rapid change in rainfall pH (2008 to 2013). DEQ found pH levels in May of 2013 to be noticeably higher than they had been in 2008. Additionally, there was a 2-unit spike in pH that July, associated with a relatively short duration algae bloom.

Figure 7. How Algae Blooms Can Affect pH

The Importance of Photosynthesis

Plants and algae use the energy of the sun and nutrients to grow and multiply (and produce oxygen), and this process is called photosynthesis

At night, respiration occurs, as the primary producers use oxygen (a weak base), and release carbon dioxide (a weak acid)

At times of high photosynthesis, the lake water becomes supersaturated with dissolved oxygen, and pH increases, 2 or more units

State standards consider a water body with pH levels above 9 to be impaired, as there can be harmful effects to aquatic life

Figure 8. Why is Alkalinity Important?

The Importance of Alkalinity

Alkalinity is a measure of the amount of dissolved minerals found in lake water. These minerals act to limit changes in pH, much like a speed governor in a vehicle can restrict excessive speeds.

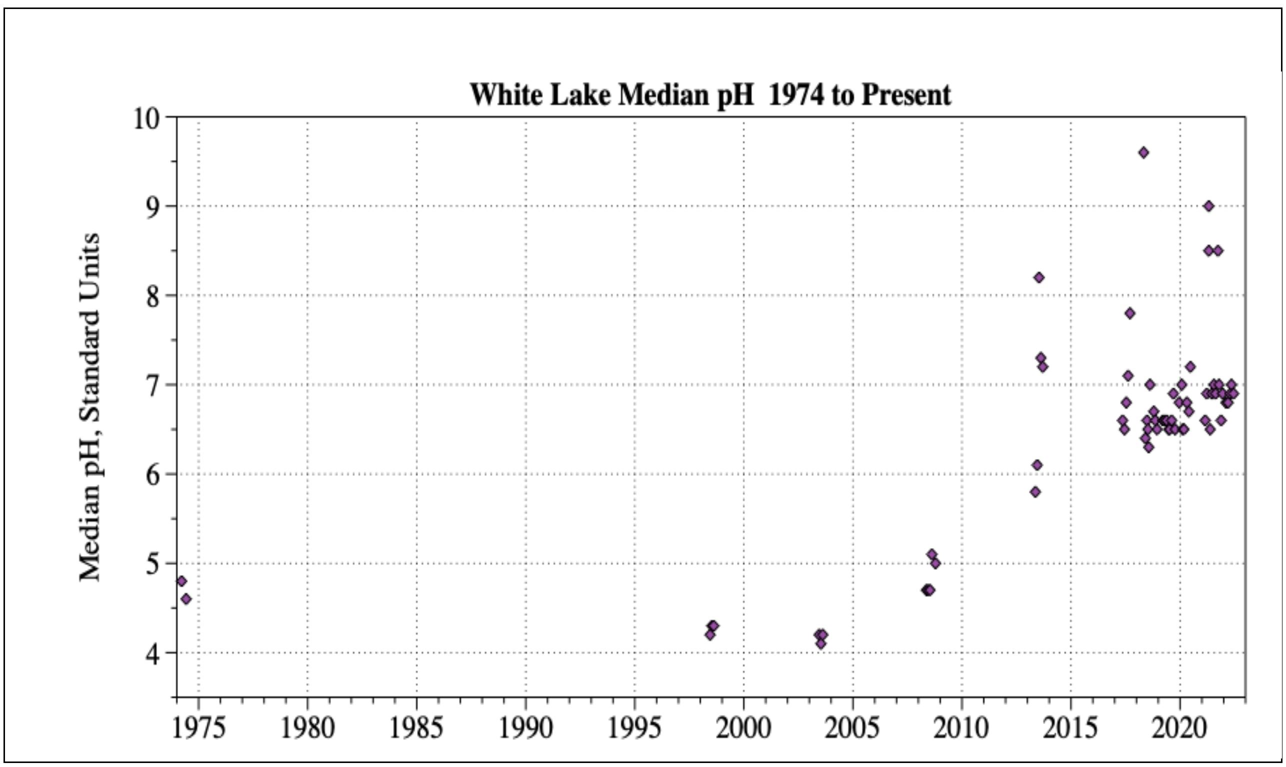
Because rainwater is the primary source of water for White Lake, the alkalinity of its water is **very low.**

This means that there are no natural limits

to high pH levels in the lake.

During algal blooms, photsynthesis is high and increases in pH can be rapid; once the algae bloom subsides, pH levels decline to a range (6.5-7.0) that is shown as a cluster on the graph in ***Figure 9***.

Figure 9. White Lake pH levels from 1974 (Weiss and Kuenzler 1976), 1998-2017 (NC DEQ), and 2018 to June 2022 (LIMNOSCIENCES).



Summary of Observations from Atmospheric/Rainfall Monitoring

- The pH of White Lake has increased over the same time as the rainfall pH has increased—this is the answer to the question of "what the pH happened?".
- The additional increases in pH are related to the high dissolved oxygen content and photosynthetic activity in the lake.
- During algae blooms pH levels can ratchet up to 9 or above, with the highest daily levels found in the afternoon.
- Non-bloom pH levels are now generally in the range of 6.5 to 7, which is similar to what is found at Lake Waccamaw.

Nutrients in White Lake and Comparisons with Other Bay Lakes

Nutrients play a fundamental role in lake systems. Nutrients are chemical elements critical to the development of plant and animal life. In healthy lakes and streams, **nutrients are needed for the growth of algae that form the base of a complex food web supporting the entire aquatic ecosystem**. The most important nutrients in lakes and streams are nitrogen and phosphorus. Eutrophication is the process of enrichment of lakes and streams with nutrients, and the associated biological and physical changes. Eutrophication is a natural process, but human activity has dramatically increased the rate of nutrient enrichment in many waterbodies.

In many lakes, external sources of nutrients supply greater amounts than internal sources (from nutrient recycling), but each lake needs careful study for years to understand the relative importance of all sources, both external and internal. An assessment of White Lake's nutrient sources conducted in 2019-2020 indicated that rainfall on the lake surface is by far the largest external source of nitrogen to White Lake. Rainfall contains several forms of nitrogen, including inorganic forms that can be readily utilized by phytoplankton, so big rain events can provide the equivalent of "liquid fertilizer" to White Lake.

Research into the presence of nitrogen in the atmosphere led us to a program conducted by the EPA using the CASTNET reporting system, (the National Atmospheric Deposition Program [NADP] National Trends Network [NTN] discussed earlier is a component of this program). The Clean Air Status and Trends Network (CASTNET) operates 98 monitoring stations throughout the contiguous United States, Alaska, and Canada for the purpose of air quality monitoring, including the inorganic nitrogen compounds nitrate (NO_3) and ammonia (NH_3).

Atmospheric monitoring conducted by EPA shows that the total annual input of nitrogen, both wet (rain) and dry (dust) is very high in this region of North Carolina. (U.S. EPA Clean Air Status and Trends Network map for 2018 https://www.epa.gov/castnet [Accessed 1/4/22]). This high concentration of nitrogen released into to the atmosphere eventually returns to the land and lake surfaces in rain and dust, delivering what is sometimes very high concentrations of nitrogen directly and relatively rapidly. This study also reveals a "hotspot" for an inorganic form of nitrogen, ammonia (which is strongly basic), in the Coastal Plain Region (see ***Figures 10a and 10b).***

Figure 10a. Atmospheric monitoring of Total Nitrogen in 2018, including both dry and wet forms. (U.S. EPA Clean Air Status and Trends Network https://www.epa.gov/castnet [Accessed 1/4/22]).

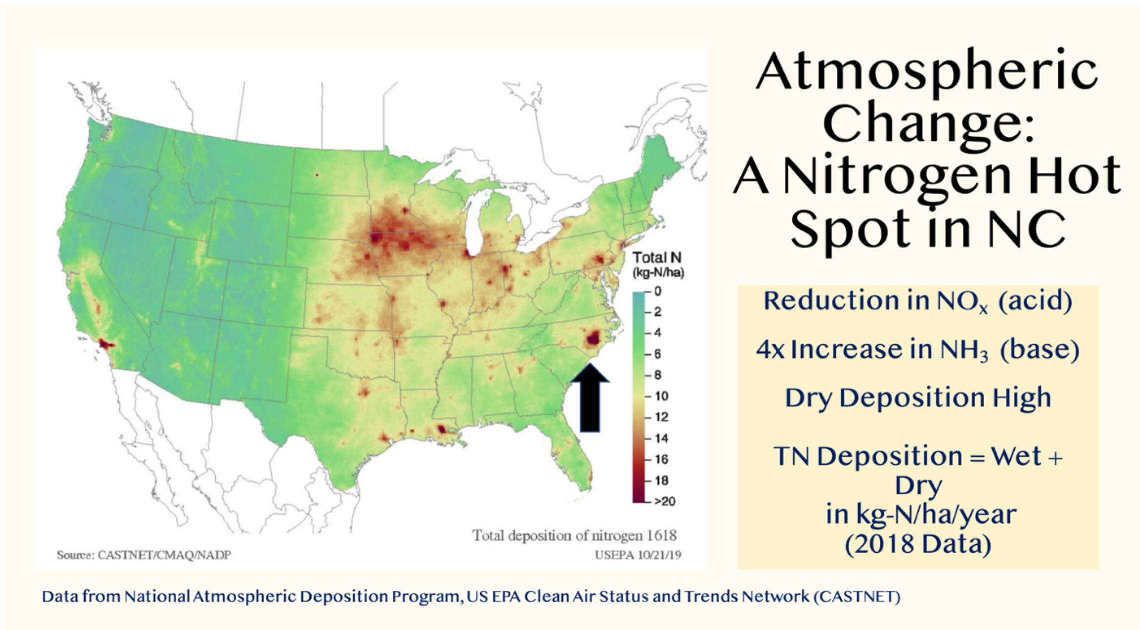
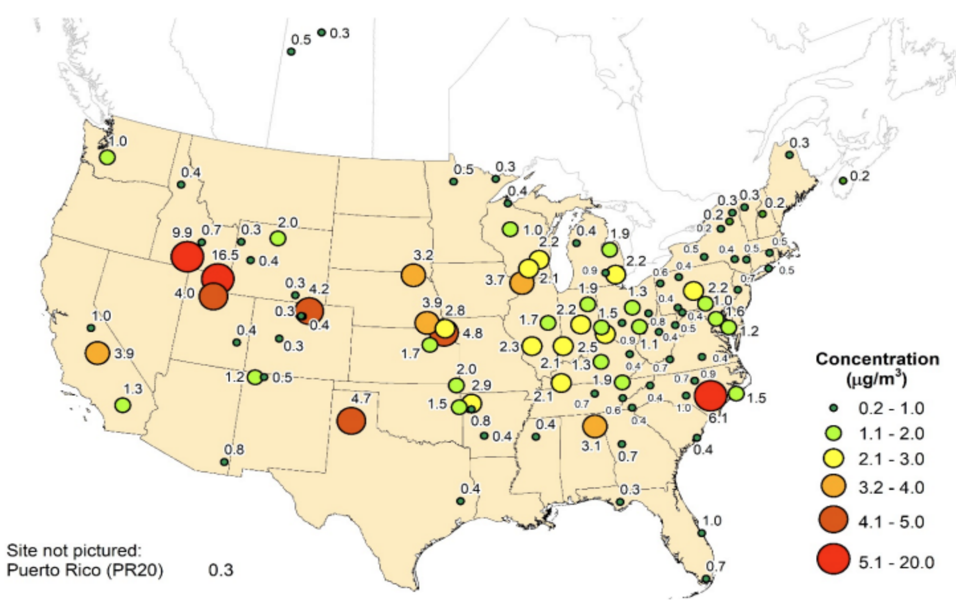


Figure 10a: Annual Mean NH 3 Concentrations at AMoN sites for 2019.



Source: USEPA, CASTNET 2019 Annual Report, pg. 12.

Other potential sources of nitrogen input to White Lake which were examined included the more than 50 stormwater outfalls and ditches which drain to the lake, but their flow depends on enough rainfall to generate runoff from impervious surfaces and yards.

Groundwater enriched with nutrients from the town's wastewater collection system may seep into the lake in places, although groundwater flow rates are variable and dependent on water table levels adjacent to the lake. Large flocks of roosting seagulls (5,000-7,000 birds) are found at the lake during winter months, but their contributions to the nutrient pool are likely minor. Internal loading of phosphorus can occur when muddy sediments are re-suspended due to wind and wave action and boating activity, and during algae blooms, when pH levels are high (*Attachment WQ6*).

The Town is actively addressing exfiltration from the wastewater collection system. The Town has completed Phase Two of a three planned phase project to replace some of the oldest pipes in the system. Once completed, this project will have replaced nearly one-third (26,000 feet) of the collection system piping.

Summary of Observations from Nutrient Monitoring in White Lake

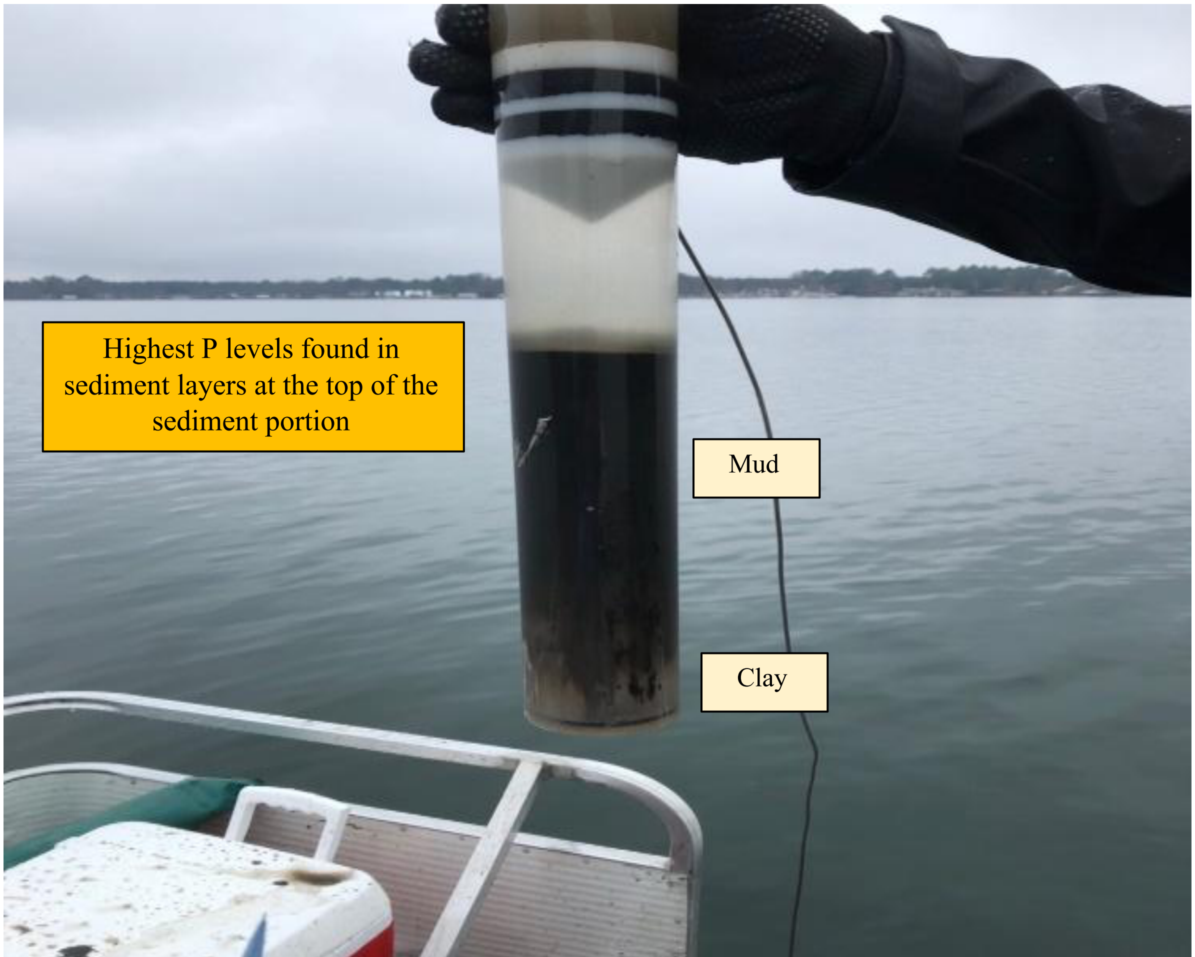
- White Lake nitrogen levels were historically very low, and it ranked lowest among the Bay Lakes in Total Nitrogen levels in 1974.
- Nitrogen levels have increased in all the Bay Lakes (Bay Tree is an outlier, however, as it was drained in the late 1960s) and White Lake's nitrogen levels are now similar to the other Bay Lakes.
- Rainfall is a significant source of nitrogen, and big rains can fuel algae blooms in White Lake.
- White Lake was, and remains, a nitrogen-limited system
- Phosphorus levels have remained consistent over time in all the Bay Lakes (Bay Tree excepted).
- Boating activity can introduce phosphorus-rich sediments into the water column.
- Phosphorus levels can increase during algae blooms.

White Lake Sediments

As reviewed earlier in this report, muddy sediments comprise about half of the lake bottom area (Frey used the description "pulpy peat" in his 1947 publication on the Bay Lakes), while sand is found in the shallow perimeter of the lake. These muddy sediments can tell their own story of the history of the lake; Frey studied sediment core samples in several Bay Lakes including White Lake, and found the rate of accumulation of sediments was very low and that the lakes were formed at a time when the climate was much different.

Sediment core samples taken in the middle of the lake in February 2019 show a dark brown mud layer with a light gray clay layer below the mud shown in ***Figure 11*** below. Phosphorus levels were measured in sections, or slices of sediment cores, and were consistently highest in the topmost sections (*Attachment WQ9*).

Figure 11. A sediment core sample taken from White Lake in February 2019.



Source: LIMNOSCIENCES

Summary of Observations from Sediment Sampling in White Lake

- Sediments are a storehouse for the nutrient phosphorus, which rooted vegetation can easily utilize
- At White Lake, the top inch of muddy sediment contains the highest concentration of phosphorus
- In general, the top 4 inches of muddy sediment can be easily stirred up by boating activity

- When sediments are introduced into the water column, the phosphorus levels increase
- Sediments can be the greatest source of phosphorus for algae suspended in the water column (phytoplankton)

Lake Life: Bottom Algae and Aquatic Vegetation

During the time that David Frey was working at White Lake (late 1940s-early 1950s), there were three issues that generated much interest among various stakeholders:

- Low lake levels (boaters)
- Abundant mats of bottom algae and vegetation that were considered a nuisance, as they were dislodged by boating activity and washed ashore to decompose, particularly on the southern and western sides of the lake (residents and swimmers)
- Need to improve the recreational fishery (Wildlife Resources Commission)

Several ideas have been promoted to rid the lake of the bottom algae, including the algaecide copper sulfate, and herbivorous (plant/algae-eating) carp. These treatments have been requested repeatedly over the years by residents and other users of the lake.

A survey of the lake by NC Wildlife Resources Commission in 1978 indicated that the lake supported a healthy community of plant and animal life, and that no algaecide treatments or herbivorous fish were warranted (Nichols 1979).

Decaying algae and vegetation which accumulate along the shoreline is unsightly produces a strong, foul odor across a large area. (See ***Figure 12***). In the summer of 2022, it was very evident that a large amount of muddy dark brown sediments were being stirred up from boating activity, in addition to the organic material (algae and vegetation).

Figure 12. View of lakeshore at Lake Place condos, 8/18/22. The algae and vegetation clumps are coated in muddy sediments, and all this material can be churned up by boating activity.

Source: LIMNOSCIENCES

Summary of Observations on Bottom Algae and Vegetation in White Lake

- The diversity in filamentous green algae found in the lake in 1950 is indicative of a healthy community rather than one influenced by nutrient pollution from septic systems as has been suggested in the past.
- The same types of mat-forming green algae are still found in the lake and their abundance varies from year-to-year.
- There have been no reports of filamentous cyanobacterial mats, as have been found in Lake Waccamaw.
- Much of the material which has and continues to collect around sea walls is muddy sediments and decomposing algae mats. Residents in some areas like the western and southern shores report the same situation year after year.
- The submerged vegetation found in White Lake is for the most part characteristic of acidic and/or low nutrient conditions.
- There are only two native taxa common to both White Lake and Lake Waccamaw: microalgae (Chara and Nitella) and spikerush.
- The invasive aquatic weed, Hydrilla verticillata found throughout most of the lake in 2017, is not thriving under present lake conditions, as no tuber bank has been found in lake sediments.

Lake Life: Phytoplankton

Most of the algae productivity in White Lake has been associated with the lake bottom where filamentous green algae and aquatic vegetation are found. As the lake is very shallow and sufficient light for photosynthesis reaches the lake bottom, vegetation can utilize the sun combined with the nutrients in the sediments to flourish. The productivity of phytoplankton, which is algae suspended in the water column, has generally been moderate to low because of low nutrient levels.

White Lake experienced a relatively short-duration phytoplankton bloom in July of 2013, and since that time the color of the water has often been green, to a greater or lesser degree, over the summer months. ***Figure 13*** explains an algae bloom.

Figure 13. Explanation of an Algae Bloom

What is an Algae Bloom?

Phytoplankton are small to very small algae that float in the water column and are not visible to the naked eye, but when they are very abundant, they can cause the water to look green, red, or brown (depending on the type of algae or cyanobacteria).

During blooms, dominance by a single type of algae can be found, and blooms generally end when nutrient availability is diminished

This "discoloration" generated a flurry of concerns from 2013 onward, which escalated considerably when a filamentous cyanobacterial bloom established a chokehold on the lake in late 2017, along with an infestation of the aquatic weed *Hydrilla (*which was found in most of the lake). ***Figure 14*** shows an aerial view of the 2017 bloom at White Lake, with the color or the water being a deep green due to the high concentrations of phytoplankton suspended in the water (the filamentous cyanobacteria).

Figure 14. Aerial view of the cyanobacterial bloom at White Lake on October 21, 2017.

Source: Limnosciences

To address this algae bloom, the Town of White Lake received permission to apply a low-dose alum treatment to strip phosphorus and cyanobacteria from the water column in early May 2018. The treatment reduced phosphorus and eliminated the filamentous cyanobacterial bloom. However, the effort resulted in a significant fish kill while the pH levels were above 9. Following this episode, DEQ issued a letter stating that it will require an NPDES (National Pollutant Discharge Elimination System) permit prior to any additional discharges into the lake. DEQ also stated that since it is a state lake, and the Division of Parks and Recreation is the "owner", DPR will have to apply for any permit. ***Attachment WQ12***

Since the treatment, the phytoplankton communities have reverted to the types of things that have been commonly found in the lake, and their abundances relate to season and nitrogen availability. Some of these species can reach bloom levels at times, with the largest bloom seen in a small desmid (algae) species in early 2021. This bloom was fueled by very high rainfall in February (which added nitrogen to the lake), peaked in April, then disappeared by early May.

Big rain events (such as June-July 2013, and February 2021) deliver readily available nitrogen, and algae can respond to this very quickly.

There has been an increase in the number of different phytoplankton in the lake in the past four years, and this diversity offers a stabilizing influence—there are lots of competitors for the nitrogen and dominance tends to be relatively brief. The "good guy" phytoplankton are managing the nitrogen, and the "bad guy" filamentous cyanobacteria have not gotten enough of a toehold to establish dominance once again. This is an unusual situation by comparison with other lakes that tend to experience frequent, or annual cyanobacterial blooms.

Summary of Observations on Phytoplankton Dynamics in White Lake

- White Lake's phytoplankton community is very dynamic, with changes from month to month (sometimes substantial changes can happen in a few weeks' time).

- Small algae, with a relatively large surface to volume ratio, can respond rapidly to increases in bioavailable nitrogen provided by big rainfall events.

- *Blooms in White Lake generally dissipate when inorganic nitrogen is no longer available.*

- *Phytoplankton diversity is increasing over time, which is indicative of a healthy community and ecosystem.*

- Cyanobacterial biovolume has generally been relatively low since the May 2018 alum treatment, although the harmful cyanobacterium *Aphanizomenon* sp. had more of a presence in 2021.

- *Comparisons with Singletary Lake indicate that acidity does not mean no algae.*

- Continued monitoring of the lake should include detailed monitoring of phytoplankton, with samples checked relatively quickly for potential cyanobacterial bloom development.

Monitoring the Impacts of Boats and other Watercraft

The association between increased boating activity (particularly on weekends and holidays) and reductions in water clarity in this very shallow lake have long been recognized, as evidenced by numerous letters, memos, reports, and newspaper articles produced since the 1940s.

With smartphones, we can now document the changes in shoreline clarity over the course of a holiday weekend, and over the course of a summer, when boating use is highest. Conditions at Lake Place condos/Nathan's Cove have been monitored for several years, as it is one of the areas where material churned up from the lake bottom accumulates. This year (2022) has provided the opportunity to show how dramatic the change can be, as April and May clarity was excellent. By the end of the Memorial Day weekend, however, a swath of muddy sediments and vegetation was found along the lakeshore. The amount of material has continued to increase over the course of the summer (as it generally does), with conditions in August being very unsightly, overwhelming the efforts to rake up and remove what washes up on the sandy beach ***Figure 15.***

Figure 15. Muddy sediment and rotted vegetation awash on shore.

Source: LIMNOSCIENCES

During lake monitoring in late September 2021, a dark brown plume was seen down the middle of the lake, generated from a wake surfing boat. A water sample was collected from the plume, and the phosphorus concentration was 2x the concentration of the other samples collected that morning. See ***Figure 16*** below.

Figure 16 a and b. Dark sediment plume generated by a wake board boat (left), and a close-up of the plume (right). Photos taken September 28, 2021

Source: LIMNOSCIENCES

The churned-up sediments, along with dislodged vegetation, migrate to shallow areas like Nathan's Cove/Lake Place, where they decompose and congeal, creating the unsightly and smelly mess for much of the summer and fall. See ***Figure 17*** below.

Figure 17a and b. (left) View in front of Lake Place on September 28, 2021; (right) view towards Nathan's Cove pier (the same location) on September 28, 2021.

Source: LIMNOSCIENCES

Over the decades, recreational boating/watercraft activity has been cited repeatedly as a major cause for many of the problems associated with poor water quality and clarity. Attached to this study are a significant number of reports, studies, and archived correspondence dating back to the 1930s which speak to this issue.

In the Action Steps section located at the end of this study is a recommendation for the consideration of some kind of recreational capacity use formula for limiting the use of boats and other motorized recreational watercraft on the lake. This type of capacity formula is being used in lakes in several states as a way to protect the lake while accommodating recreational use by residents and visitors. In whatever way, this is an issue which needs to be addressed sooner than later.

Comparative studies of different boat types (including wake surfing and other recreational boats) indicate that *lake depths of 10 feet or greater* are needed to prevent sediment resuspension caused by propeller turbulence. The greatest impact from turbulence from all boats tested was seen just before reaching planing speed, and for wake surf boats, impacts were equal regardless of whether the ballast bag was filled or empty (Keller 2017, Fay et al. 2022, Marr et al. 2022). *Maximum depths in White Lake are in the 8.5-to-9.5-foot range, with half of the lake at or below 6 feet, so lake bottom disturbance and sediment resuspension from boating activity is almost certain.* High-powered bass boats (designed to cover large distances quickly) were not included in the studies mentioned above, but given their increasing presence in White Lake, their impact should be determined.

Researchers note that small lakes are likely to be more sensitive to boat wakes than large lakes, so that much greater operational distances from shore are needed to minimize shoreline disturbance from wakes (e.g., Marr et al. 2022).

An additional factor that can affect nearshore clarity is the presence of seawalls, which are found along half of White Lake's shoreline. These hard surfaces deflect wave energy from boat wakes back to the lake, lengthening the period of disturbance. This can also cause material to remain suspended in the water for extended periods, particularly fine sediment particles.

The numbers of sea walls (151), mooring buoys (445), and piers (298) continues to increase, while the number of boat ramps (14) is quite remarkable for a lake this size, with a total shoreline length of less than five miles. This intensity of use, coupled with the trend towards larger, high-powered boats, far exceeds the carrying capacity of this lake.

Because White Lake's sediments are a storehouse for phosphorus, it is no surprise that sediment resuspension from boating activity can increase phosphorus levels in the water column, where the nutrient can be utilized by phytoplankton. This relationship has been noted by researchers working on other shallow lakes as well (e.g., Keller 2017).

Summary of Observations on Water Quality and Lake Clarity

White Lake is a unique and valuable resource whose quality is being significantly impacted by:

- Unlimited recreational boating that is not suited to a small and shallow lake.

- Lakeshore alterations and dense development, with insufficient safeguards for the lake, such as stormwater controls.

- Increasing amounts of nitrogen entering the lake, particularly from rainfall (which is also seen in the other Bay Lakes).