# Management of Cyanobacteria, pH and Nutrients in White Lake, NC

Diane Lauritsen, Ph.D.
LIMNOSCIENCES/Envirochem Inc.

Linda Ehrlich, Ph.D.
Spirogyra Diversified Environmental Services

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# White Lake: A Recreational Icon in NC

Exceptionally clear water

Low pH (4.5-5 su)

Believed to be “spring-fed”

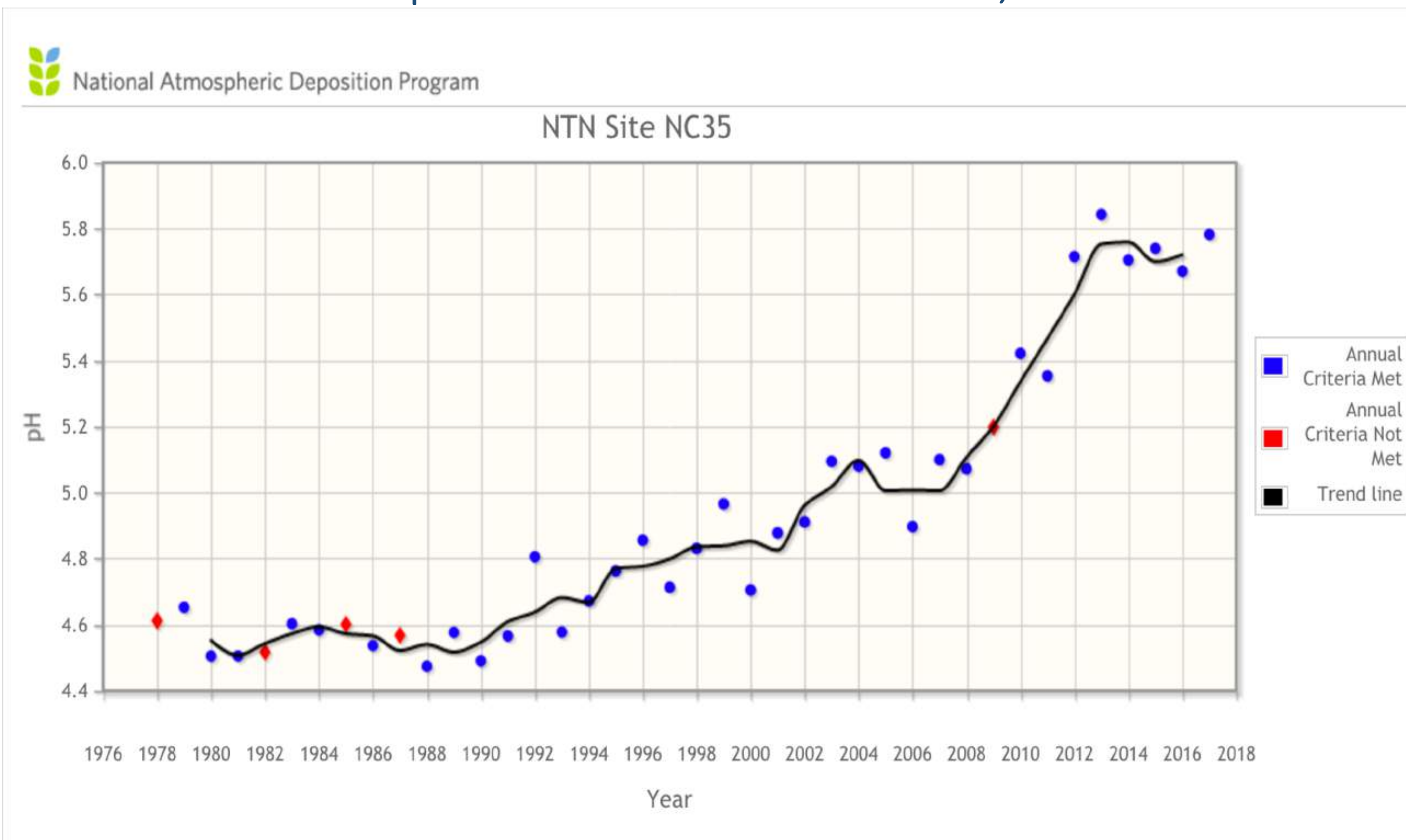
Bay Lake with no surface water inputs

Most of productivity (filamentous algae and submerged aquatic vegetation) associated with lake bottom

# The pH of Source Water Has Changed

## BHIC/UNC-W study: primary source water (> 90% of volume) for White Lake is rainfall, not groundwater

### The pH of rainfall measured at Clinton, NC:



# Increased Productivity, Increased Photosynthesis

In recent years, pH increases of 2 full units over the summer season

Very low alkalinity—little capacity to buffer change due to elevated photosynthesis

Figure from Tucker, C.S. and L.R.D'Abramo. 2008. Managing High pH in Freshwater Ponds.

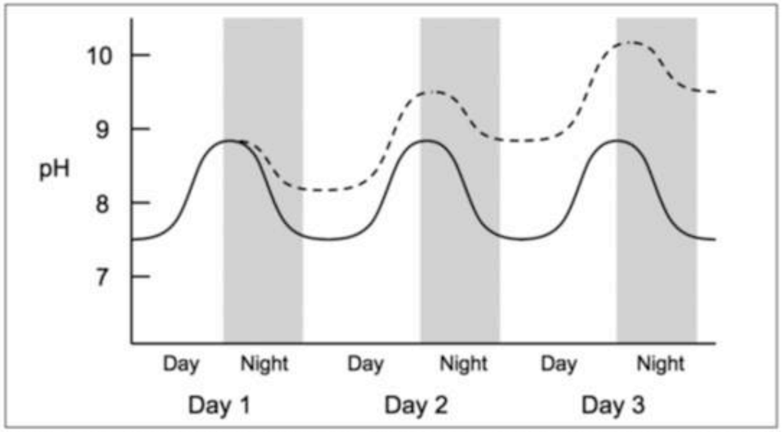



**Figure 1.** Idealized depiction of pH cycling during a 3-day period in two ponds. In both ponds, pH rises during the day as carbon dioxide is removed through photosynthesis and falls at night (shaded vertical bars) as carbon dioxide is added to the water through respiration. The solid line represents pH changes in a pond where carbon dioxide taken up in photosynthesis is offset by carbon dioxide respired at night. The dashed line represents pH changes in a pond where more carbon dioxide is fixed in photosynthesis than is produced at night, and pH values increase from day to day.

# White Lake Shifted to a Turbid State in 2017

Cyanobacterial bloom in late summer, with pH levels near 8

*Planktolyngbya*

Invasive aquatic weed *Hydrilla* also found in much of the lake

# A TAC is Formed, A Brochure is Offered

*"If you are not sure whether a bloom is present, it is best to stay out of the water"*

**Distribute this to a recreational lake community?**

**Conflicting viewpoints:**

**Is any lake treatment really necessary?**

**What about the health of the ecosystem?**

The NC Department of Health and Human Services recommends the following steps to safeguard children and pets from harmful cyanobacterial (bluegreen algal) blooms:

- Keep children and pets away from water that appears discolored or scummy
- If your child appears ill after being in waters containing a bloom, seek medical care immediately
- If your pet appears to stumble, stagger, or collapse after being in a pond, lake or river, seek veterinary care immediately
- Do not handle or touch large accumulations ("scums" or mats) of algae
- Do not water ski or jet ski over algal mats
- Do not use scummy water for cleaning or irrigation
- If you accidentally come into contact with an algal bloom, wash thoroughly
- If you are unsure whether or not a bloom is present, it is best to stay out of the water

For more information on precautions to take around bluegreen algal blooms, visit the DHHS website at:

http://epi.publichealth.nc.gov/oee/algae/protect.html

**For More Information, Contact...**

**Singletary Lake State Park**
6767 NC 53 Hwy East
Kelly, NC 28448
Phone: (910) 669-2928
Website: www.ncparks.gov

**Division of Water Resources Fayetteville Regional Office**
Systel Bldg, Suite 714
225 Green Street
Fayetteville, NC 28301
Phone: (910) 433-3300

**Division of Public Health: Occupational & Environmental Epidemiology**
5505 Six Forks Road
Raleigh, NC 27609
Phone: (919) 707-5900

**NC DWR Algal and Aquatic Plant Assessments**

https://deq.nc.gov/about/divisions/water-resources

[1] DWR 2017 White Lake Water Quality Report

[1] https://files.nc.gov/ncdeq/Water%20Quality/Environmental%20Sciences/ISU/White%20Lake%202017%20WQ%20Report%20Final%20121217.pdf

**Why does White Lake look Green?**

Provided by the North Carolina Division of Parks and Recreation in cooperation with the NC Division of Water Resources

April 2018

# Ecological Impacts of Cyanobacteria Blooms

Lethal and Sub-lethal Impacts to Aquatic Life Include:

High pH

Toxin Production

Low DO with bloom collapse

Figure from Havens, K.E. 2008. Cyanobacterial blooms: effects on aquatic ecosystems

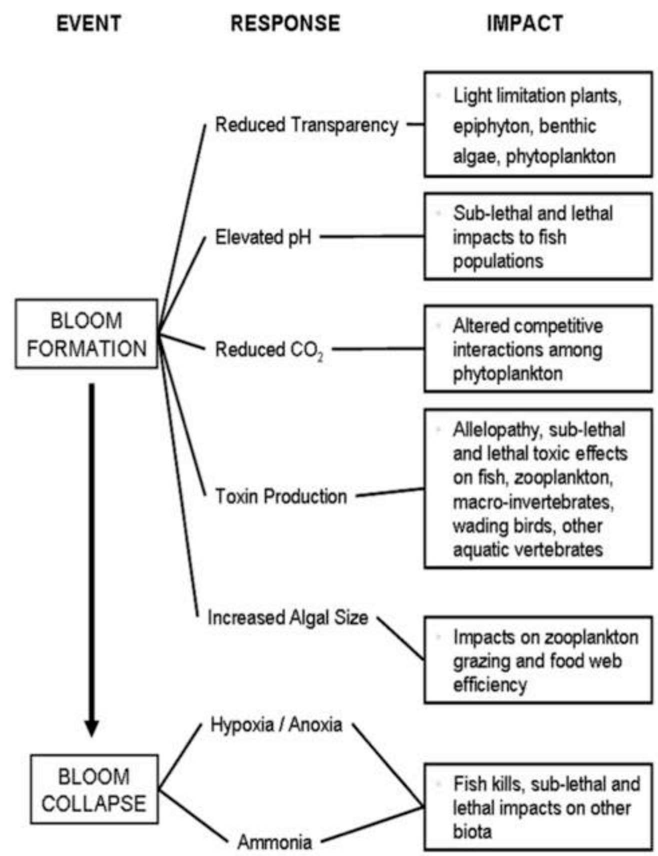


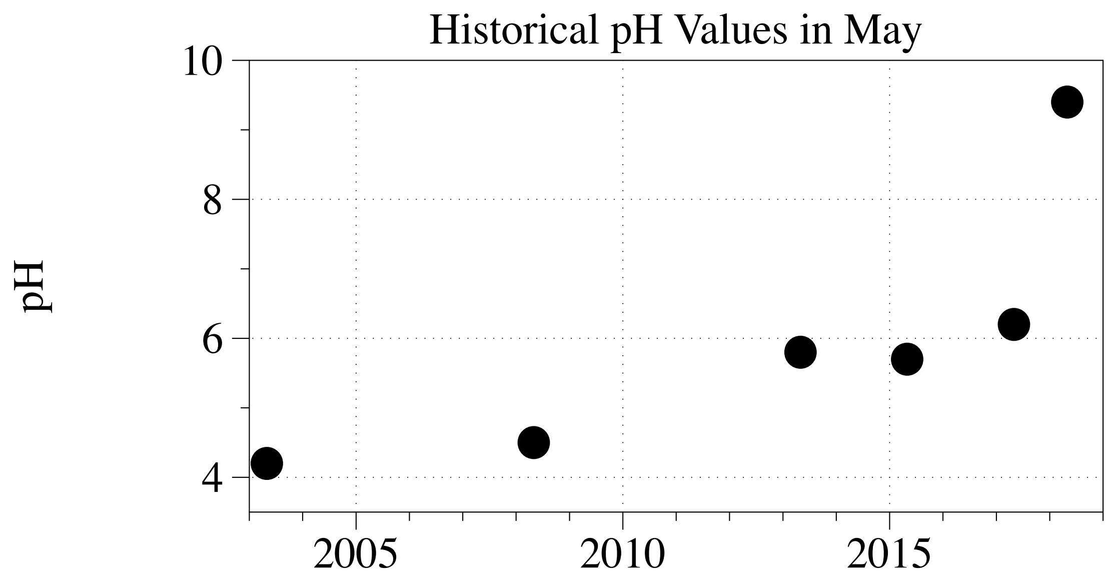

**Fig. 1.** A summary of ecological responses and impacts associated with blooms of cyanobacteria in lakes, rivers, and estuaries.

# White Lake pH Over 9 by Early May 2018

The lake was impaired for both chlorophyll a (mean 52 µg/L) and pH (9.1-9.6 su)

Secchi depth 0.5 m

*How high could the pH have gotten? Another 2-unit rise?*



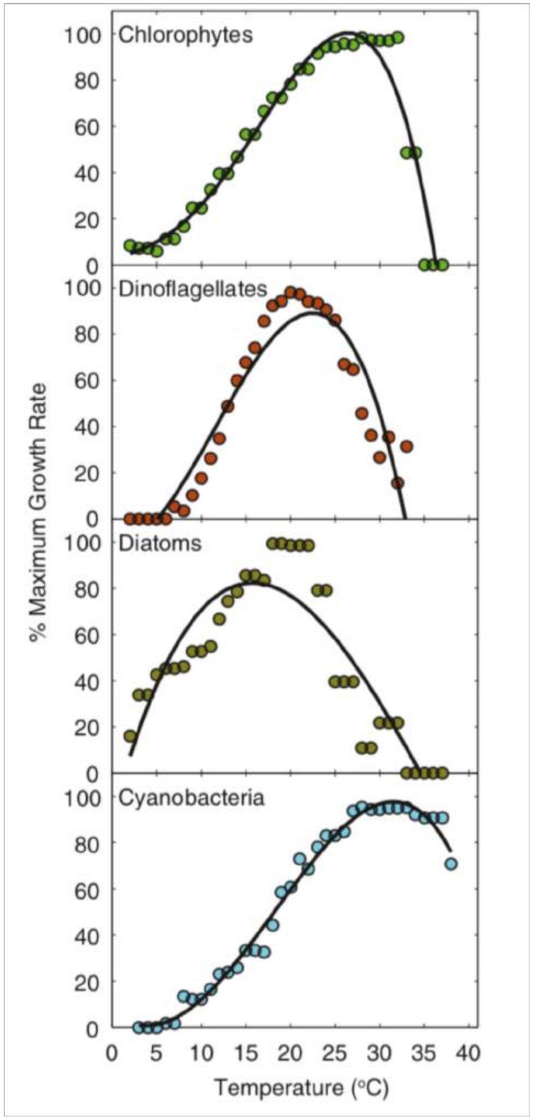
# Cyanobacteria Growth Related to Water Temperature

A Cyanobacterial bloom early in the season could continue as long as nutrients, light are available

Early May water temperature 23° C

At some point would have a bloom crash—low DO/high $CO_2$ would help lower pH

Figure from Paerl and Otten 2013. Harmful cyanobacterial blooms: causes, consequences, and controls.



# Large Fish Kill in White Lake in early May 2018

Dead fish seen in late April, #s increased sharply in early May as pH spiked

No pH refuge—well-mixed water column

Ammonia toxicity increases by 10x for each 1-unit rise in pH and 2x for each 10$^{o}$ C rise in temperature

# Managing P in White Lake—the Alum Treatment

## May 3-16, 2018

A low, water-column stripping dose to remove P and floc algae

Low alkalinity (buffering critical) but high DOC

Filamentous cyanobacteria removed--less photosynthesis, lower pH

70% of P and 45% of N removed from water column

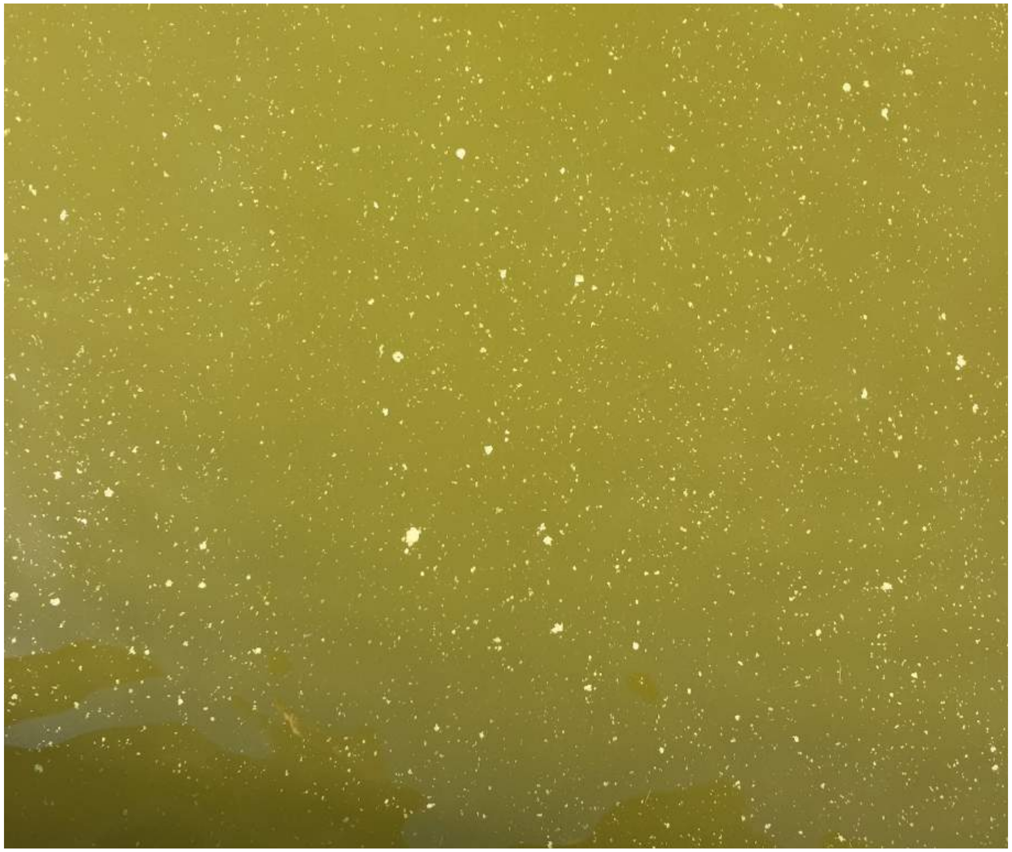


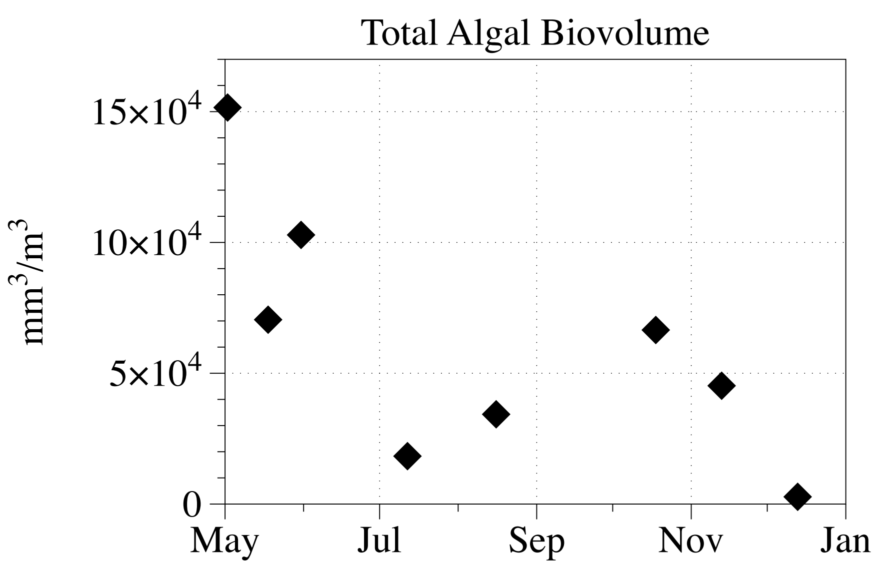
Photo taken from Goldston's Motel pier March 15, 2018

# White Lake Phytoplankton Before (May 2) and After Alum Treatment

## Mean Total Algal Biovolume

**Treatment: May 3-16**

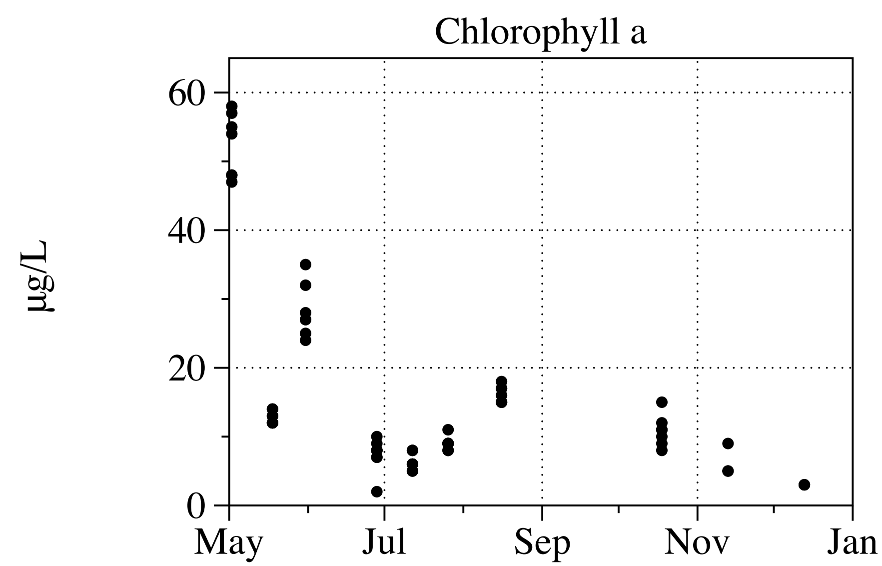
**Hurricane Florence in September: 35" of rain**




## Chlorophyll a Values

**7 Stations May-Oct.**

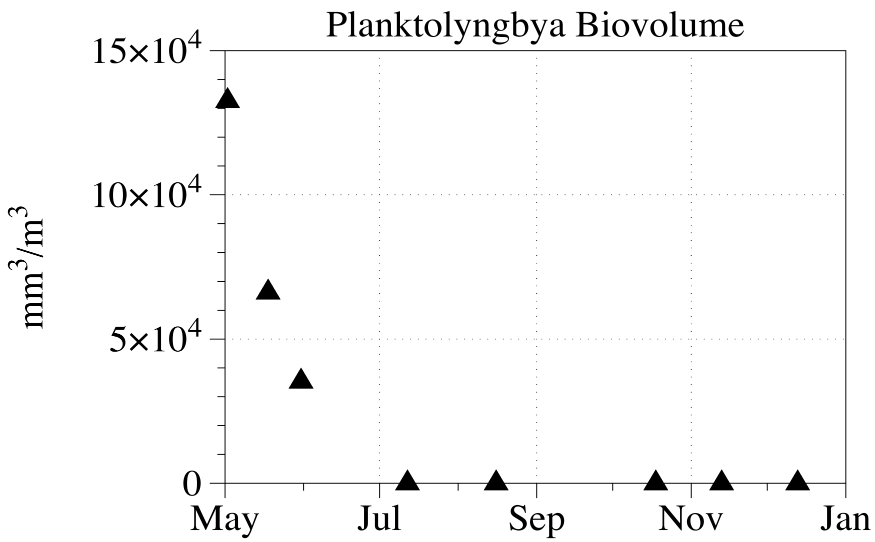
**3 Stations in Nov. and Dec.**



# White Lake Cyanobacterial Biovolume Before and After Alum Treatment

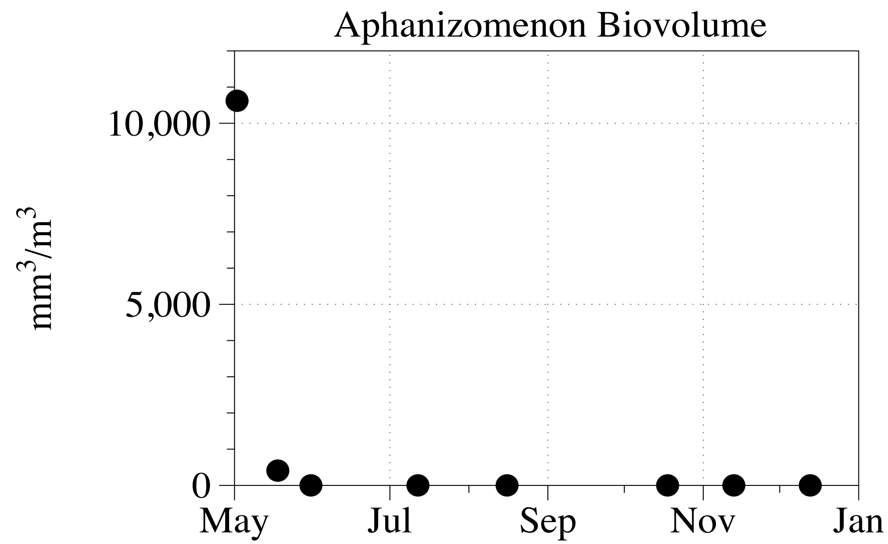
### *Planktolyngbya limnetica*

**87% of Total Biovolume Before Treatment**




### *Aphanizomenon* sp.

**7% of Total Biovolume Before Treatment**



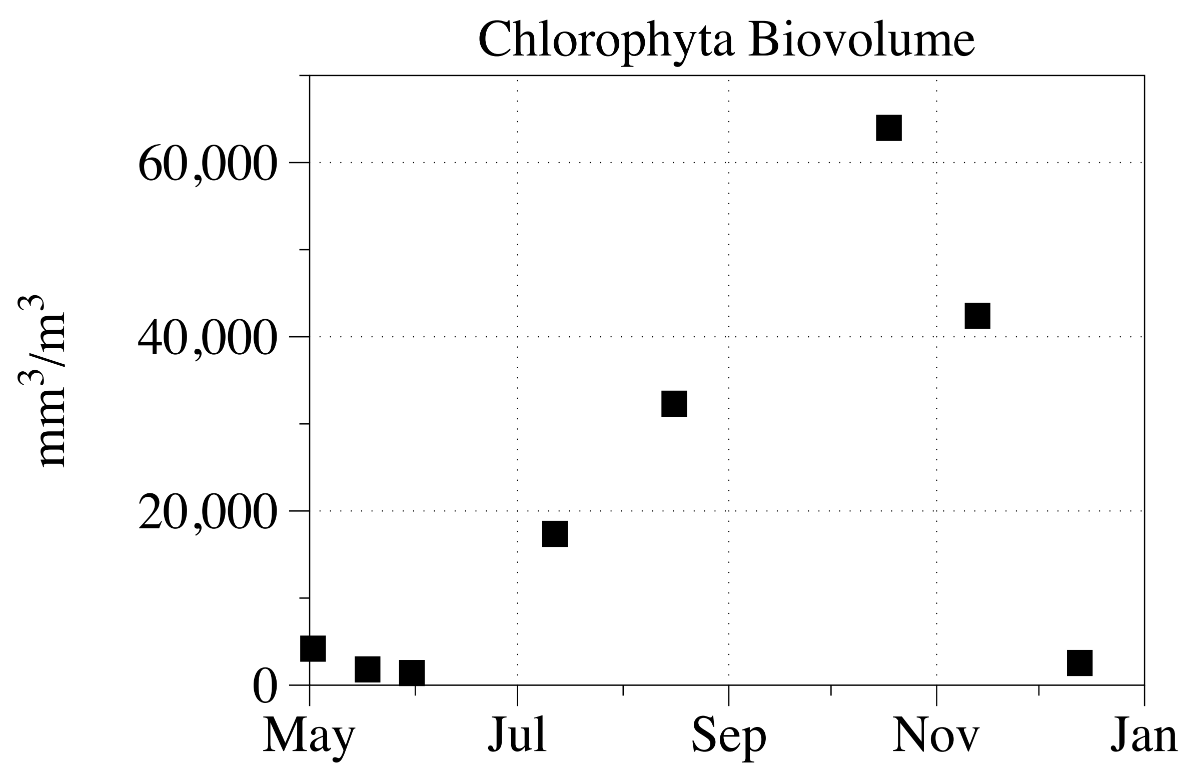
# White Lake Chlorophyta Biovolume Before and After Treatment

Greatest diversity in this group throughout 2018

21 chlorophyte species on May 2

Desmids dominant from July-December

*Staurastrum americanum* dominant species



# White Lake Gradually Shifted Back to a Clear Water State

pH range after treatment: 5.6-7.6

More filamentous algae in early winter (*Microspora*), characteristic of cooler, acidic waters (Dec. pH 6.2-6.7)

Very little *Hydrilla* found in 2018—30% less total vegetation coverage lake-wide compared to 2017

# White Lake—A Recreational Icon, <u>and</u> an Ecosystem at Risk

”New normal” with higher base pH around 5.8

Low alkalinity makes it susceptible to photosynthetic elevations in pH, which can favor cyanobacterial and *Hydrilla* growth

Long-term, frequent monitoring critical—nutrients, phytoplankton, filamentous algae, vegetation—and a science-informed management plan

# What are the Objectives for Managing White Lake?

Meet Water Quality Standards

Maintain Desirable Aesthetic Conditions

Support Lake-Based Recreation and Tourism

Maintain Natural Ecological Functions

**Manage P to prevent Cyanobacterial blooms**

**Control/eradicate *Hydrilla***

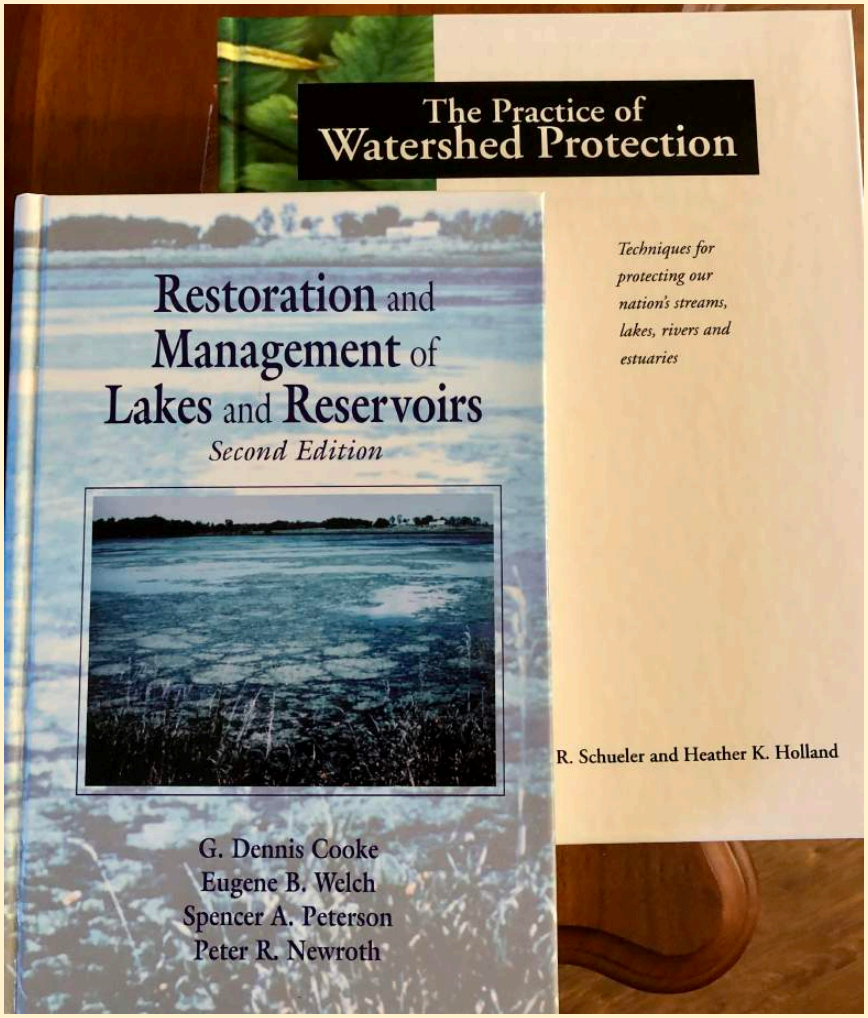
# Managing P is Critical in Shallow Lakes

Sediments important—**Internal P loading** likely significant—muck bottom in deeper portion of lake

- Sediment core sampling and P-flux incubations in lab

**External P loading** via groundwater and surface runoff

- Groundwater monitoring and modeling study—flow rates
- Stormwater assessments—grant funded



# Thank You, David Frey (NC WRC)

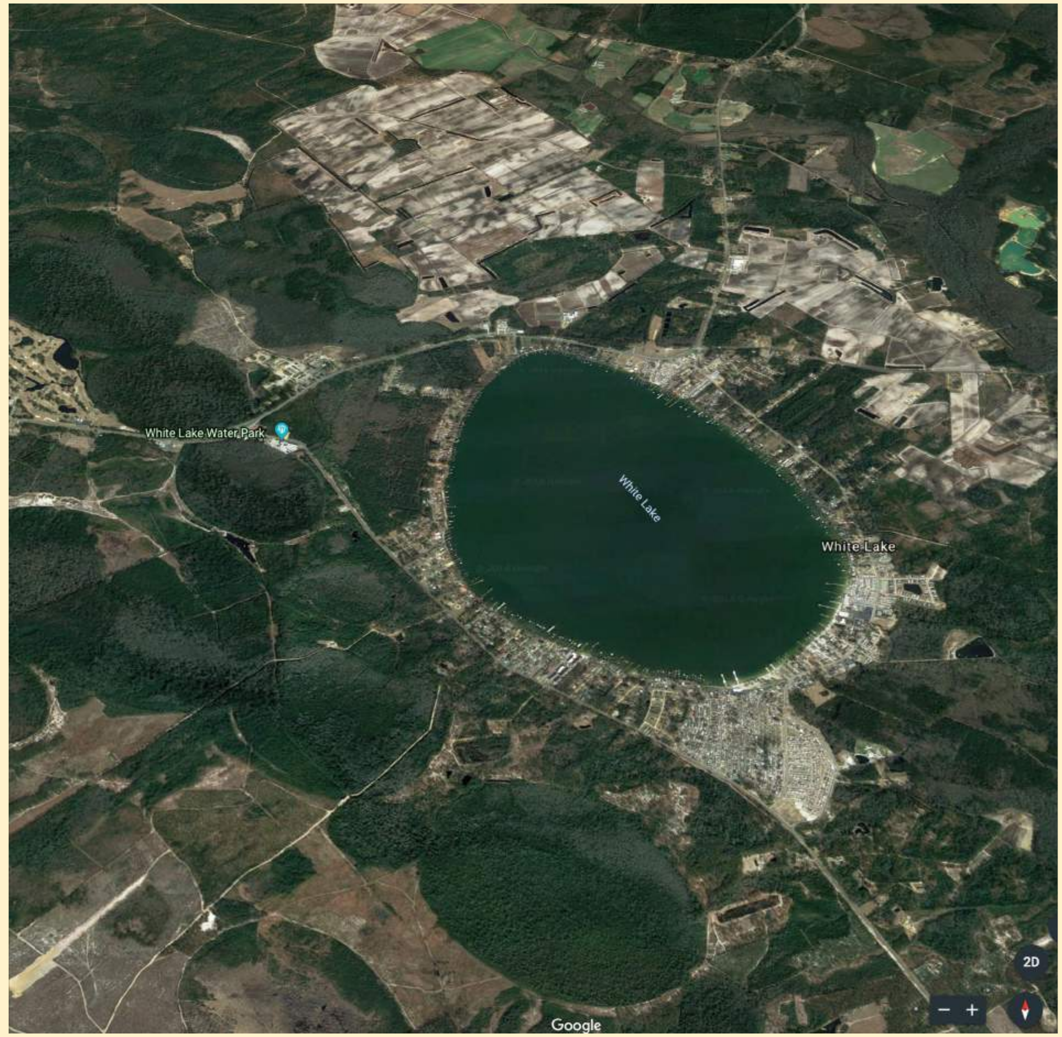
And all of the other NC agency personnel and researchers who have worked on the Bay Lakes—they are fascinating and unique natural systems, worthy of further study and science-based stewardship actions


Diane Lauritsen

ddlauritsen@gmail.com

Linda Ehrlich

spirogyra@juno.com

Sectioning sediment core samples at White Lake, February 2019, to measure P-fractions in 2-5 cm depth increments

Additional cores taken for lab P-flux incubations (under oxic and anoxic conditions)

# Managing Internal P Loading

**Phosphorus Inactivation—several possible methods**

**Changes to use of the lake—**

**Boating restrictions?**

**Wakeboard boats are problematic—stir up sediments**

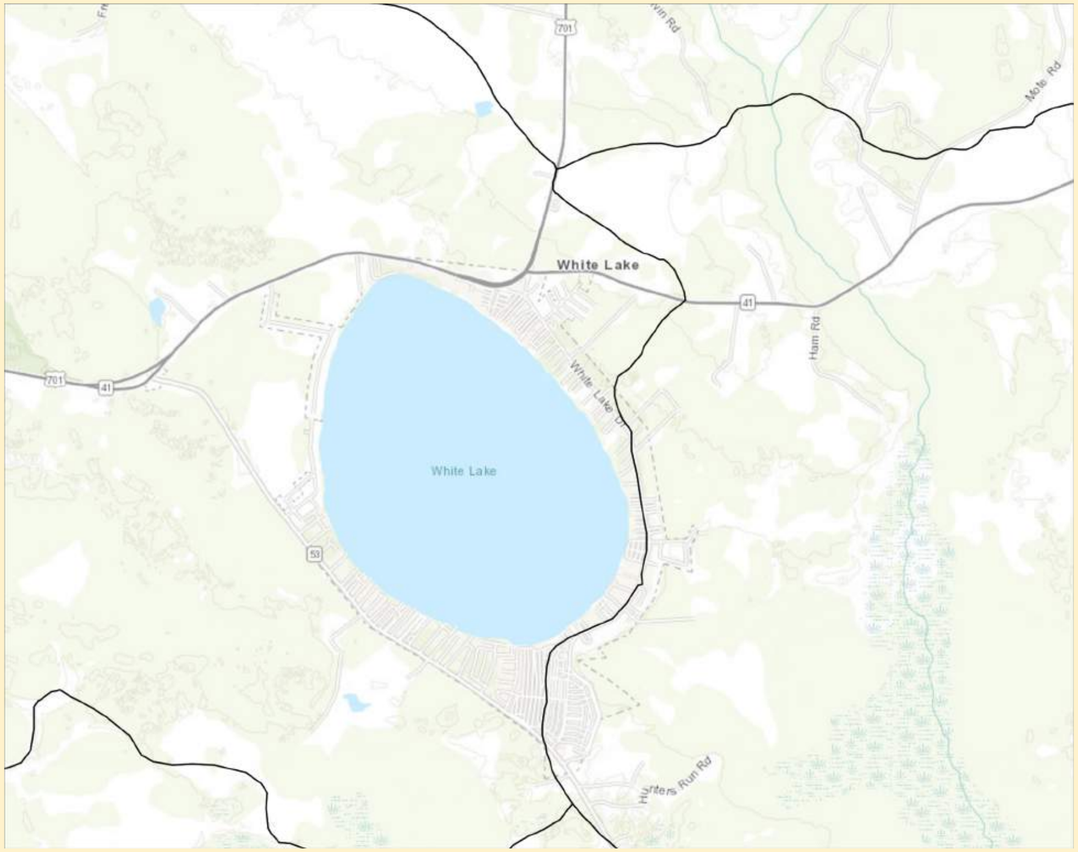
# Groundwater Studies

Shallow GW entering Northeastern portion of the lake

Lake water moving into GW on west side

Rate of GW flow into the lake: External nutrient loading from GW

Report completed April 2019



# Stormwater Assessments

DOT Drainage ditches enter lake—low pH, draining wetland areas, but nutrients in the water

Drainage in general is an issue in many lakeshore areas when the GW level high

Direct drainage to the lake

Assessments to inform best management options