Exploring In-Lake Management Techniques for Cleaner and Healthier Water Quality

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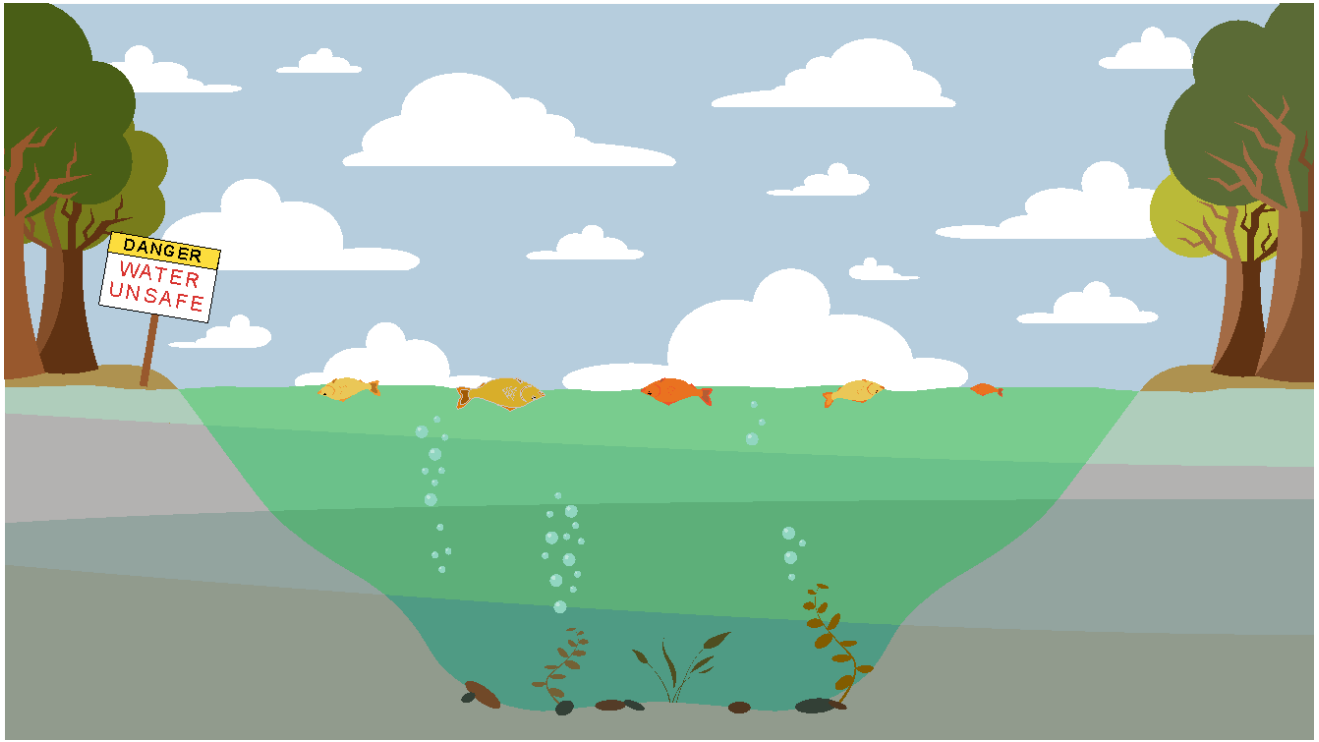
SOLITUDE
LAKE MANAGEMENT

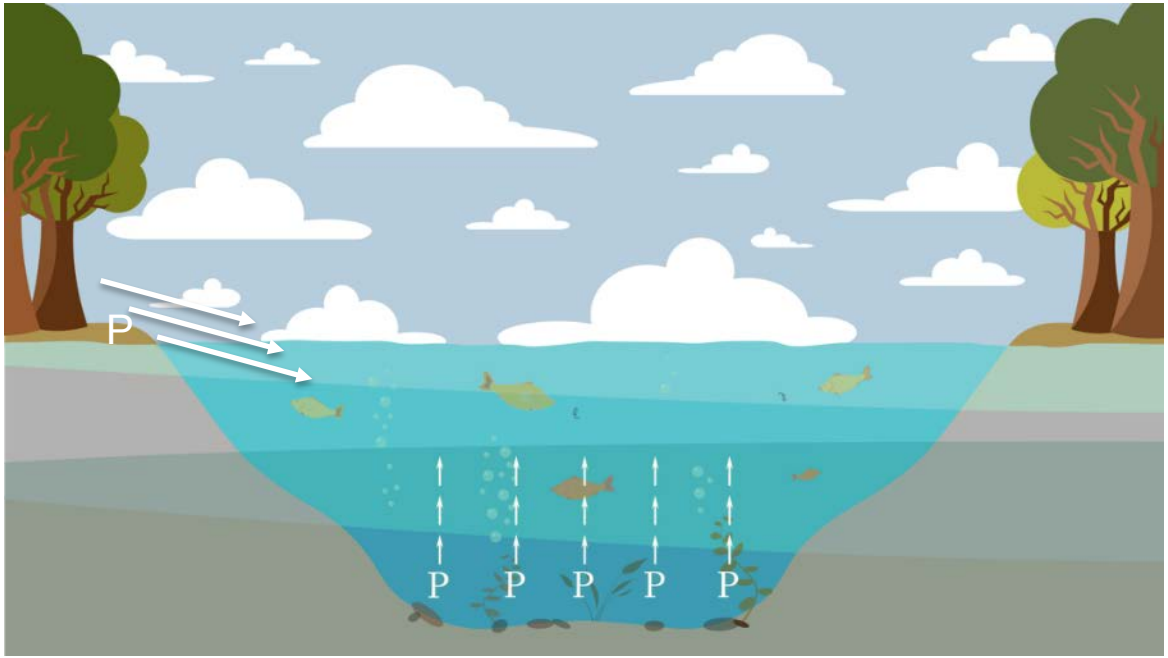
Restoring Balance. Enhancing Beauty.

The Problem: Poor Water Quality



- Poor water quality in lakes has many symptoms and most are associated with *excessive algal growth*

The Cause: Too Much Phosphorus



- High P causes excessive algae & associated water quality issues
- Both external & internal P loads combine to determine water column P
- P budgets can be needed in some cases

The Cause: Too Much Phosphorus

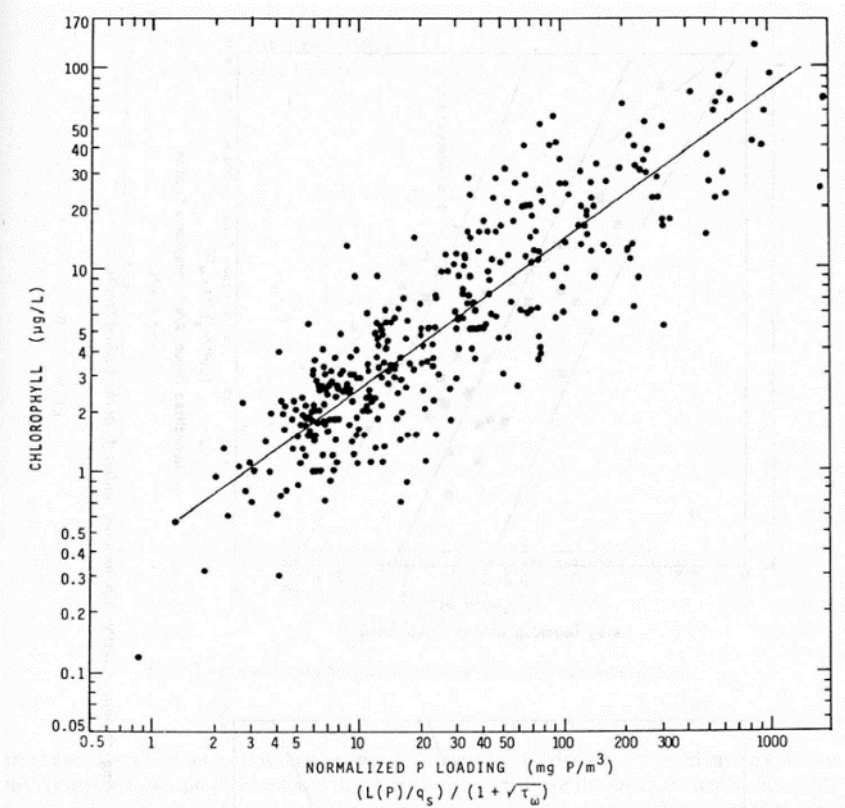
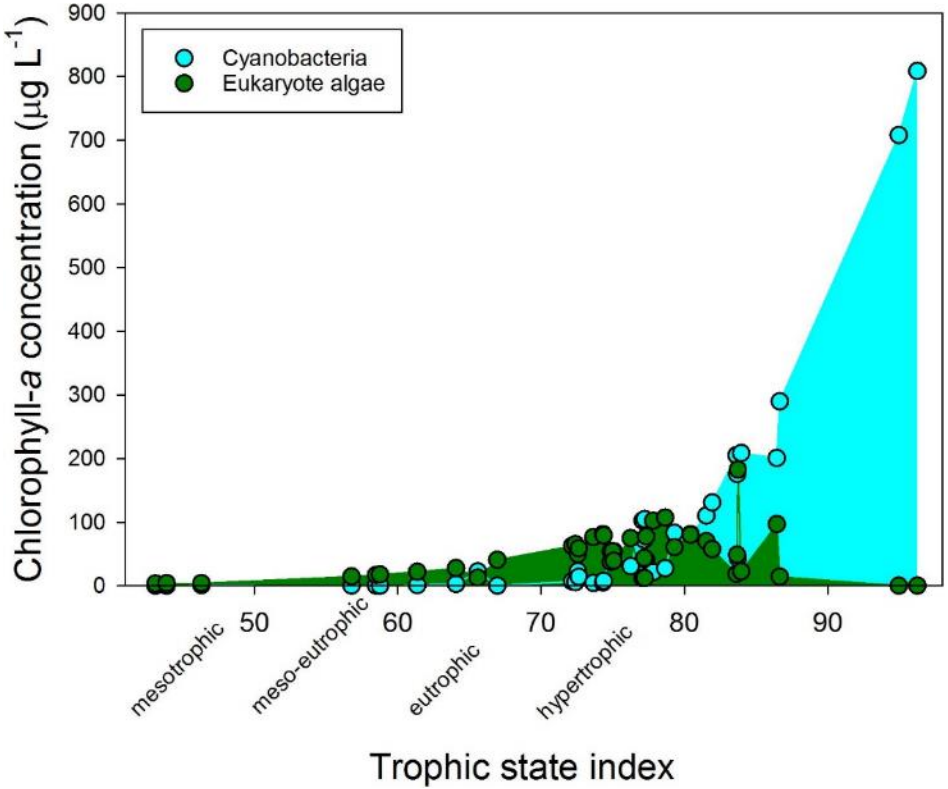


FIG. 1—*Updated Vollenweider-OECD normalized phosphorus loading–chlorophyll response relationship* [7] *for bodies of water throughout the world.*

Vollenweider 1968



Lurling et al. 2018

Common Issues

- Too Much Algae
- Algal Toxins (**HAB's**)
- Low Clarity
- Odors
- Low Oxygen
- Potential Fish Kills
- Recreational Impairment
- Reduced Property Values

What's Being Done?

What is currently being done to control harmful algal blooms in the United States?

Local, state, tribal, and federal agencies and researchers across the United States are involved in efforts to prevent harmful algal blooms and HAB-associated illnesses, including:

- Monitoring for algal blooms and associated toxins in recreational water, drinking water, and fresh and marine water fish or shellfish
- Reducing nutrient loads in water
- Conducting health surveillance for HAB-associated illnesses in humans and animals and harmful algal blooms events
- Collaborating among agencies to better coordinate activities within and across states and nationally
- Providing guidance for safe levels of harmful algal bloom toxins in waters used for drinking and bathing
- Engaging with citizen scientists and other partners to monitor for harmful algal blooms in marine and fresh water

Source: Centers for Disease Control and Prevention (https://www.cdc.gov/habs/general.html)

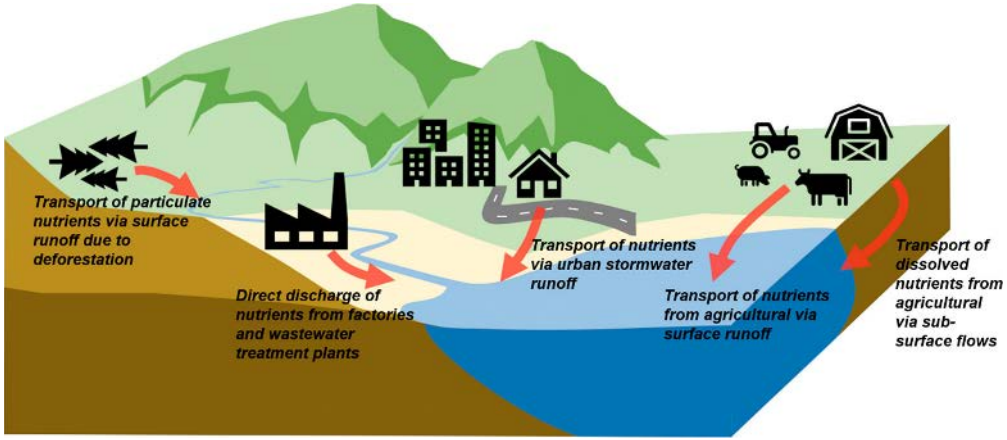
Assessing the Situation

- Every body of water may require different management strategies depending on the use and goals for that waterbody.
- Successful lake and pond management strategies begins with establishing a baseline understanding of the current conditions.
- A proactive approach to lake and pond management involving sustainable solutions to help maintain a natural, healthy aquatic ecosystem is always preferred.

Surface Water Quality Influences

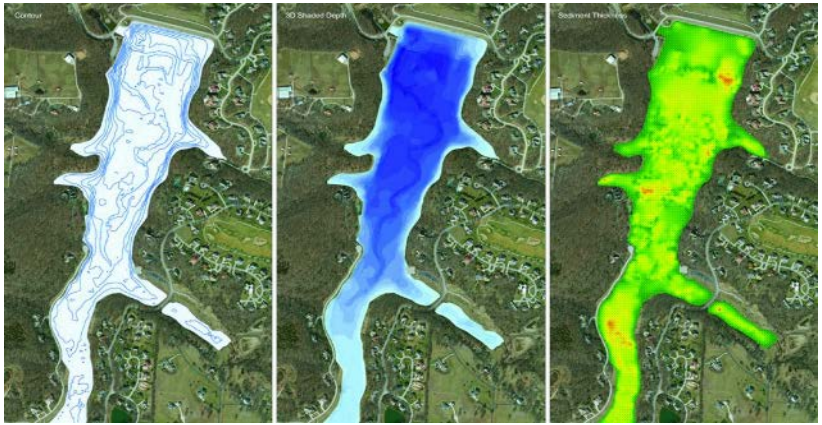
External (Watershed) Influences

- Drainage basin:Lake basin ratio
- Land use



Internal (Lake/Pond) Influences

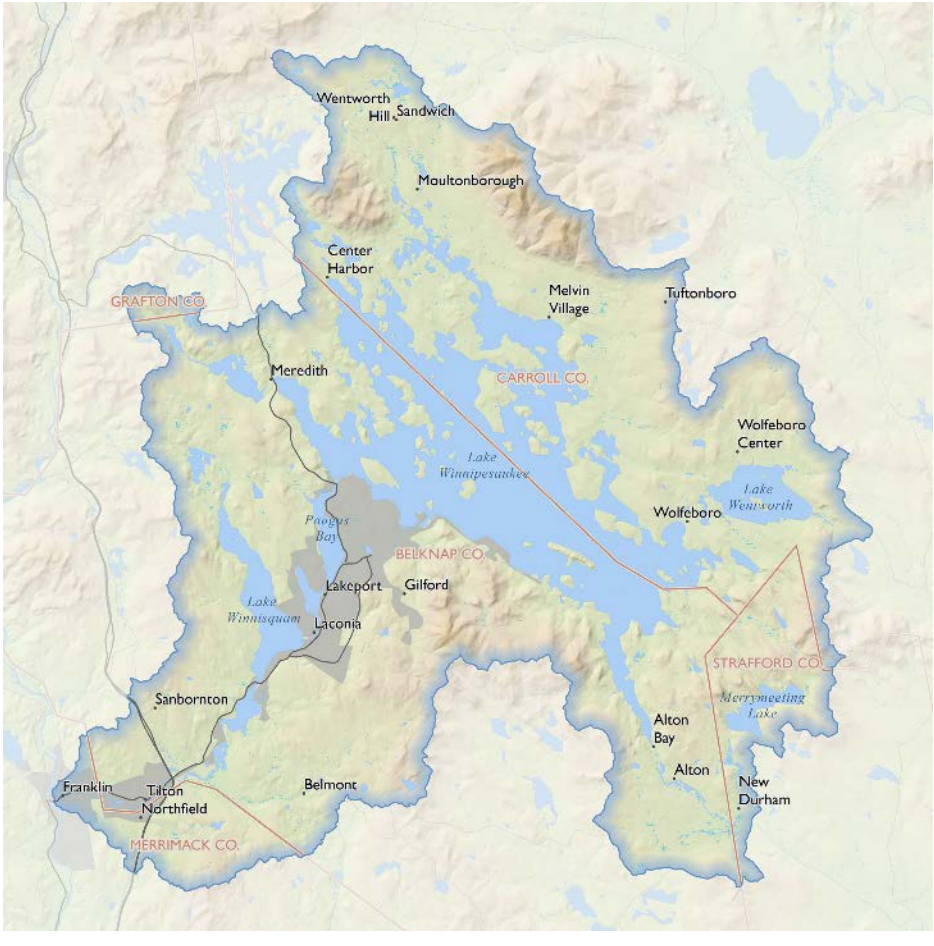
- Ecosystem balance
- Use/Management practices
- Temperature
- Bathymetry
- Oxygen concentrations



Watershed vs. In-Lake Management

Why is Watershed Management Sometimes Not Enough?

- May take many years to make a difference
- Difficult/Expensive to implement
- May not be feasible to lower nutrient concentrations below critical threshold
- Contributions of internal recycling



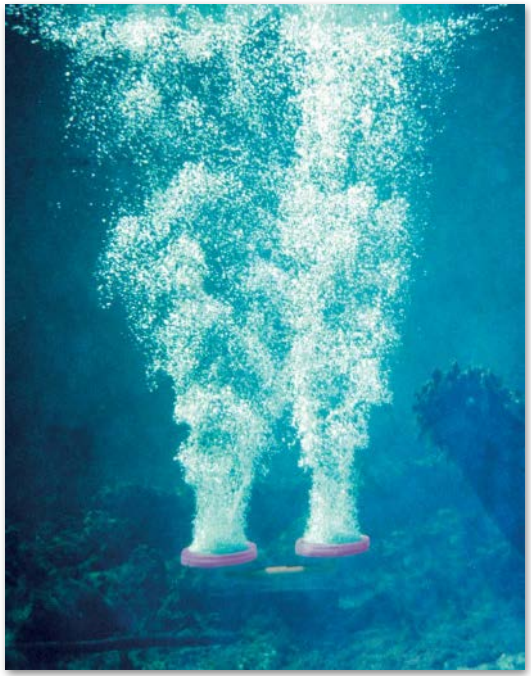
Watershed Management Strategies

- Follow Best Management Practices (BMP's)
- Maintain Vegetated Buffers
- Erosion Control: Bioengineered Living Shorelines
- Retention Basins and Filtration

NO DUMPING
DRAINS TO WATERWAYS

In-Lake Management Strategies

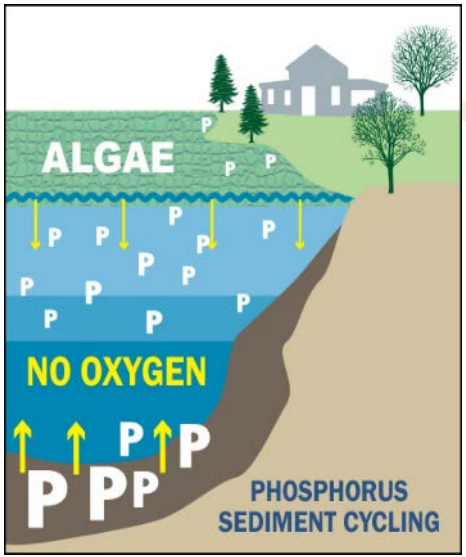
- Dredging
- Biological Augmentation
- Beneficial Aquatic Plants
- Algaecide Applications
- **Circulation and Aeration**
- **Nutrient Remediation**

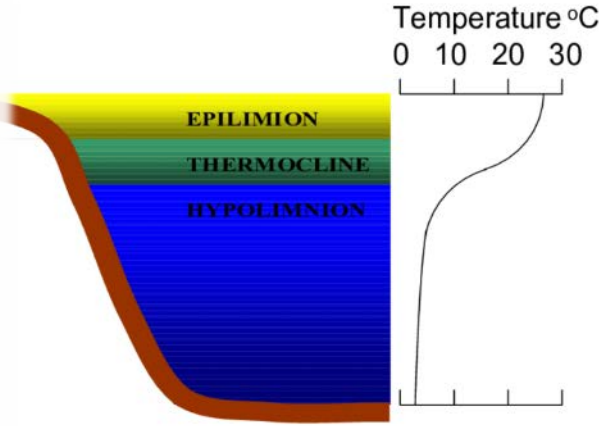


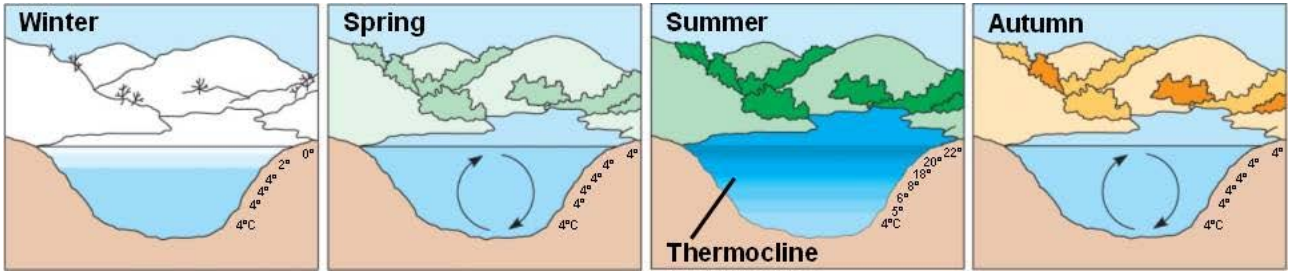
Preventing Phosphorus Release

Phosphorus is typically the limiting nutrient for plant & algae growth in freshwater systems

- Phosphorus can be bound in the sediment in many forms, but iron-bound is a significant fraction of of total sediment phosphorus
- Under anoxic conditions Phosphorus is released from iron into solution with the overlying water
- Maintain >2.0 mg/l of oxygen







OXYGENATION vs CIRCULATION

Circulation:

- ➔ Improve the distribution of oxygen throughout the water column
- ➔ Increase oxygen by increasing atmospheric exchange
- ➔ Disrupt thermal stratification

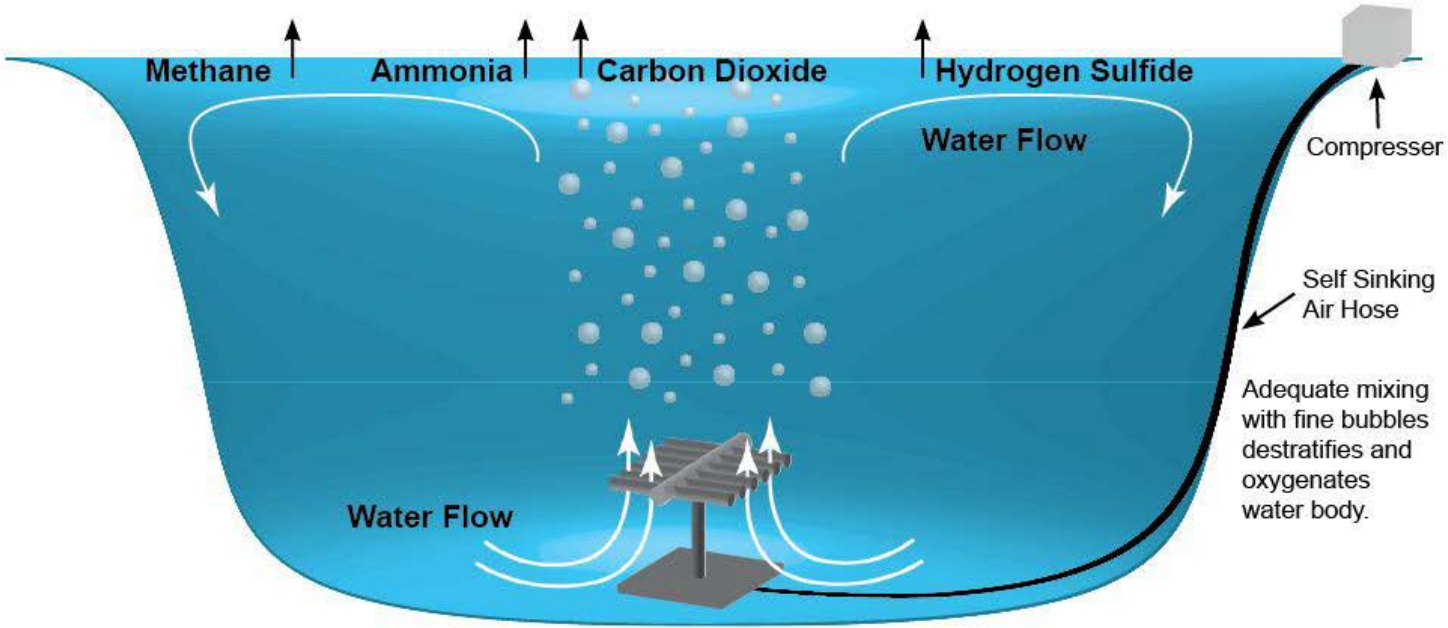
Oxygenation:

- ➔ Add oxygen through injection of gas (air and/or pure oxygen)
- ➔ Preserve thermal stratification

Submersed Aeration

This style of aeration more effectively oxygenates the water and decreases stratification without disturbing the natural look of the lake or pond.

Submersed Aeration



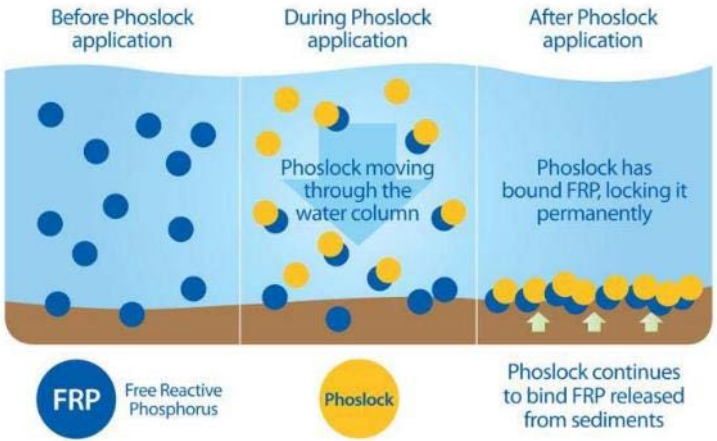
Nanobubble & Oxygen Saturation Technology

These are new, cutting-edge gas transfer mechanisms designed to help improve water quality. Benefits could include:

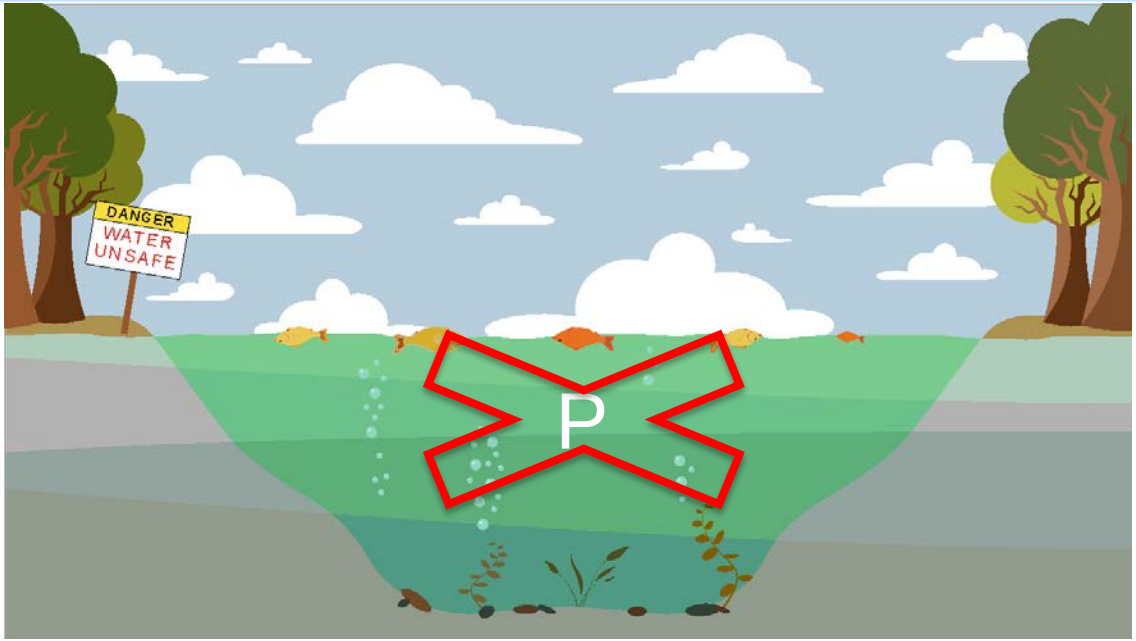
- Saturating water with significantly more oxygen than submersed aeration systems
- Creating reactive oxygen species
- Helps promote beneficial bacteria
- Can reduce nutrients responsible for fueling nuisance algae
- Can reduce bottom muck and sludge
- Helps control cyanotoxins

Nutrient (Phosphorus) Remediation

- Aluminum sulfate (Alum), Phoslock (lanthanum modified bentonite) and rare earth minerals can be applied to bind excess phosphorus in lakes and ponds.
- Applications can help lower phosphorus levels in order to make the lake or pond system less hospitable to abundant algae growth.

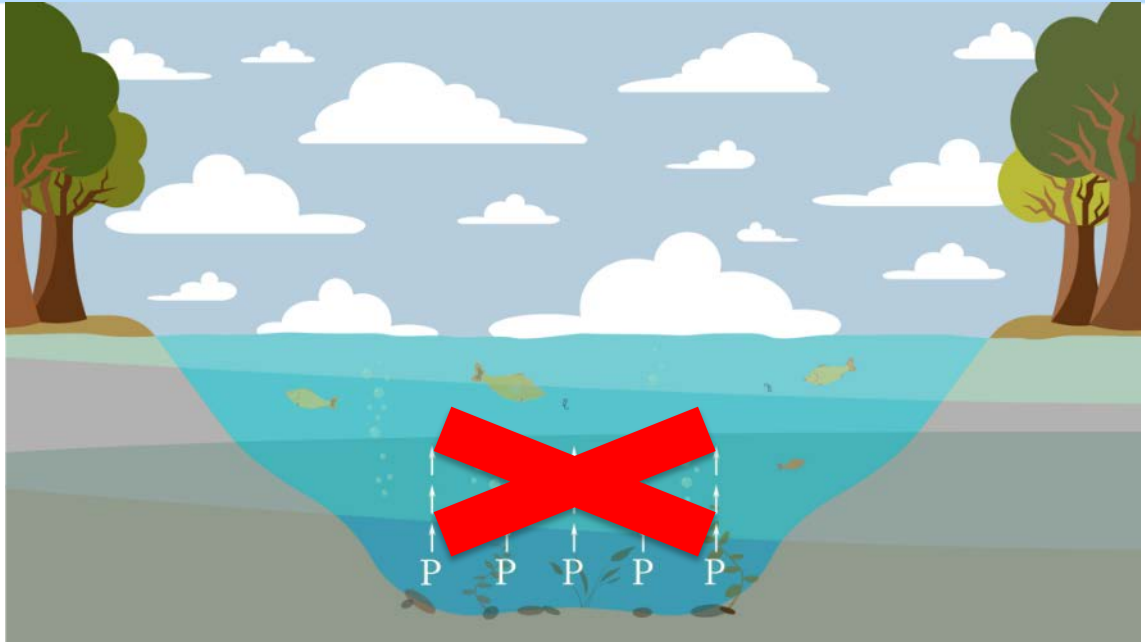


Water Column Stripping



- Goal is to bind & remove P in the water column
- Results in less P for algal growth & less algae in the water
- Lower doses, repeat applications, less sophisticated application & equipment, lower costs

Sediment Inactivation



- Goal is to bind P in sediments & prevent it from leaching into water column
- Results internal P loading & less P in water for algae to use
- Higer doses, sophisticated application methods & equipment, higher costs

Water Quality Restoration with Phoslock

Immediate Impact:

- Rapid Phosphorus (P) Binding
- As Phoslock moves through the water column, it absorbs P in different depths in the water column

Short-term Impact:

- Reduction in P
- As P becomes the limiting nutrient, the N:P ratio increases
- Resulting in more balanced water quality conditions

Longer-Term Impact:

- Phoslock remains active at the bottom of a waterbody
- Adsorbs P released from sediments
- Adsorbs P from new inflow water as it settles to bottom

Alum Application

- Liquid alum applied with specialized equipment & application technology
- Holistic approach: complements external P loading reduction efforts in the watershed

Alum Application

- Alum mixes with lakewater to form a precipitate (floc)
- Floc binds P in the water (water column stripping) & settles out with unfilled binding sites to incept future P release (sediment inactivation)

Alum Application

- Alum-bound P is very stable (will not dissolve & release bound P); not sensitive to low oxygen
- pH management is important with alum use (may need a pH buffer at high doses (sodium aluminiate)

Alum Floc

Alum Floc

Alum Floc

Application/Equipment - Large Lakes & Doses

History of Alum Use & Safety

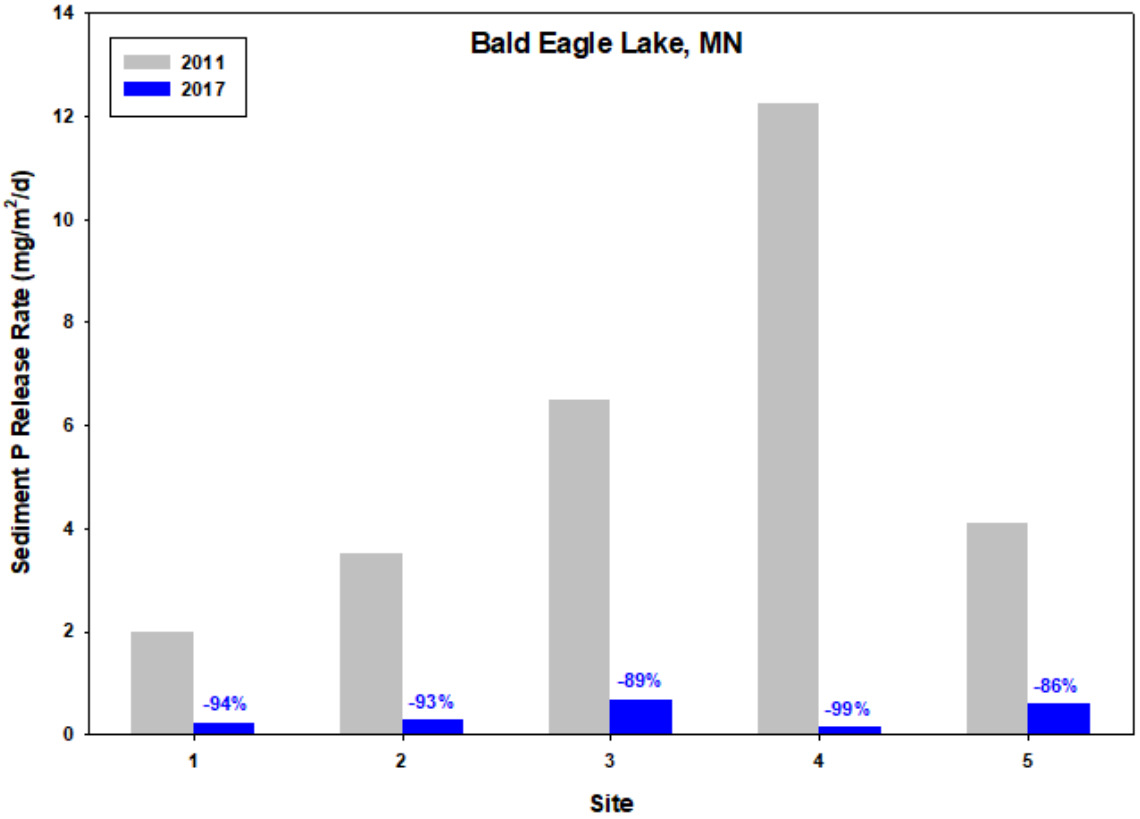
- Used for more than 200 years for drinking water clarification & its use is essential in wastewater & drinking water today
- Common food additive & used to make Maalox
- Alum chemistry is well-understood & predictable
- Extremely cost effective
- 100's of studies documenting its safe use (60 yr history of use)
- Endorsed by North American Lake Management Society
- Not toxic - doesn't kill algae directly & doesn't harm plants and fish
- Fisheries improvements are common after alum due to increased clarity & habitat

Benefits - Immediate Clarification

First Day of Application (Day 1)

Last Day of Application (Day 13)

Benefits - Reduced Sediment P Release



W. James, UW-Stout, unpublished data

Benefits - Reduced P & Algae

October 2017

May 22, 2018

↓ **P** (~70-90%)

↓ **Algae** (~70-90%)

White Lake, NC

Benefits - Reduced Toxins; Increased Clarity

July 2019

July 2020

Clarity

Toxins

Upper Prior Lake, MN

Benefits - Improved Fishery

Benefits

- ⬆ Clarity
- ⬆ Oxygen
- ⬆ Habitat

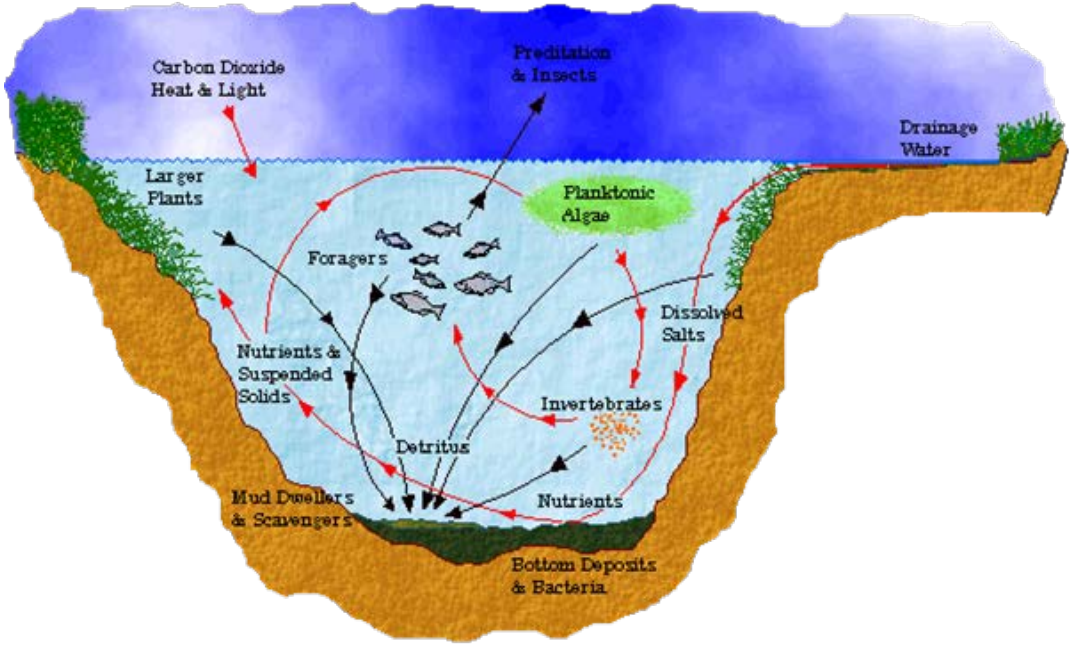
Innovations / Future Alternatives

Aiding Oxidative Processes

- ➔ Low intensity electromagnetic fields (EMFs) to increase dissolved oxygen
- ➔ Photocatalysts & polymers to create reactive oxygen species that increase natural biological reactions

Oxygen is consumed by all forms of aquatic life to facilitate cellular metabolism - conversion of food to energy

- ➔ Maintaining sufficient oxygen enables natural processes to enhance water quality
- ➔ Breakdown/decay of organic material



Questions & Discussion