Phoslock: An Effective phosphorus locking technology

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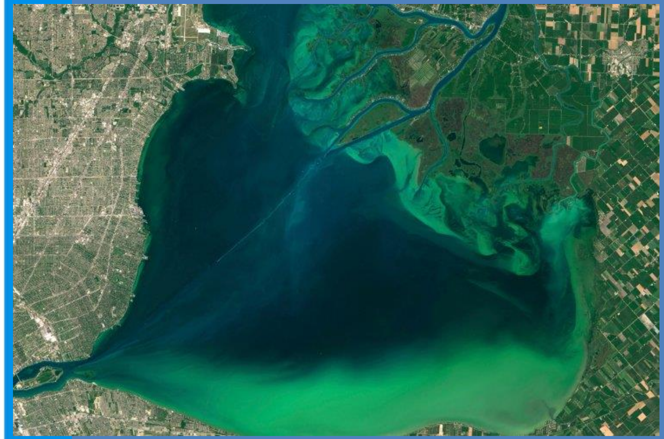
Take home

- 1 lb of P can support 500 lb algae
- 1 lb P = 92ppb in a 1 acre pond (~hypereutrophic)
- 100lb Phoslock can bind 1 lb P

- 2-4 bags/A = better management

A Dreaded Forecast for Our Times: Algae, and Lots of It

By MATT RICHTEL JULY 18, 2016



The docks behind homes at Discovery Bay are quieter than usual due to fears of blue green algae toxins. *(Lesley McClurg/KQED)*

Here's What's Causing the Toxic Algae Blooms Infesting Florida's Coastlines and Waterways

By AVIANNE TAN · Jul 5, 2016, 6:38 PM ET

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he Palm Beach Post via AP

Huge toxic algae bloom sickens more than 100 in Utah amid heatwave

Bacteria has spread rapidly to cover almost all of Utah Lake, turning the water bright green with a pea soup texture and leaving scummy foam along the shore

Utah poison control has fielded hundreds of calls related to the bloom, including 130 involving people who

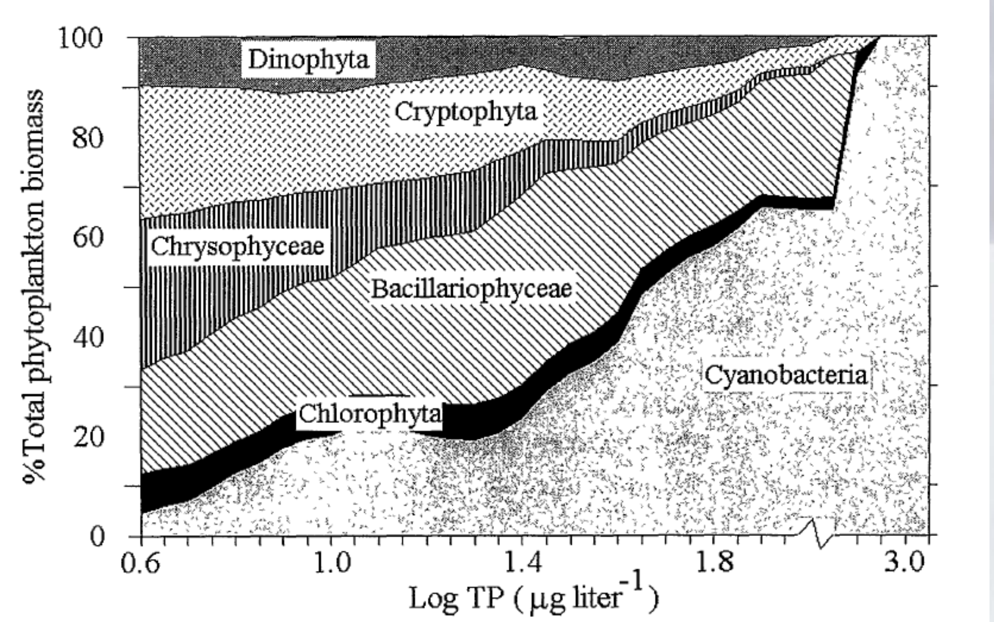
Nutrient sources

- Difficult to remove all nutrients with BMP's
  - If all retrofits conducted, New Hope Creek watershed show 6% decrease of P
    - Debusk et al. 2010

	Mass of Pollutant Removed (kg)		
	TSS	TN	TP
Bioretention	5,825.5	38.9	7.2
Green Roof	167.7	6.7	0.9
Permeable Pavemen	1,077.0	43.1	6.0
Sand Filter	29.5	0.6	0.1
Vegetated Swale	201.2	1.3	0.5
Wetland	3,008.5	26.3	4.8
Total (kg) removed	10,309	117	19

- If external curtailed, still may be decades to see results
  - Jarvie et al. 2013; Jeppesen et al. 2005
- Continued inputs
  - Soil accumulations (Reddy et al. 2011)
  - Groundwater (Martin et al. 2007; Lapointe et al. 2015)
  - Wildlife (Nürnberg and LaZerte 2016)
  - Atmospheric deposition (Wetzel 2001; Paerl et al. 2016)

Why phosphorus?



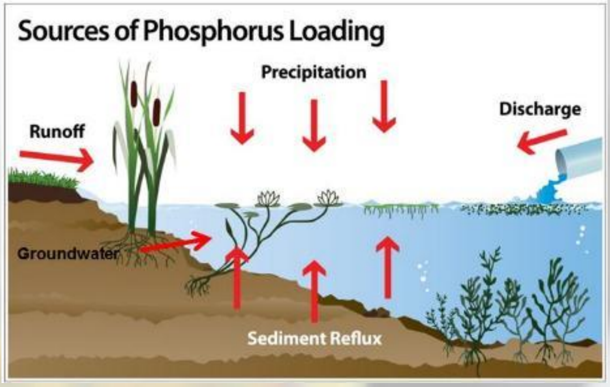
Carpenter, S.R. 2008. **Phosphorus control is critical to mitigating eutrophication.** Proc. Natl. Acad. Sci. USA 105:11039–11040.

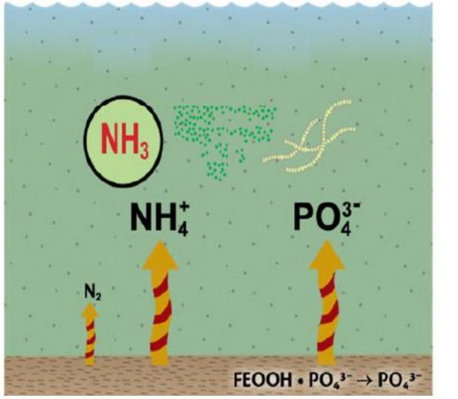
Schindler, D.W., Hecky, R. E., Findlay, D. L., Stainton, M. P., Parker, B. R., Paterson, M., Beaty, K. G., Lyng, M. & Kasian, S. E. M. 2008 **Eutrophication of lakes cannot be controlled by reducing nitrogen input: results of a 37 year whole ecosystem experiment**. Proc. Natl Acad. Sci. USA 105, 11 254–11 258.

Watson SB, McCauley E, Downing JA 1997. Patterns in phytoplankton taxonomic composition across temperate lakes of different nutrient status. *Limnology and Oceanography* 42: 487–495.

Internal phosphorus critical

- Sediment nutrient pump (Glibert et al. 2011)
- Increases in water column P measured in Okeechobeee and worse *Microcystis* blooms from internal (Bachmann et al. 2003)
- Temperature, pH, bioturbation, anoxia can cycle (Orihel et al. 2015)

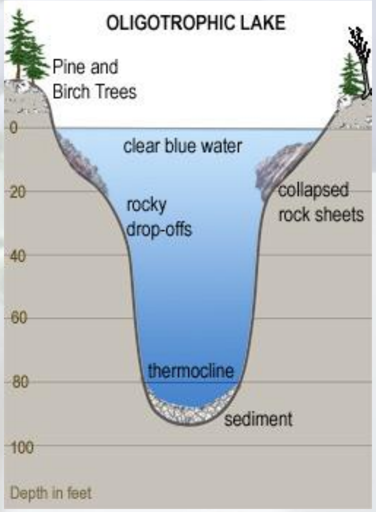




"P PUMP" – much of the stored P is released from bottom sediments;

Access to internal stores

- Limiting external supply may promote algae that can access internal stores (often sediments)
  - Chronic cyano blooms in oligotrophic systems
    - Carey et al. 2008
  - Internal accumulation is a large source
    - Paerl and Paul 2012
  - Migrate to <u>sediments</u> to acquire phosphorus
    - Perakis et al. 1996; Barbiero and Welch 1992
  - Store phosphorus
    - Ganf and Oliver 1982; Kromkamp et al 1989
  - Rapidly uptake
    - Jacobson and Halman 1982



Nutrient ratios important

- TN:TP ratio 5:1 cyanobacteria overwhelmingly dominant artificially induced (Ghadouani et al. 2003)
- Low TN:TP cyanobacteria dominate in Lake Michigan (Seale et al. 1987)
- TN:TP ratio 29:1, dominated by green algae (Smith 1983; 12 lakes throughout the world)
- Si:P < 25:1 *Microcystis* dominates, more silica more *Asterionella* (Holm & Armstrong 1981)

- **Harris et al. (2014)**
  - **Remove P and amend N to alter N:P ratio and decrease cyanobacteria abundance**

- **How can the N:P ratio be altered?**
  - **Remove P; add N or both**

N:P manipulation

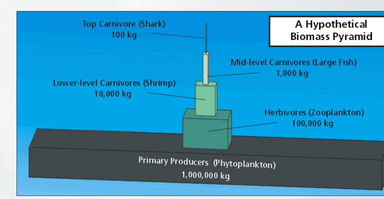
Add N

- Beutel et al. 2016
  - Add source of oxygen
  - Decrease methylmercury
  - Increase N:P

- Gobler et al. 2016
  - Spur non-diazotrophic cyanobacteria growth
  - Increase toxin production
  - Non-sustainable
  - *Pseudanabaena, Cylindrospermopsis, Planktothrix, Microcystis*

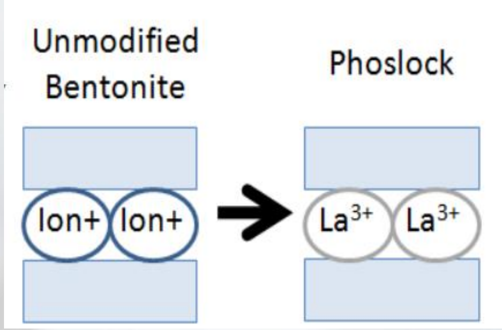
Remove P (specifically)

- Threshold level important for cyanobacteria
  - Downing et al. 2001
  - Watson et al 1997
  - Trimbee and Prepas 1987
- Increase N:P ratio
- Better assemblages, and food web interaction

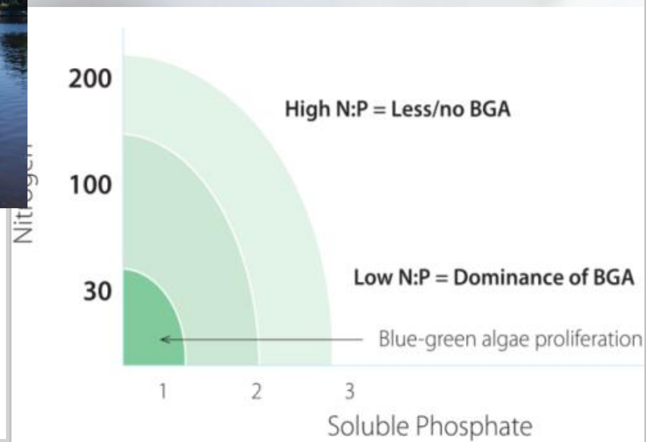


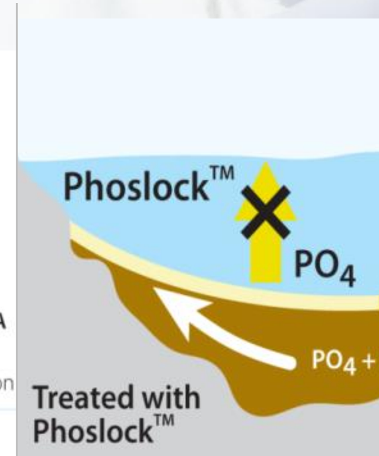
Phoslock

- Lanthanum embedded in bentonite clay layers
- Specific P binding; not other elements (e.g. silica; nitrogen)
  - Does not alter pH; nor add SO_4, no buffer needed
    - Holm & Armstrong 1981
- Increases sediment stability
    - Egemose et al. 2010
- Inhibits the passivity of P
  - Limits phosphorus release
    - Wei and Shao-yong 2015
- Bind water column and shift sediment forms
  - Hydrated mineral Rhabdophane ($LaPO_4 \cdot H2O$) => monazite
    - Jonasson et al. 1988; Cetiner et al. 2005; Dithmer et al. 2015



Water Quality Restoration with Phoslock





1) Immediate Impact

- Rapid P binding
- As Phoslock moves through the water column it adsorbs P at different depths in the water body

2) Short- term Impact

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

3) Longer- term Impact

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

Water and Sediment analyses

- Sampling
  - Top 5 cm of sediment (Eckman Dredge/ coring device)
    - Fractioning (Psenner 1988; Meis et al. 2012)
- 0.2m from surface water grab sample
  - N=3 from homogenized grab samples; 4C
  - Other algae if noted
- Water chemistries
  - ISO accredited laboratory

  Standard Methods (APHA 2005)
- Statistics
  - Compare parameters
    - pre/post
      - Monthly water quality/ algae characterization; every two months sediment fraction analysis (quarterly year two)
      - Paired t-test/ Wilcoxon Rank-Sum ($\alpha = 0.05$)

Sequential Extraction

Labile	Loosely Adsorbed
Reductant-Soluble	Fe/Mn Hydroxides
Metal-Oxide	Al/Fe Bound
Organic	Some Organics
Apatite/ Residual	Minerals

Chockyotte (CH) Irrigation Pond

Location

Weldon, NC

Size

0.95 acres (0.38ha)

Perimeter

805.6 feet (245.55m)

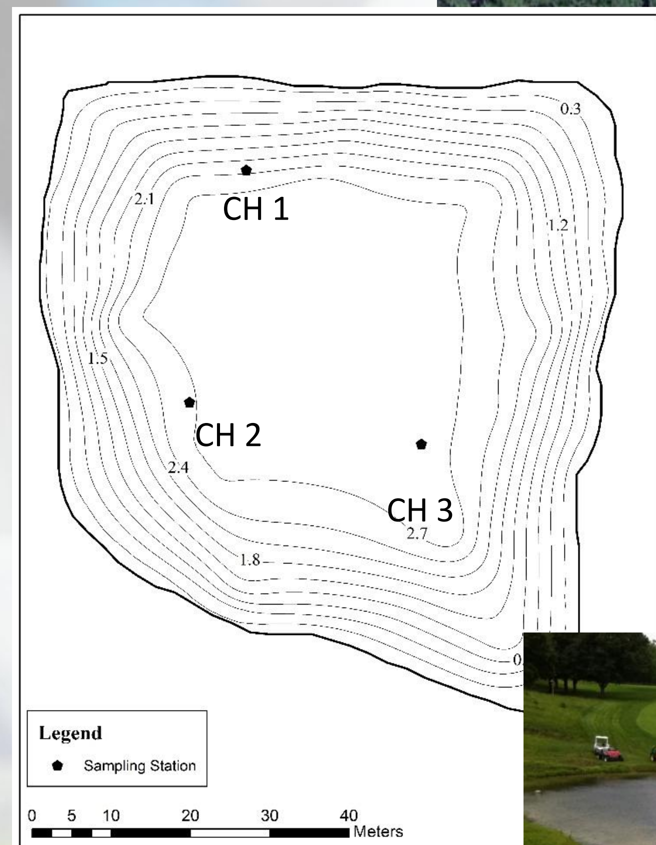
Average depth

6.13 feet (1.87m)

Volume

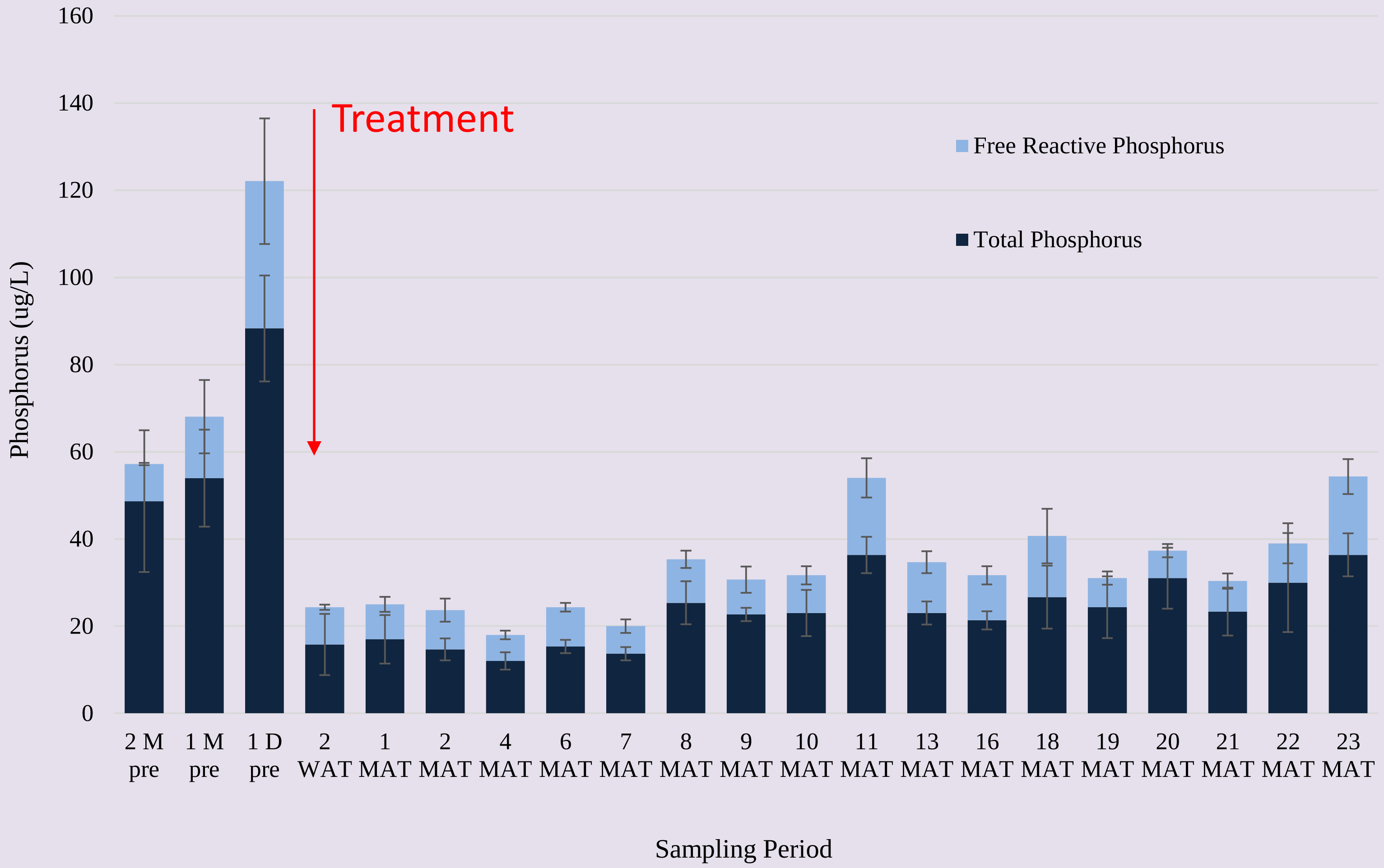
5.82 Acre-feet

(7,178.9 m^3)

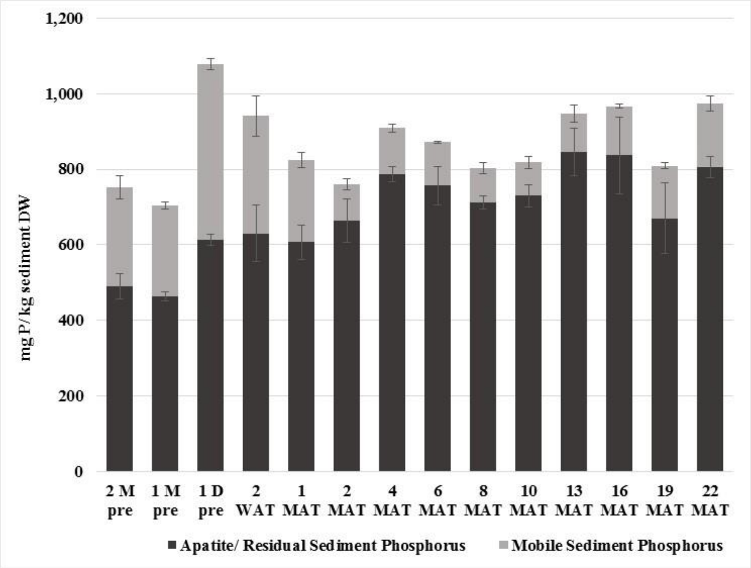


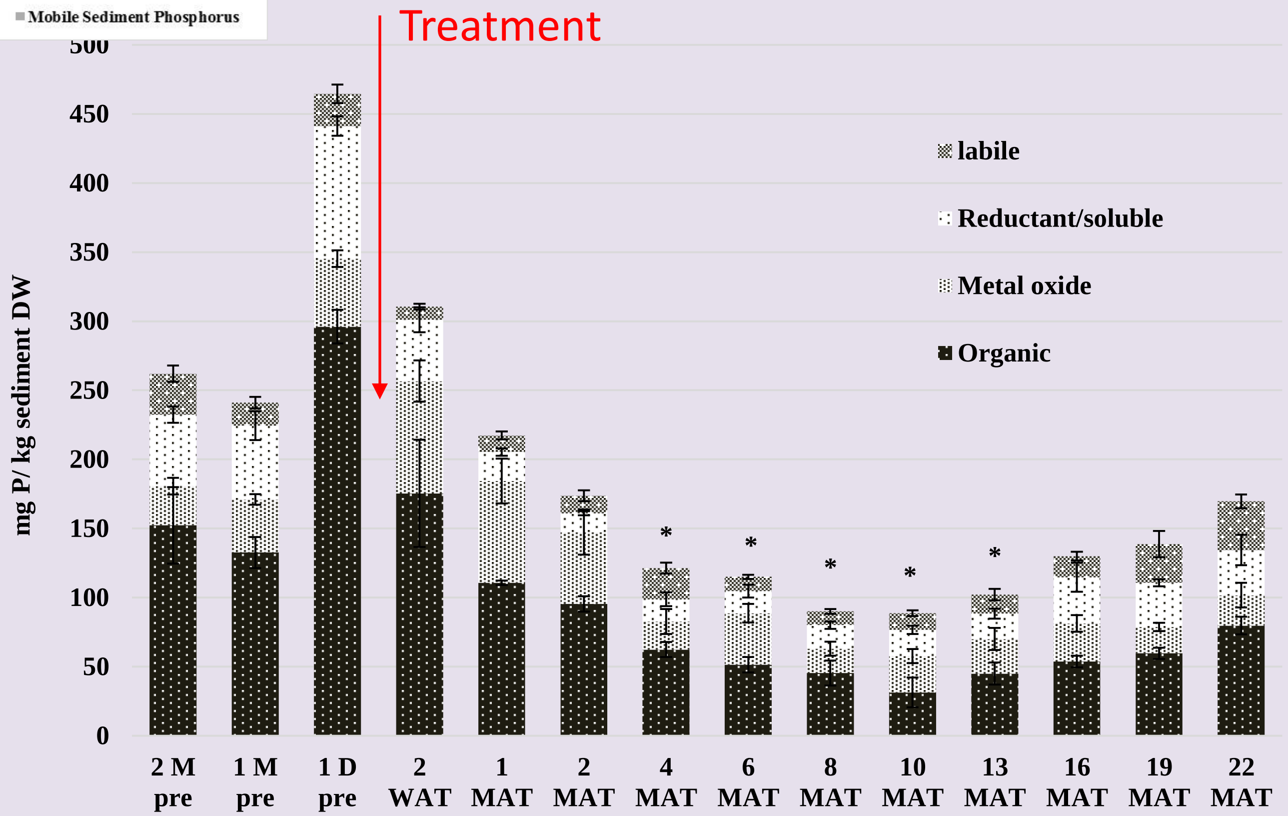
Phoslock dose= 644 kg (water and mobile sediment P)

CH water column P levels

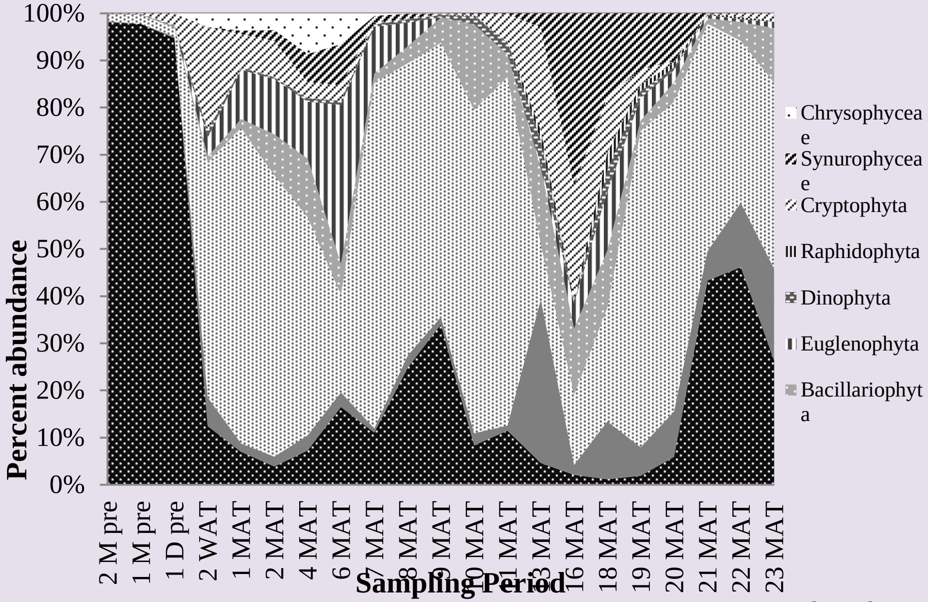


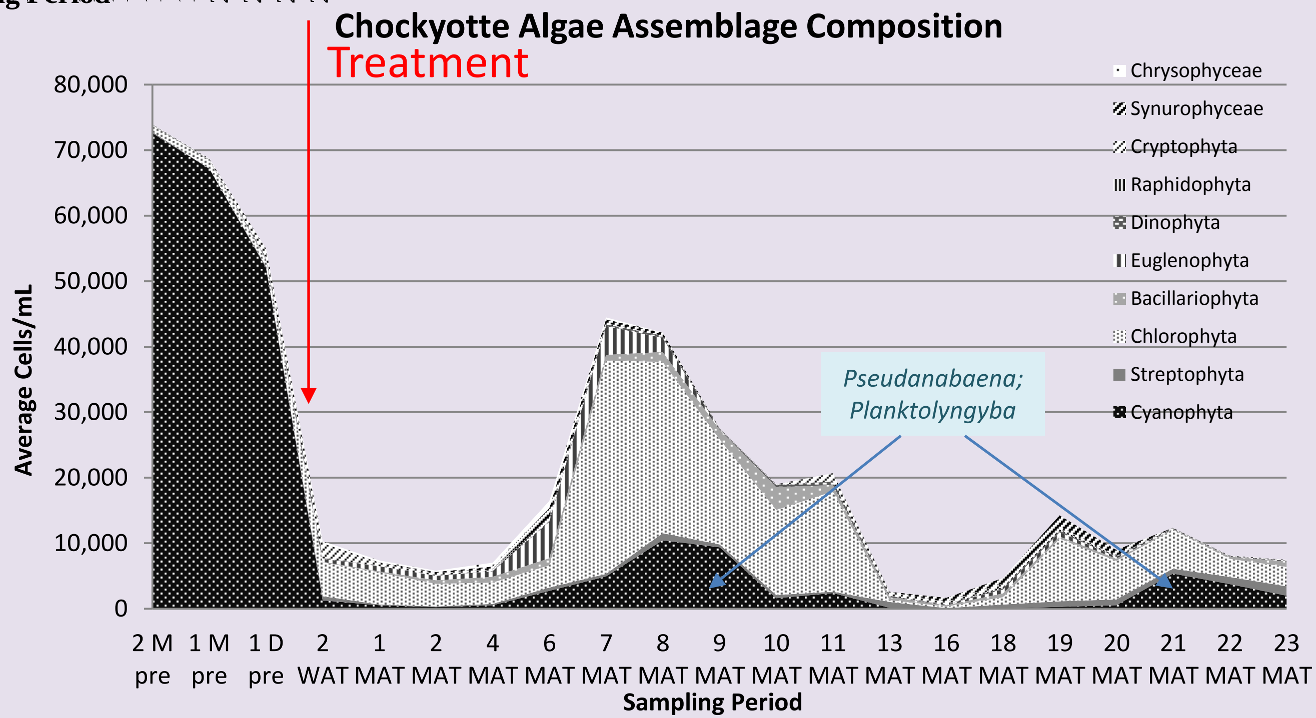
CH Sediment P levels



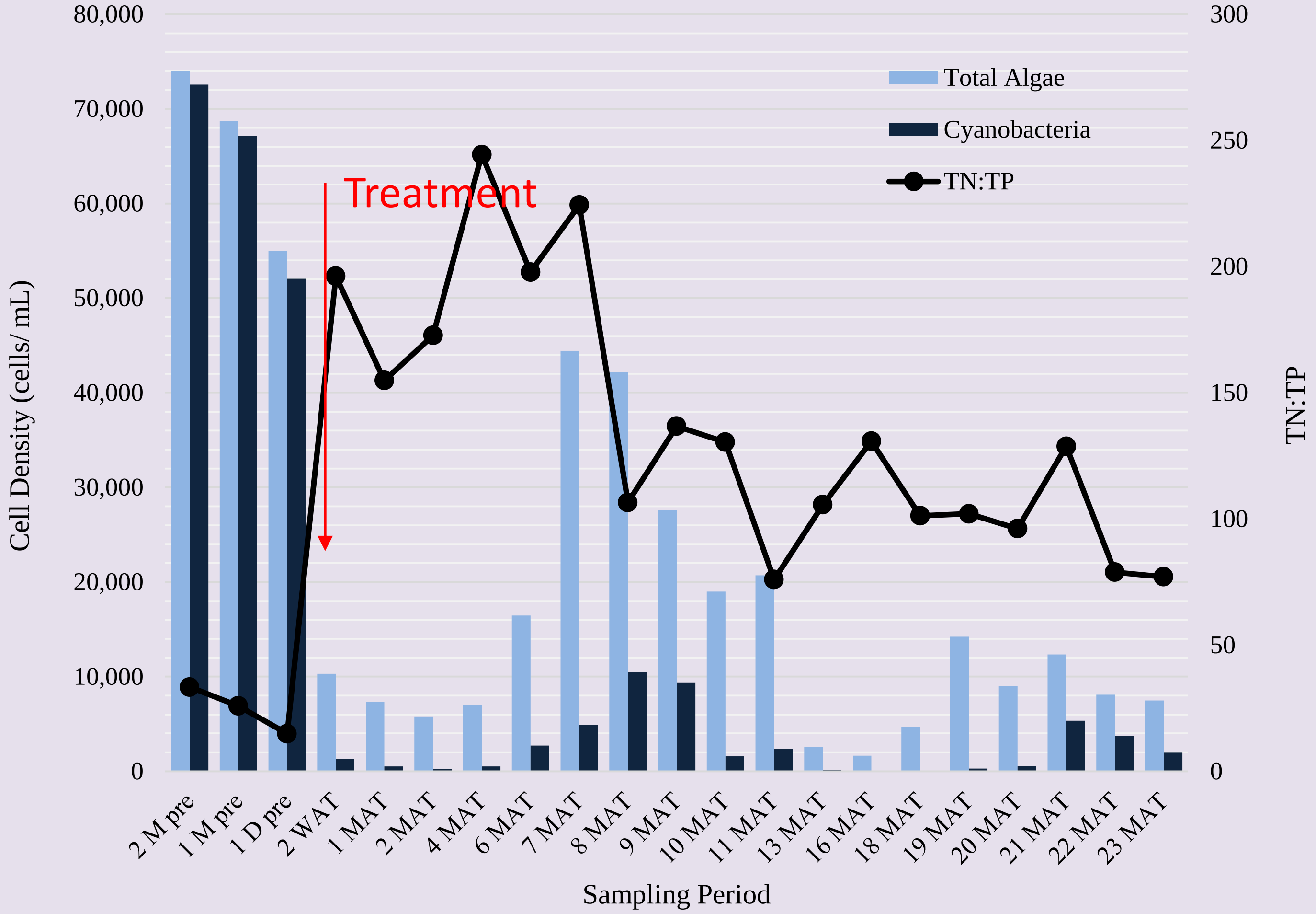


CH Algal Assemblage





Algae v N:P: CH



Treatment
Total Algae
Cyanobacteria
TN:TP
Cell Density (cells/ mL)
TN:TP
Sampling Period
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
300
250
200
150
100
50
0
2 M pre
1 M pre
1 D pre
2 WAT
1 MAT
2 MAT
4 MAT
6 MAT
7 MAT
8 MAT
9 MAT
10 MAT
11 MAT
13 MAT
16 MAT
18 MAT
19 MAT
20 MAT
21 MAT
22 MAT
23 MAT

Visual Results

Chockyotte golf course irrigation pond pre-treatment (left) and post-treatment (right)

Hickory Meadows (HM) Irrigation Pond

Location
- Whitakers, NC

Size
- 0.67 acres (0.27ha)

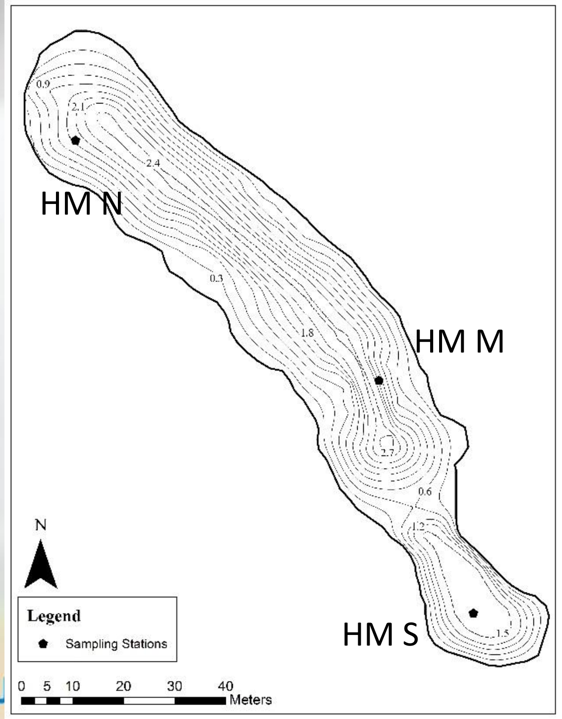
Perimeter
- 1,053.6 feet (321.14m)

Average depth
- 5.2 feet (1.58m)

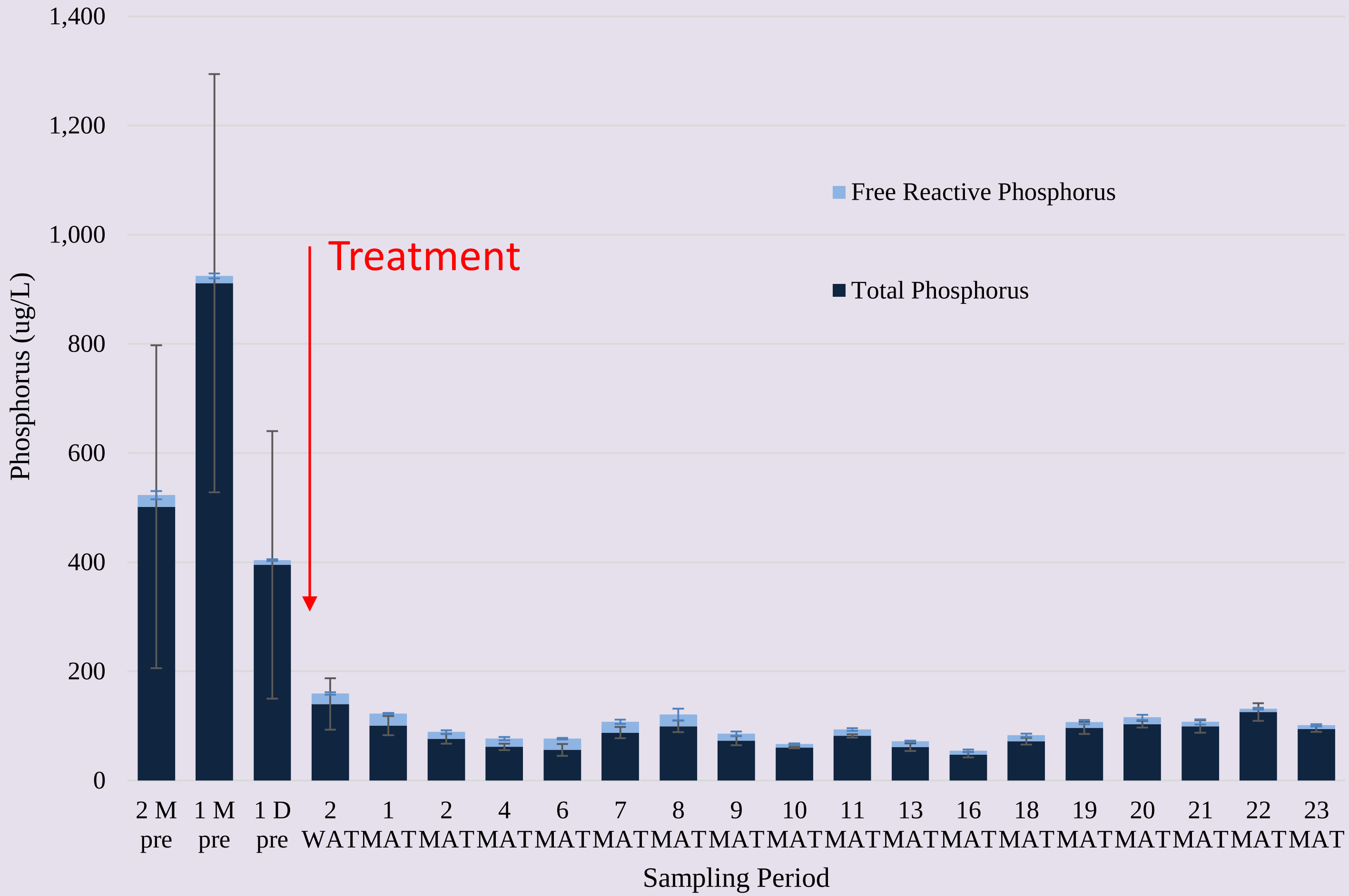
Volume
- 3.48 Acre-feet (4,292.5 m^3)

Phoslock dose= 923 kg (water and mobile sediment P)

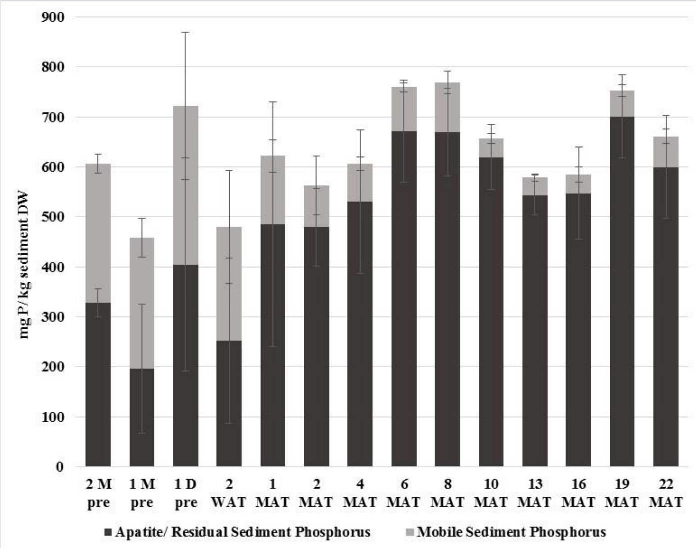
36°07′16.2″ N
77°47′47.6″ W

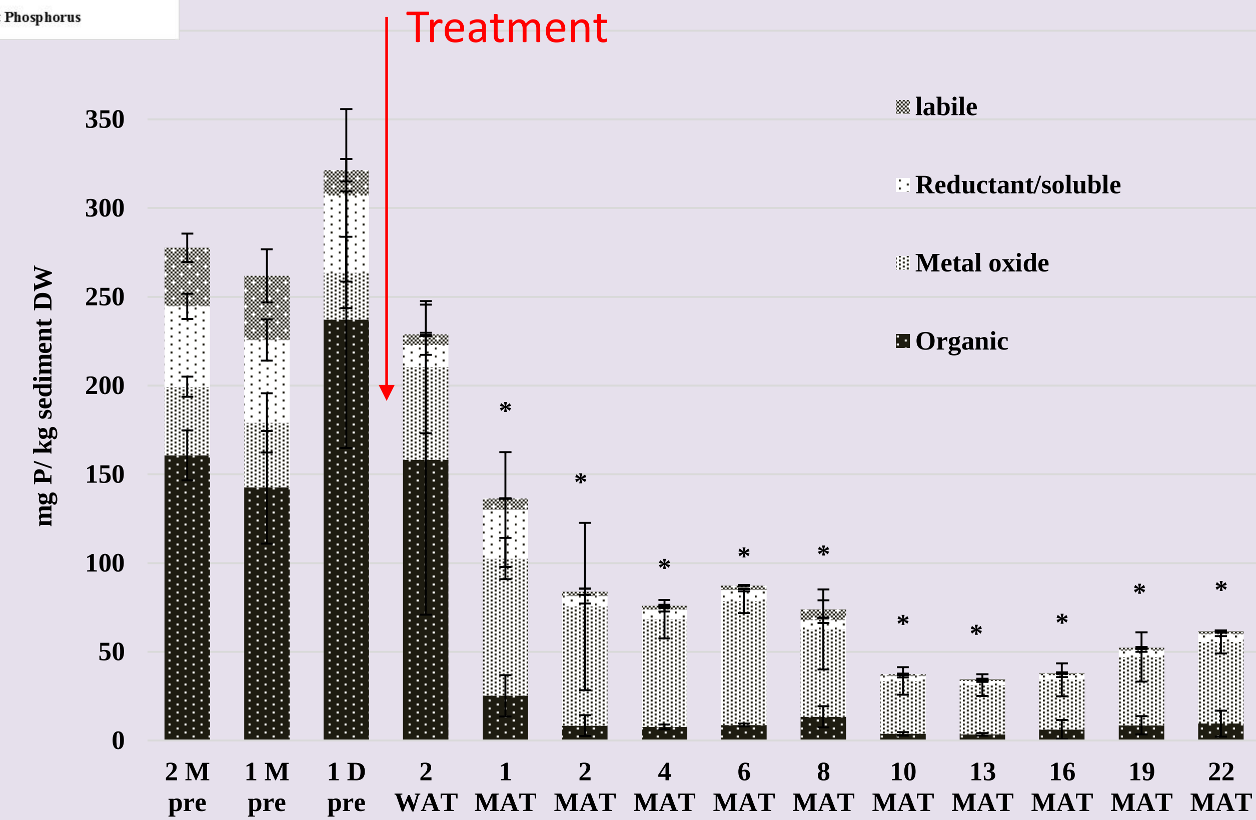


HM water column P levels

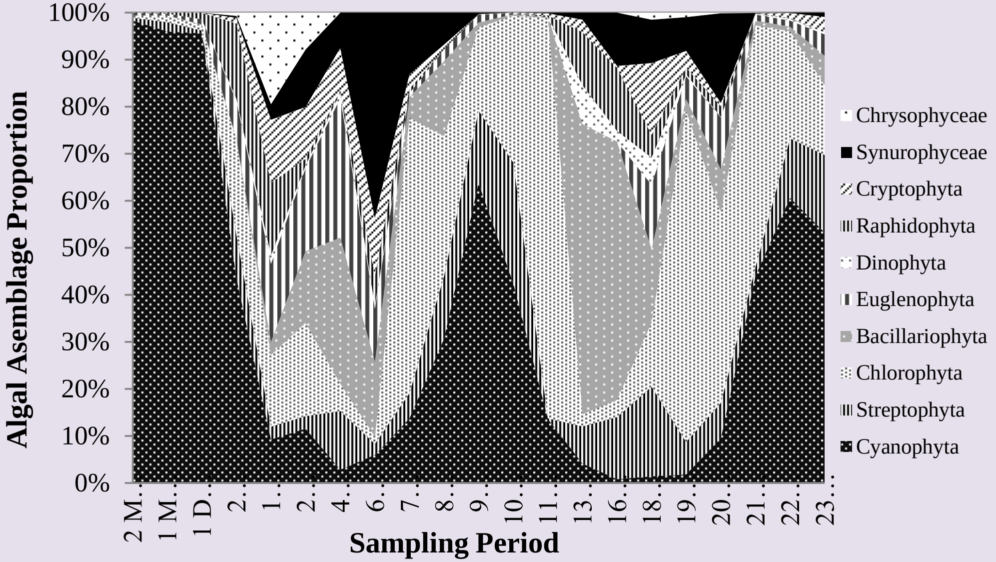


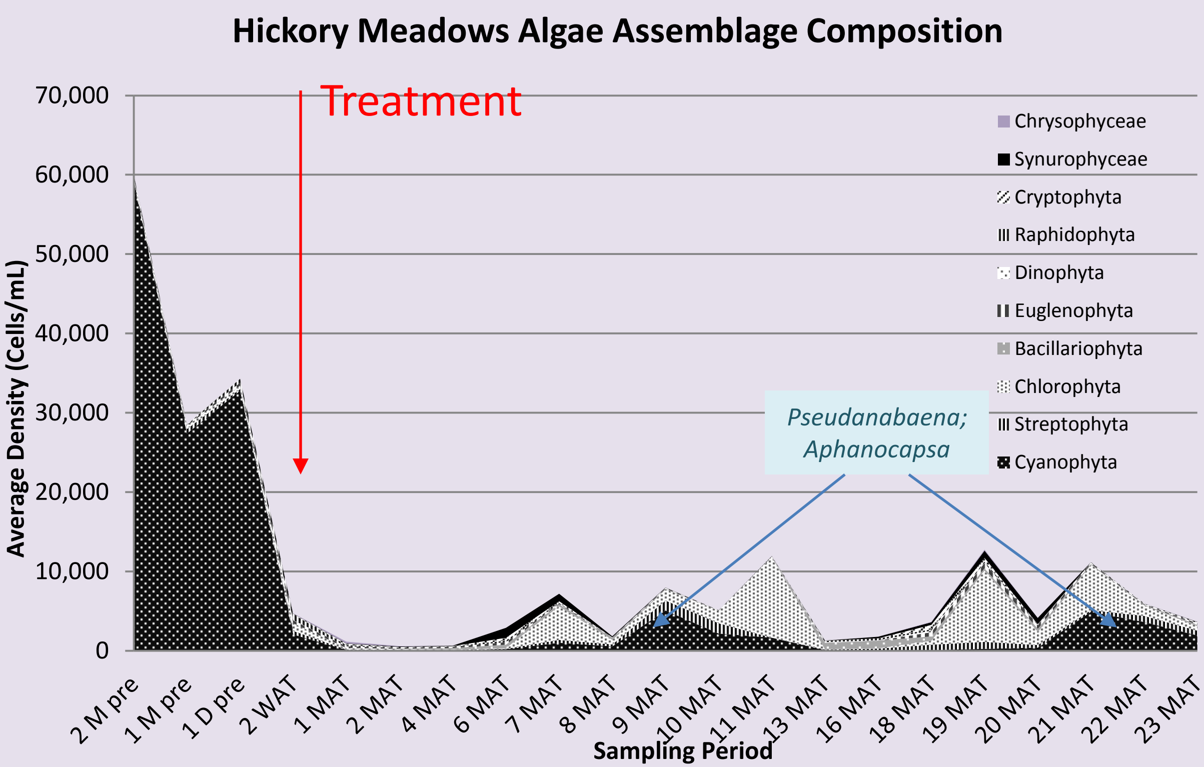
HM Sediment P levels



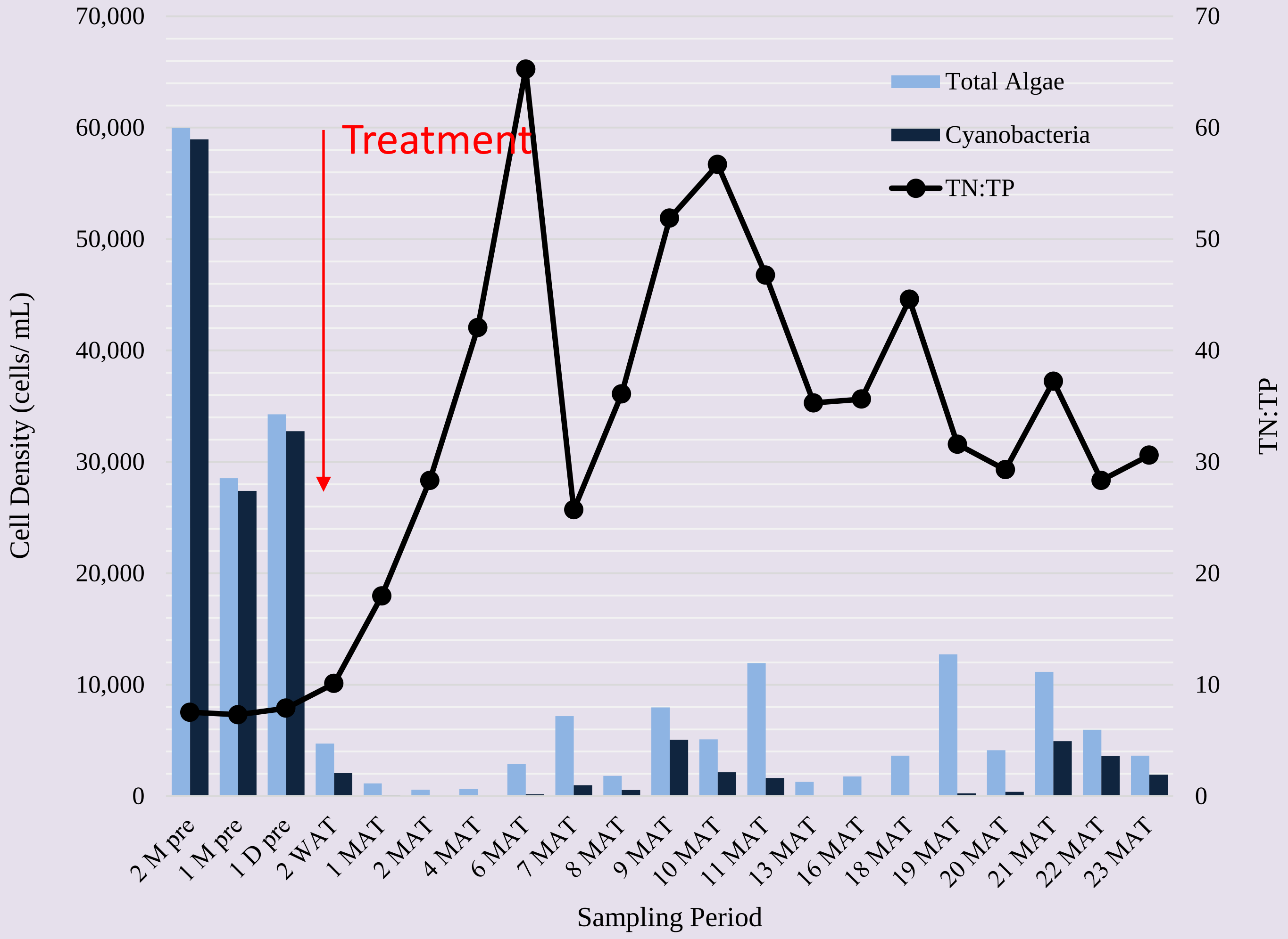


HM algal assemblage



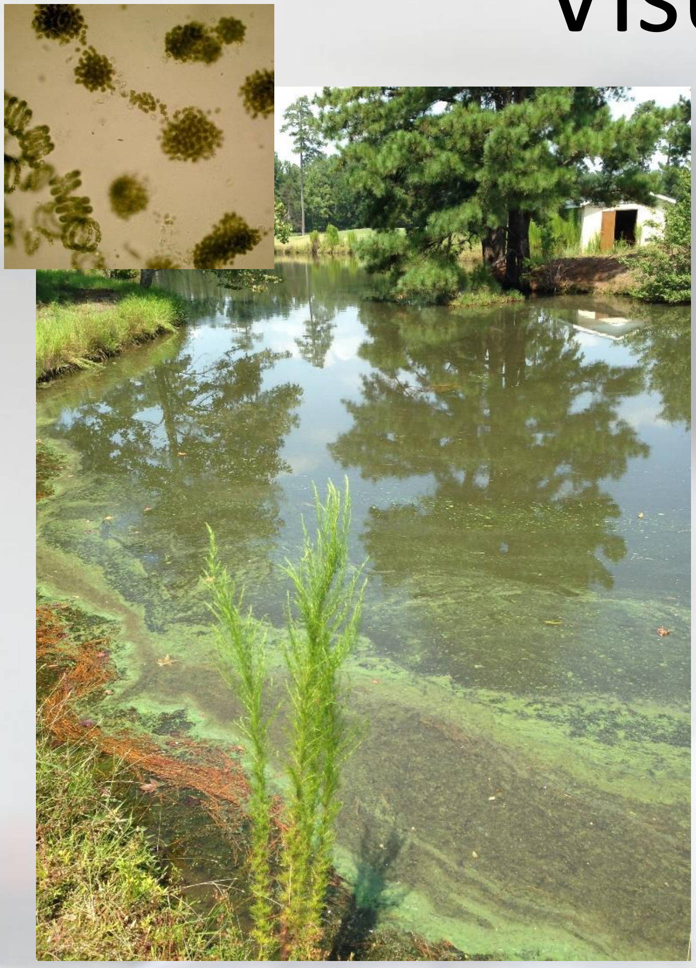


Algae v N:P: HM



Cell Density (cells/ mL)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
TN:TP
70
60
50
40
30
20
10
0
Treatment
Total Algae
Cyanobacteria
TN:TP
2 M pre
1 M pre
1 D pre
2 WAT
1 MAT
2 MAT
4 MAT
6 MAT
7 MAT
8 MAT
9 MAT
10 MAT
11 MAT
13 MAT
16 MAT
18 MAT
19 MAT
20 MAT
21 MAT
22 MAT
23 MAT
Sampling Period

Visual Results



Hickory Meadows golf course irrigation pond pre-treatment (left) and post-treatment (right)

Summary Results

- P bio-availability shift with treatment
  - Significant decrease in total P in water
  - Shift in sediment mobile forms
    - Labile, reductant soluble, organic decreases
  - Increase in Apatite/Residual forms
  - Significant decrease
    - Cyanobacteria densities/ types
- Proactive management approach
  - *In situ* P mitigation and effects
  - Algae assemblage composition

PHOSLOCK®
Phosphorus Locking Technology

Treated with Phoslock

No Phoslock Treatment

Lake Lorene Summary

- 72% decline TP
- 53% decline FRP
- No blue-green algae blooms (2012-13)
- Secchi depth to bottom (~8ft)
- No adverse impacts to beneficial aquatic organisms

August 2011

July 2012

Phoslock Results

"**Client was so impressed** with the results, they approved additional funds to use Phoslock in 3 ponds in the community as part of a **new budget.**"

Discussion/Summary

- *In situ* nutrient mitigation is critical to address cause of negative water quality
  - Legacy P
  - Sediment nutrient pump
- Phoslock
  - Removed available P in water and shifted sediment fractions
    - Increased N:P ratio
  - Decreased cyanobacteria abundance and density

Thank You

Algae Corner

- What are Algae?
- How to Identify Different Algae Types
- Toxic, Noxious, and Smelly Algae (Cyanobacteria: part 2)
- SePRO Solutions for Algae Control
- The Power of Peroxide with PAK 27
- The Problem with Phosphorus
- Growth Factors and Seasonality
- Where do Algae Come From
- Controlling Tough Algae with Captain XTR
- Removing Phosphorus & Enhancing Water Quality with Phoslock
- Controlling Algae and Improving Water Quality with SeClear
- Toxic Algae and Closed waterbodies
- SePRO Laboratory Services
- Fish Kill: Top questions to ask

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Host: algae corner

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