



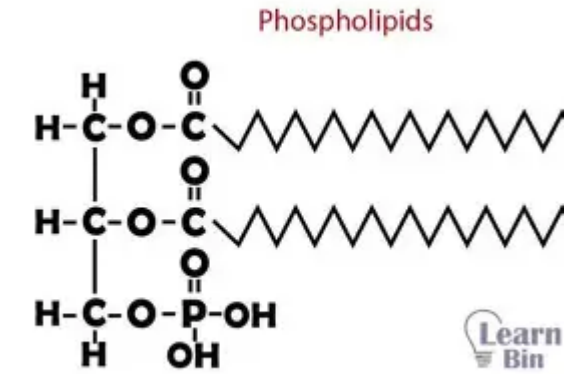
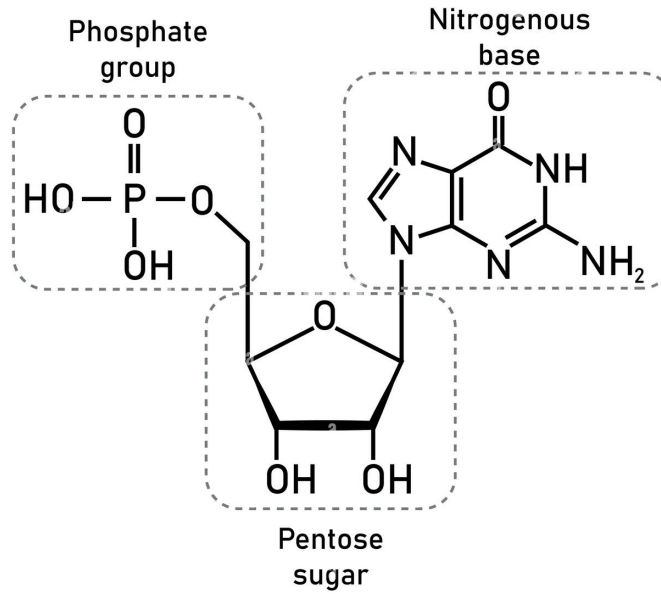
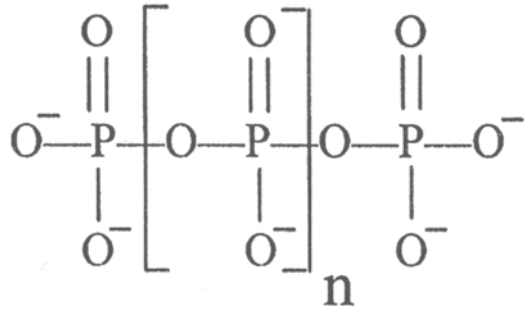
Iron-A New Approach to Control Internal loading from Organic P in Shallow Lakes

Keith Pilgrim

November 6, 2025

What is Organic P?

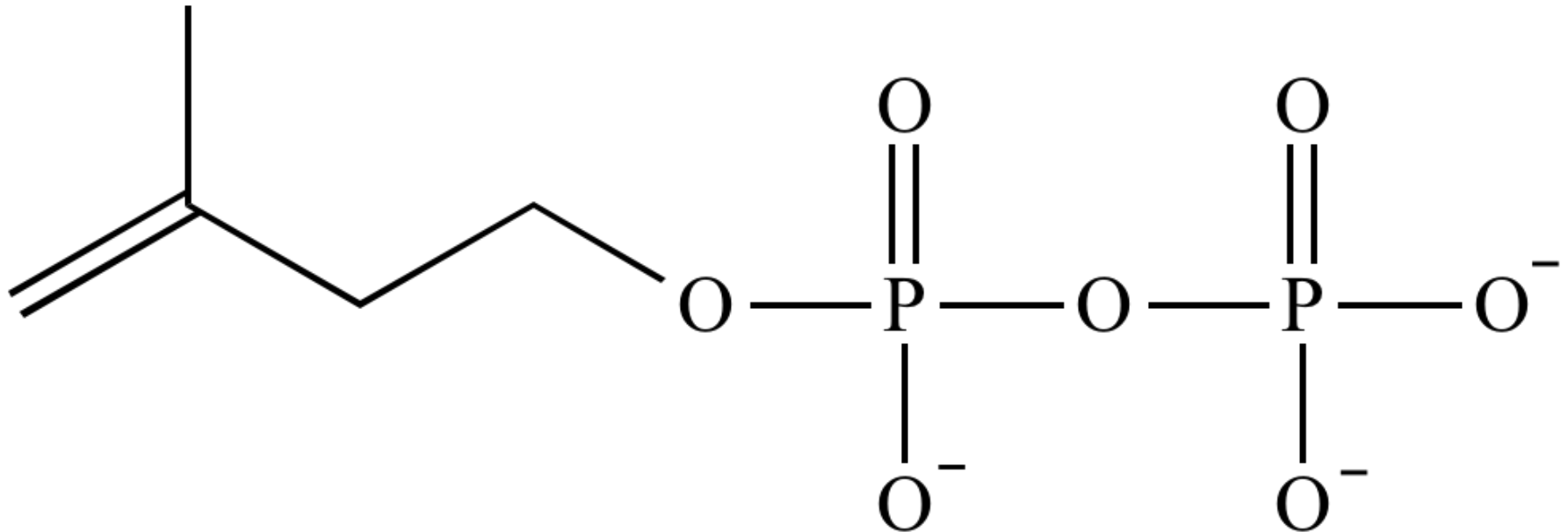
|||||||



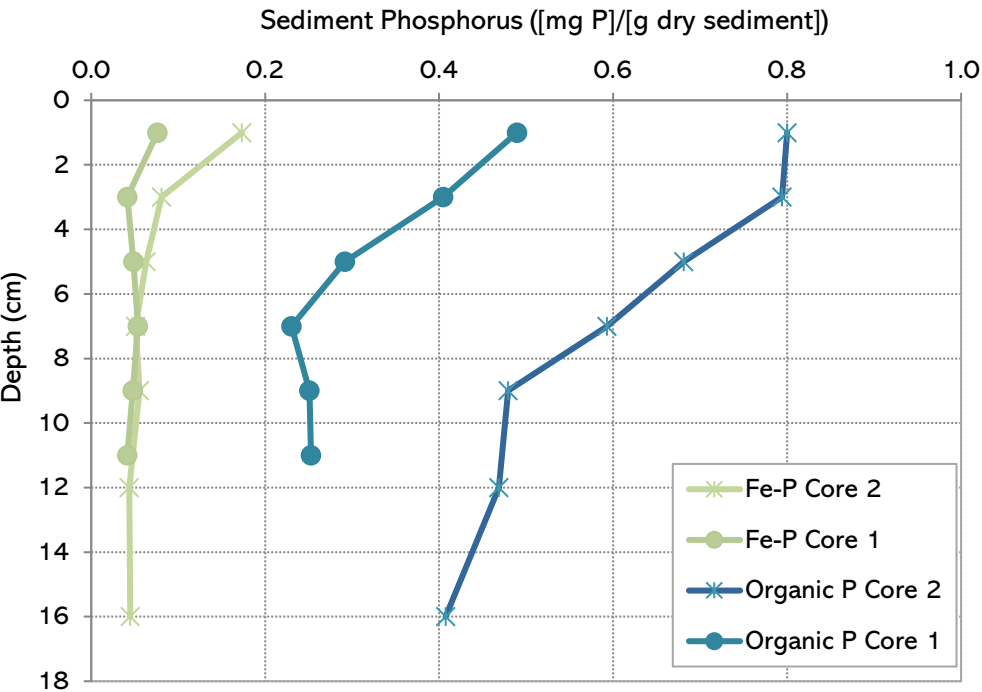
Learn Bin

alamy

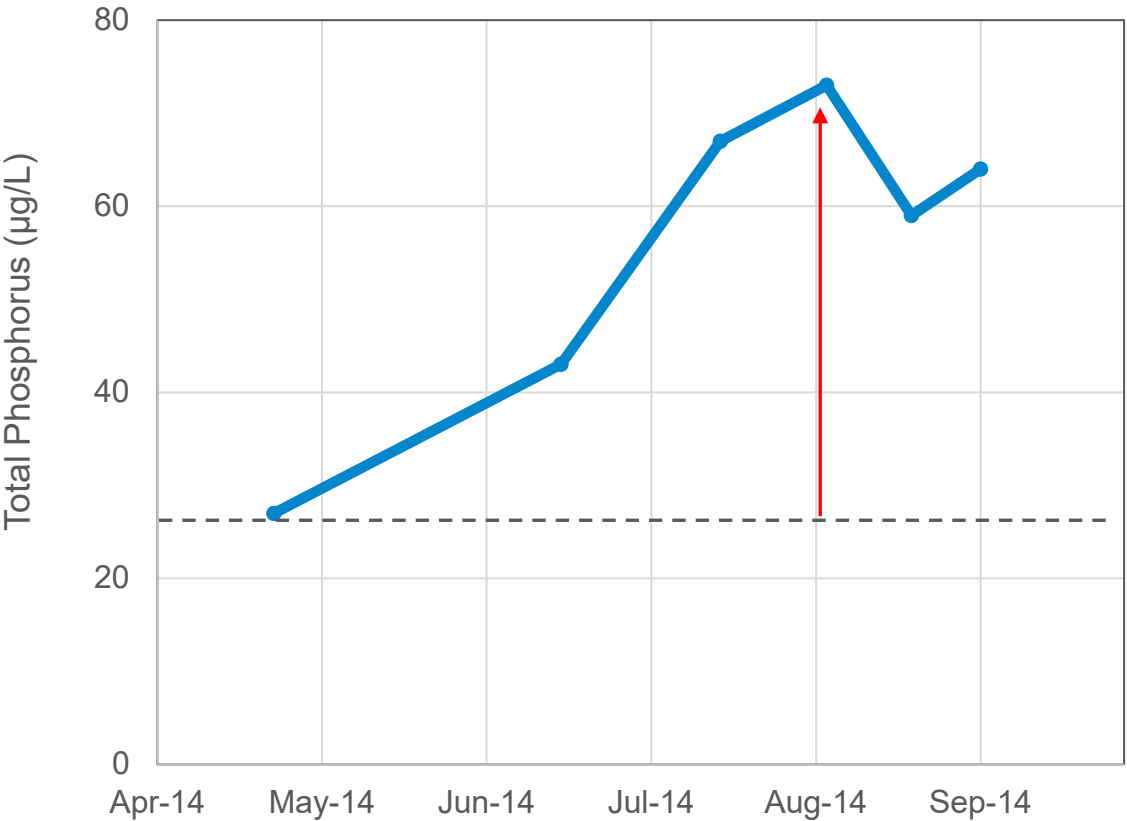
Image ID: S1C0V8T
www.alamy.com



Organic P Can be a Significant Source of Internal Loading

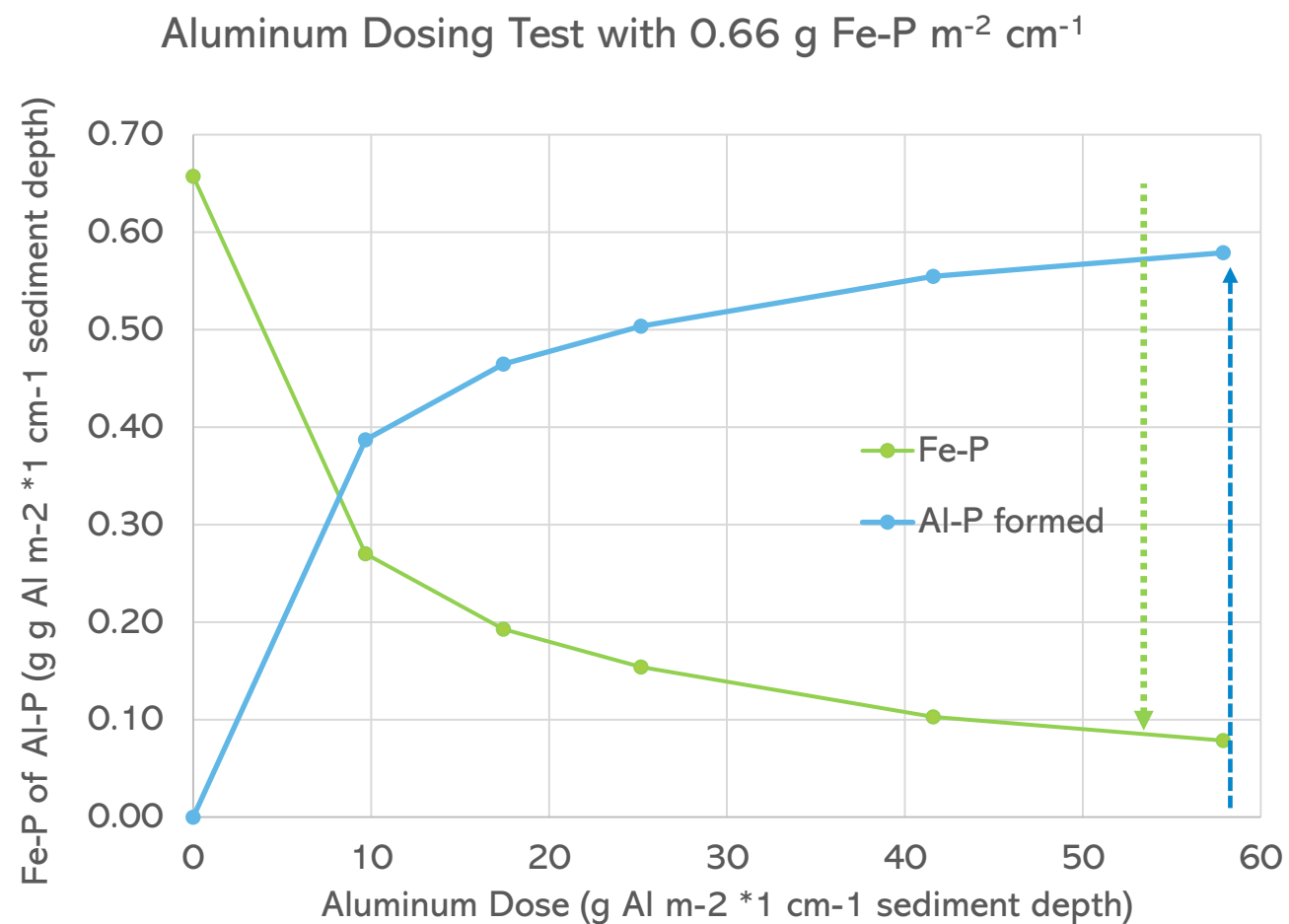


Fe-P internal load potential: $0.15 \text{ mg m}^2 \text{ d}^{-1}$
Average summer internal load: $0.9 \text{ mg m}^2 \text{ d}^{-1}$



Al-P Not Formed from Org P with Aluminum Treatment

|||||||

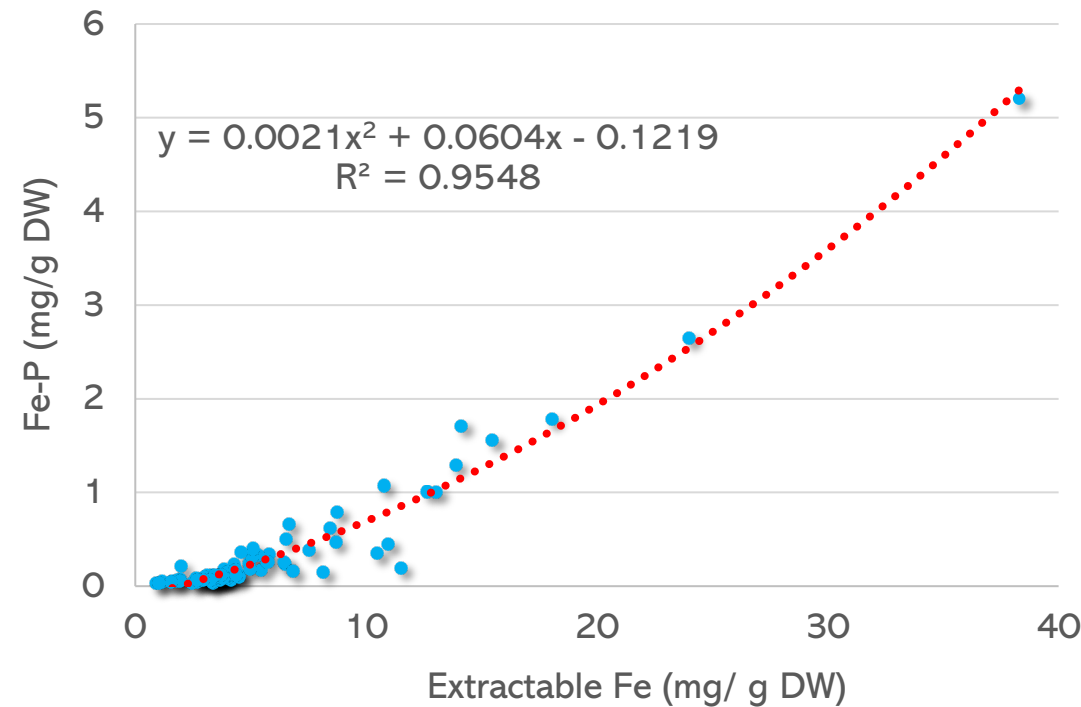


More Iron = More Iron-Bound P

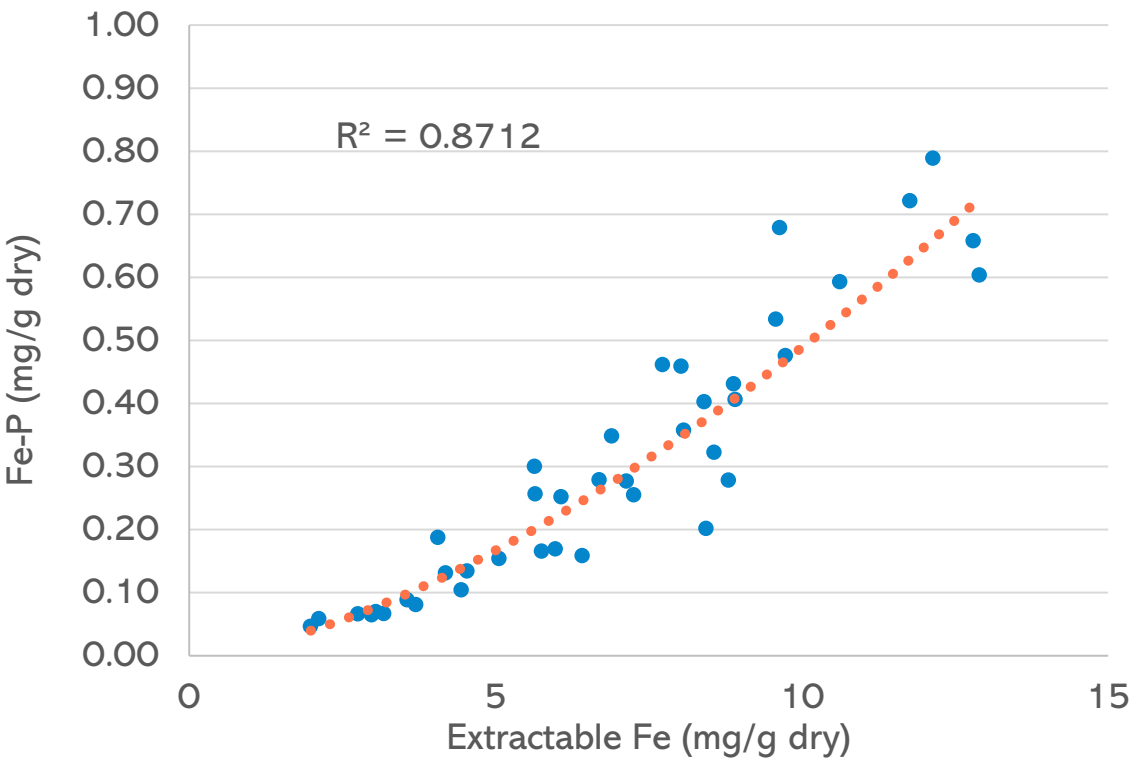


Extractable Iron to Fe-P in Sediment

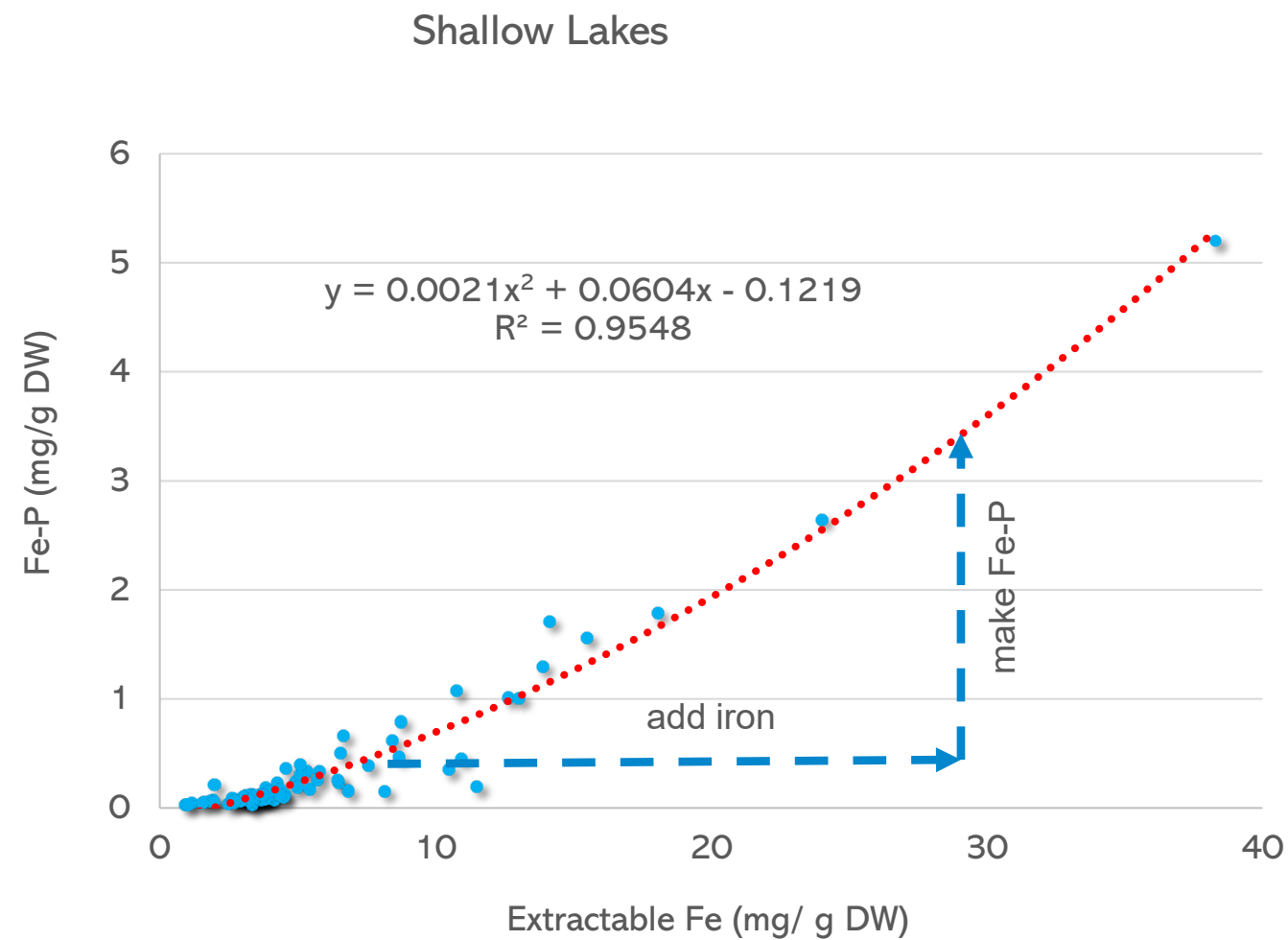
Shallow Lakes



Deep Lake: Lake Carmi



Can We Capture Decayed Phosphorus with Iron?



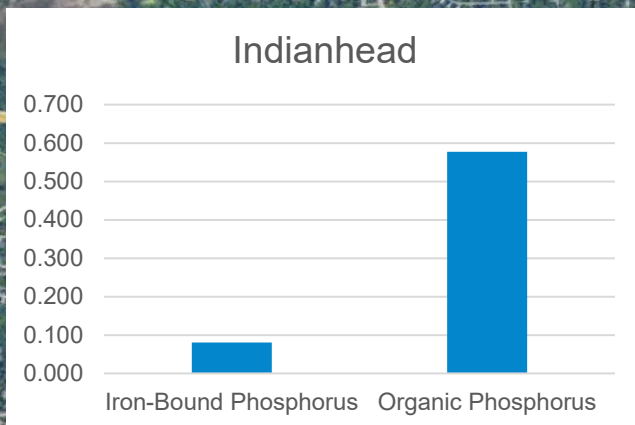
Study Lakes

Indianhead Lake

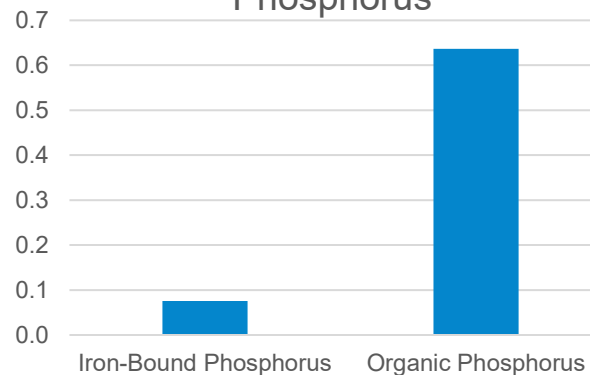
Iron-64 g Fe/m²

Sodium Aluminate-23 g Al /m²

Full Dose



Arrowhead Lake Phosphorus



Arrowhead Lake

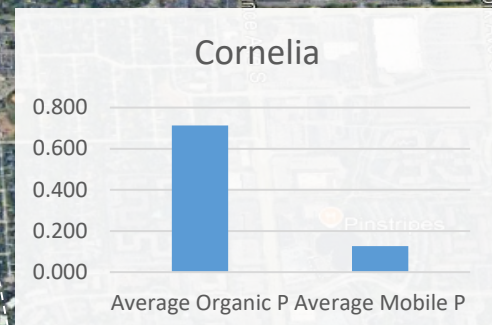
Iron-29 g Fe/m²

Sodium Aluminate-10 g Al /m²

1/2 Dose

Lake Cornelia

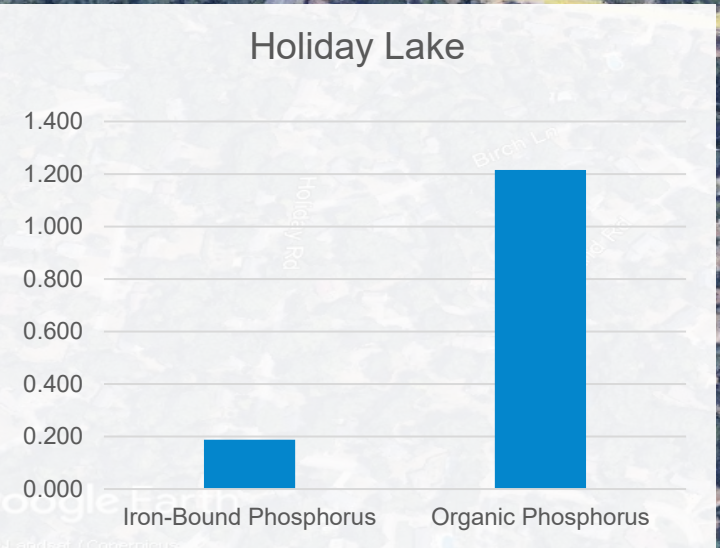
Alum + Sodium Aluminate-22-55 g Al/m²



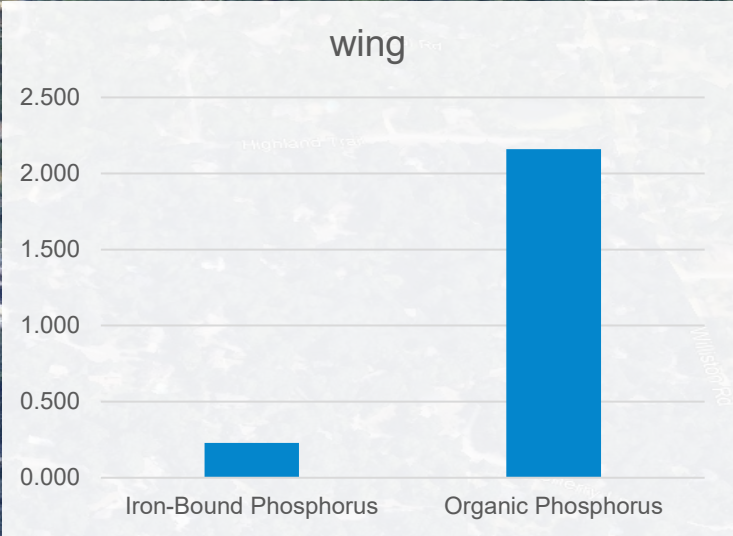
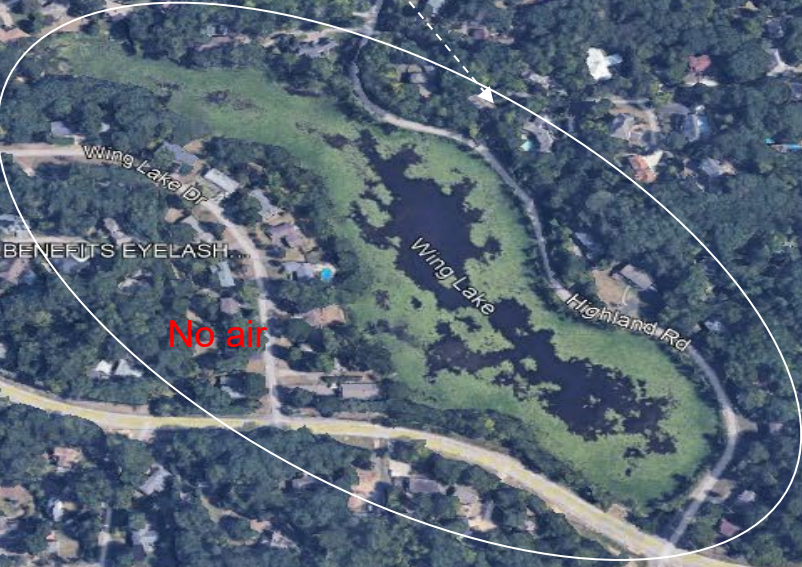
Study Lakes



Holiday Lake
Iron-76 g Fe/m²
Sodium Aluminate-54 g Al /m²
Full Dose



Wing Lake
Iron-47 g Fe/m²
Sodium Aluminate-33 g Al /m²
Full Dose / No Aeration



Experimental Matrix

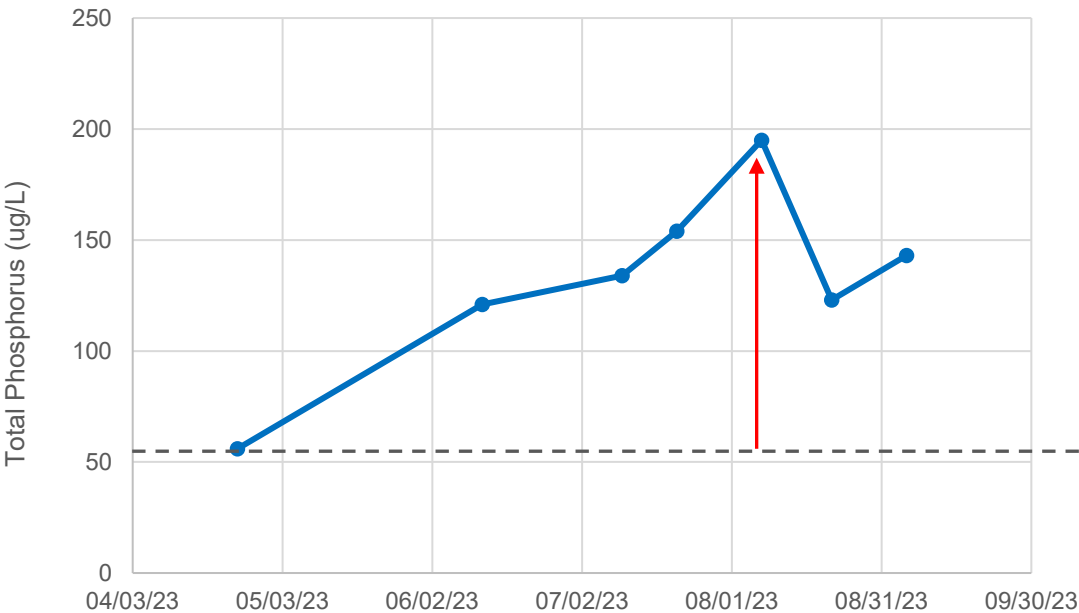
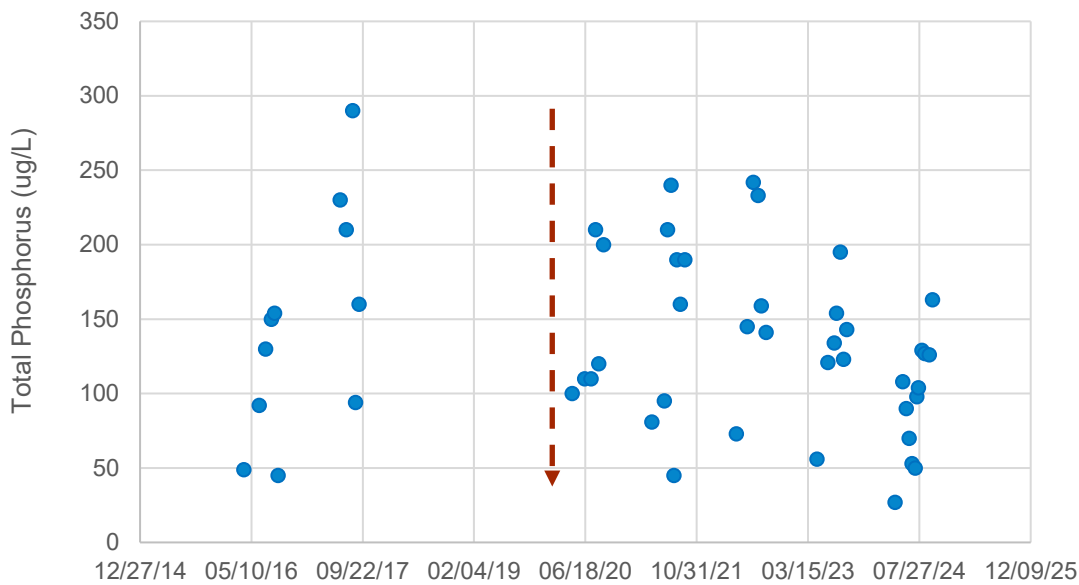


Condition		Ferric Chloride + Sodium Aluminate	Alum+ Sodium Aluminate
Aeration	Full Dose	Indianhead Holiday	
	Half Dose	Arrowhead	
No Aeration	Full Dose	Wing	
Control	Full Dose		Cornelia

Monitoring Cornelia-Surface TP



control

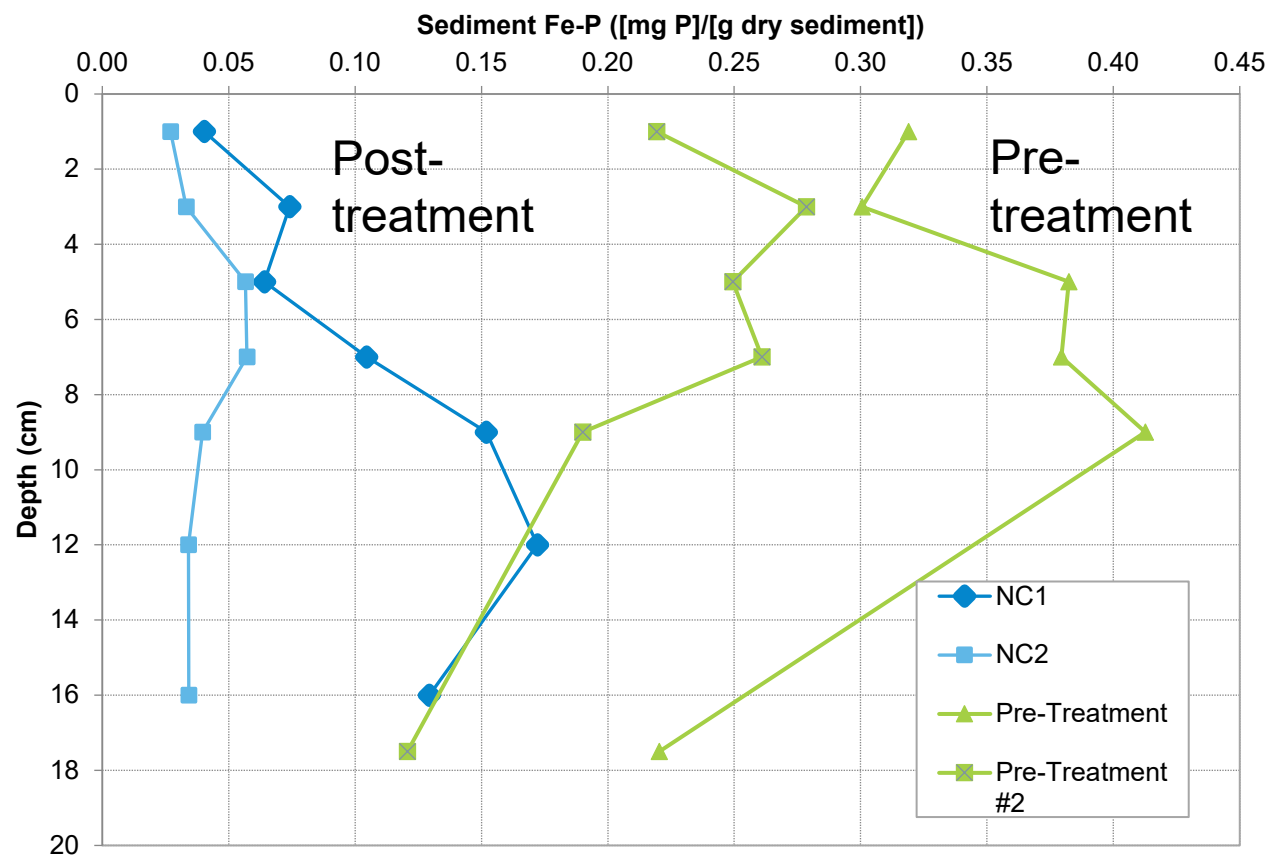


Monitoring
Cornelia-Post Treatment (Aluminum Only) Sediment

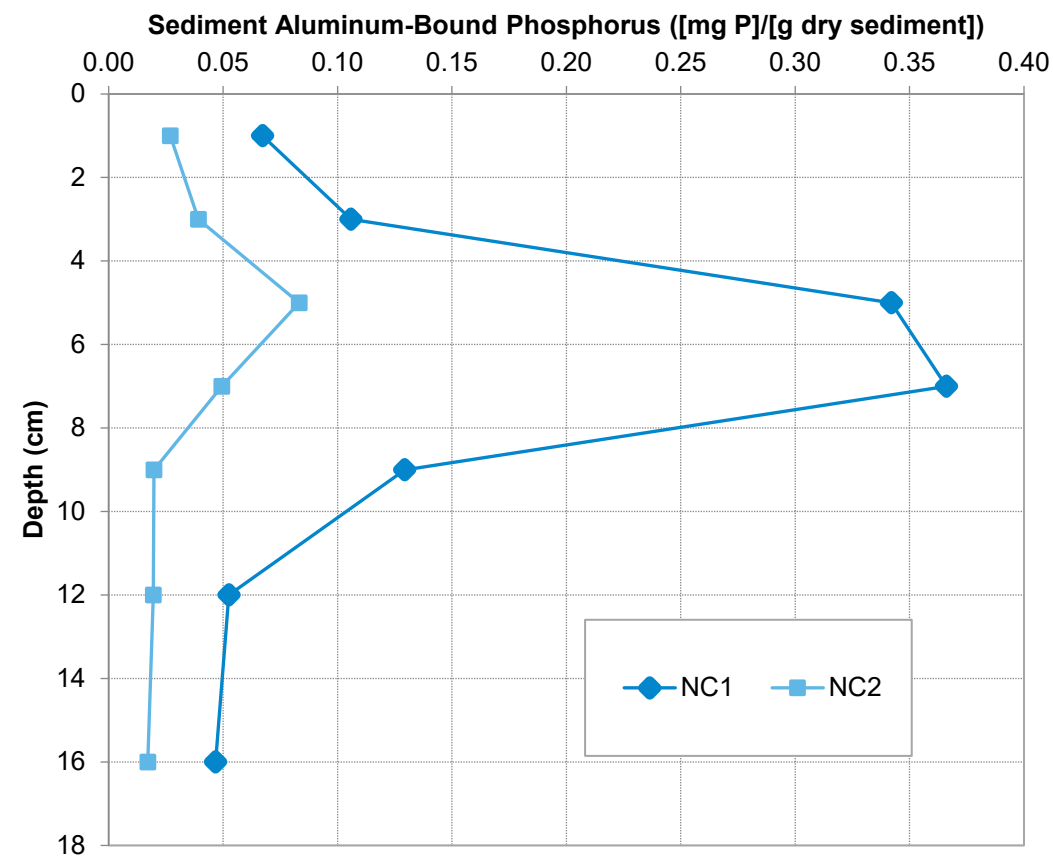
Internal Loading Even Though Fe-P is
Bound by Aluminum



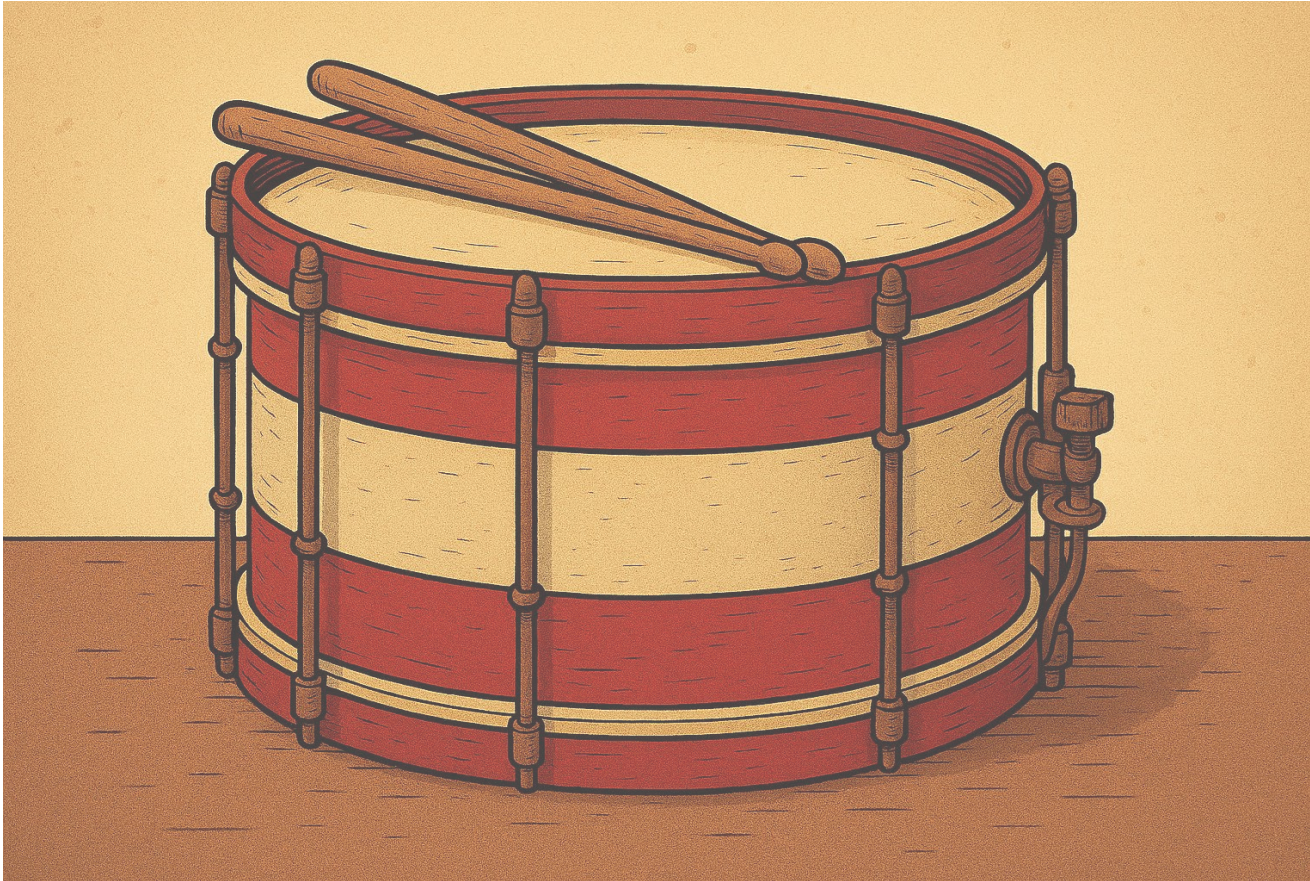
Iron-Bound Phosphorus



Aluminum-Bound Phosphorus



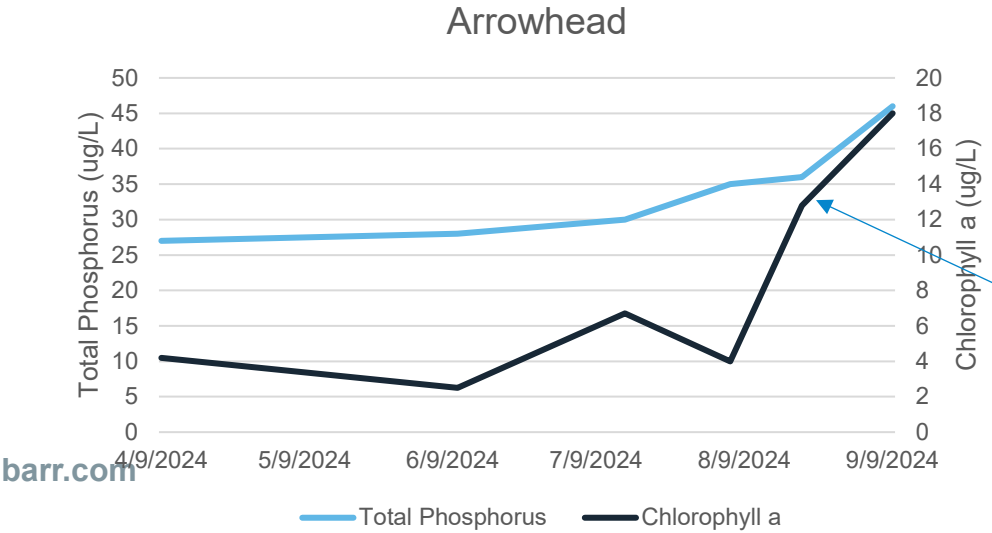
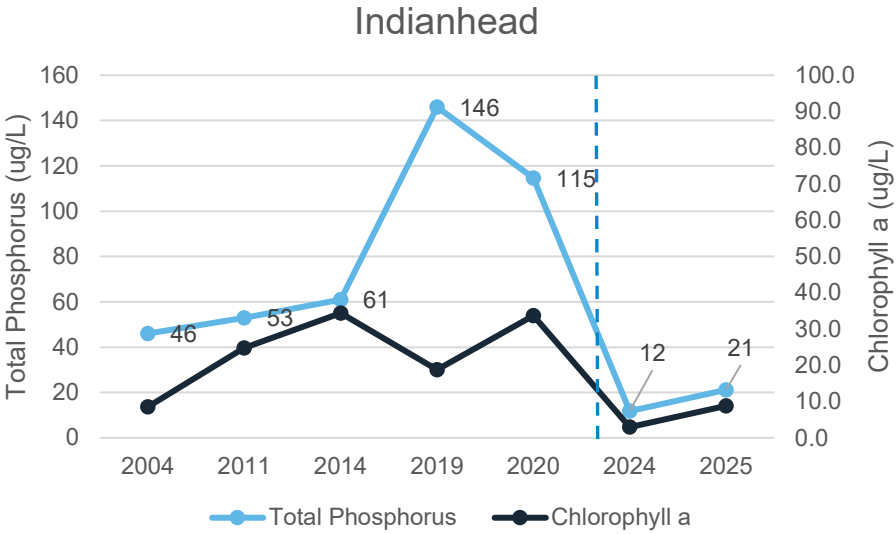
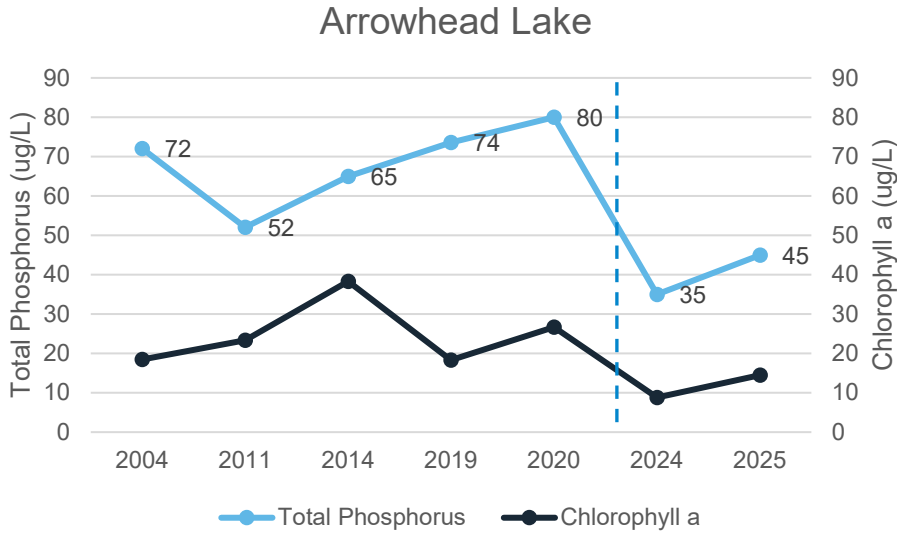
Did it Work....Drumroll Please



Monitoring Indianhead (air) and Arrowhead (air)

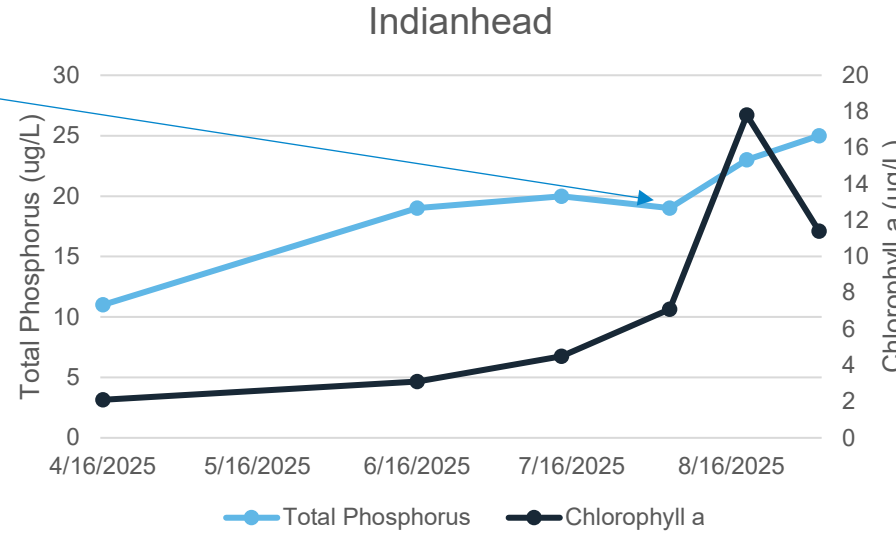


Its working, but there is room for improvement!

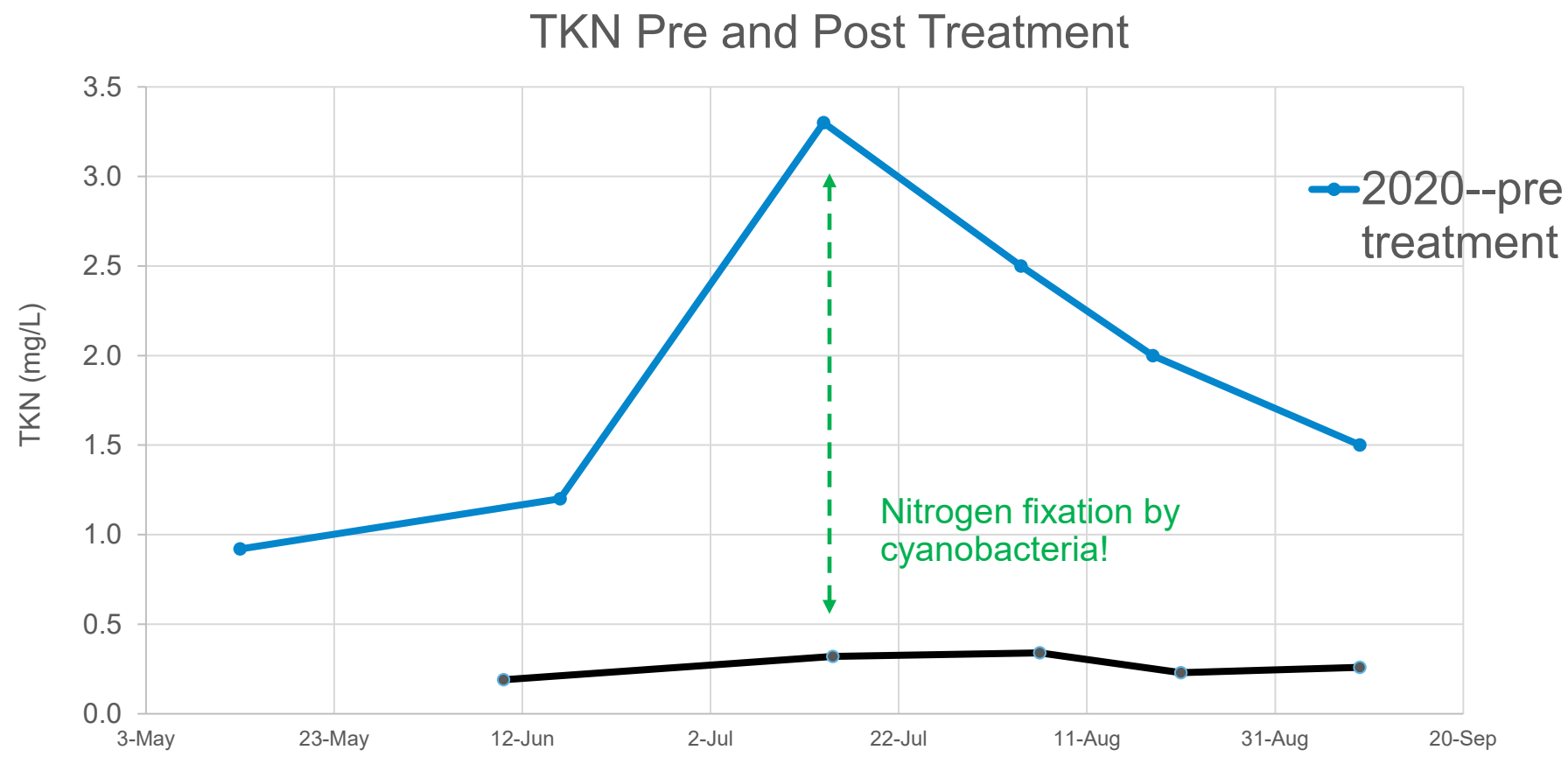


DO = 9 mg/L

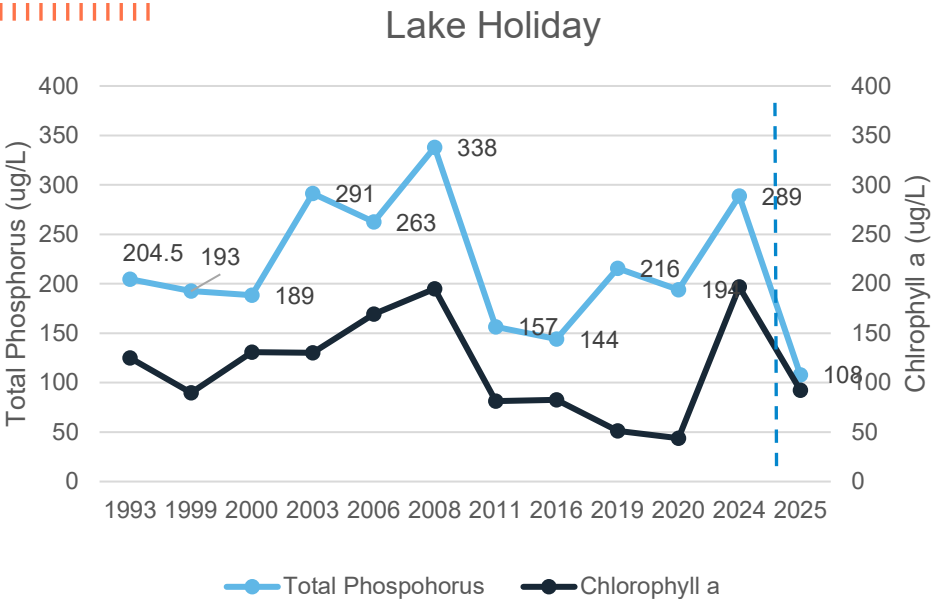
DO = 7-9 mg/L



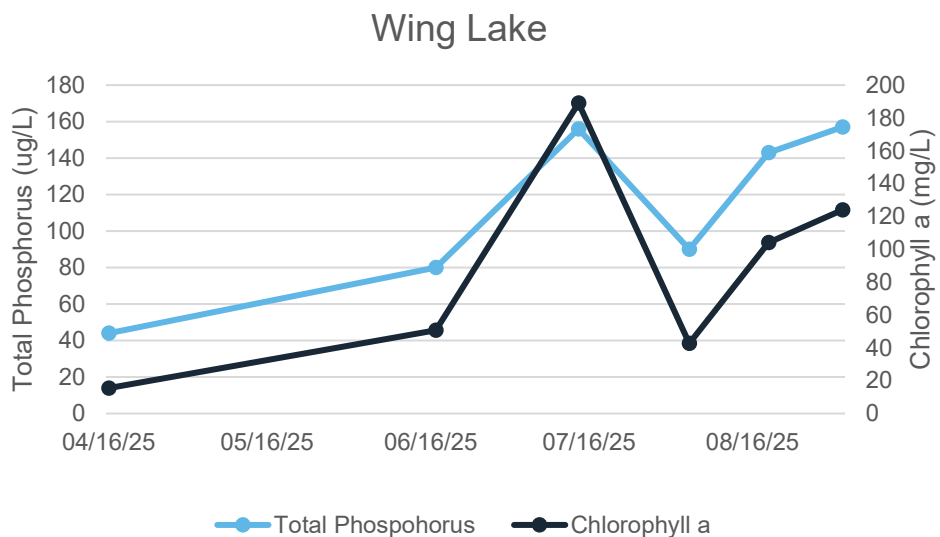
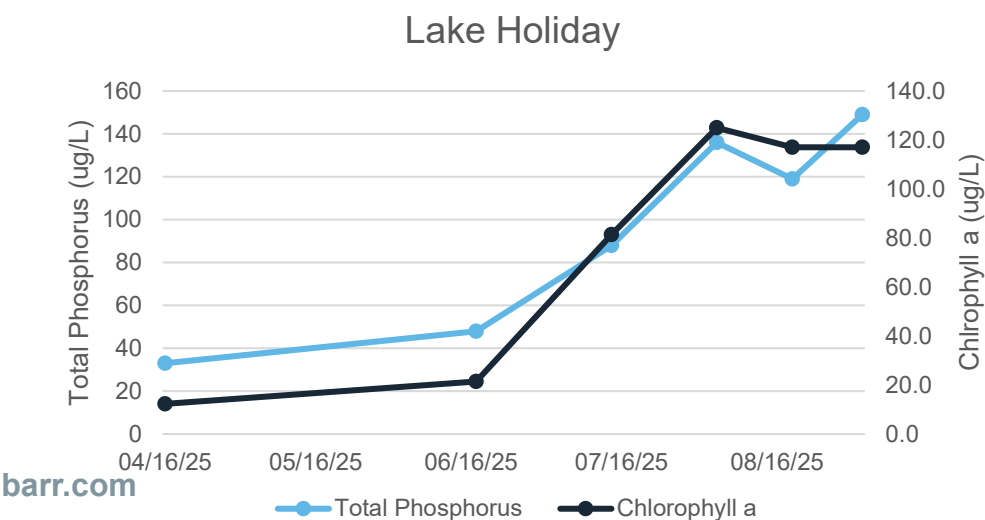
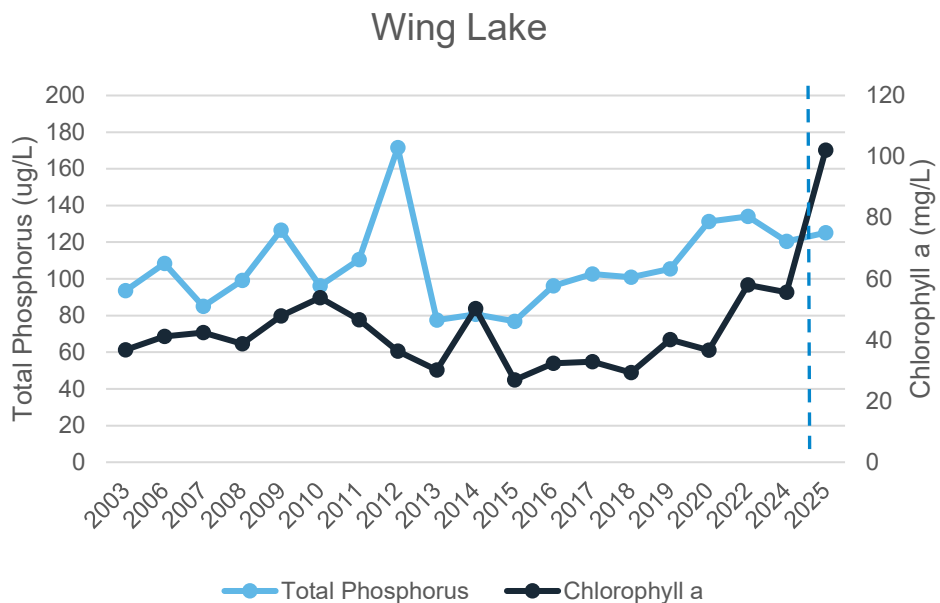
Monitoring Indianhead (air) and Arrowhead (air)



Monitoring Holiday (air) and Wing (no air)



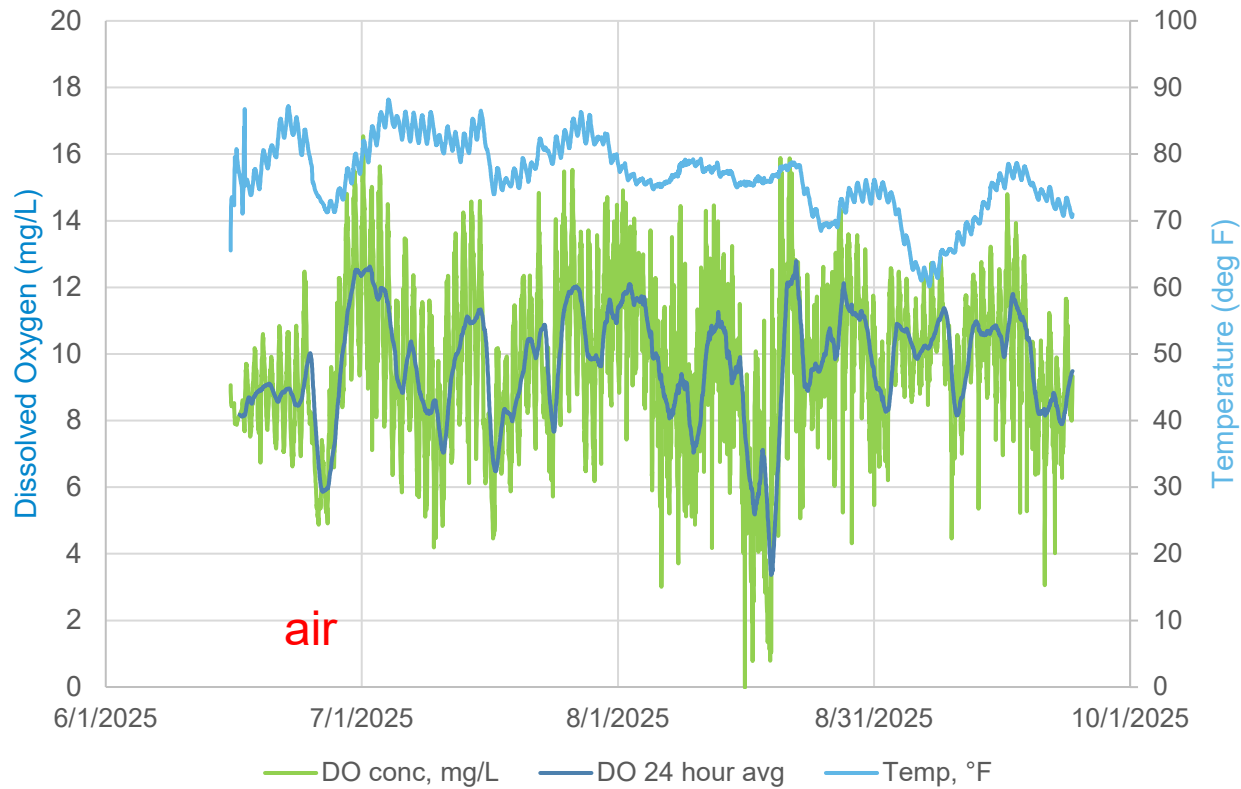
Forced Air Aeration Could Not Satisfy
Sediment Oxygen Demand



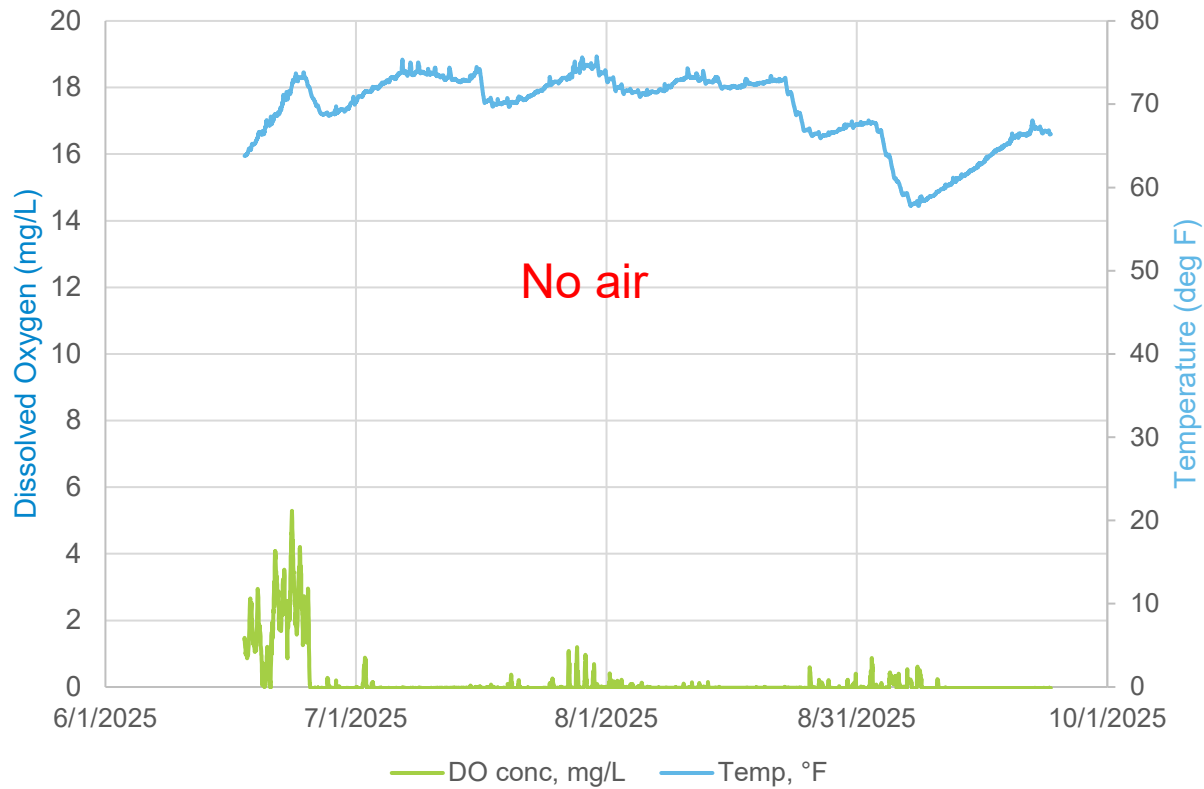
Monitoring Holiday (air) and Wing (no air)



Lake Holiday Continuous DO & Temperature



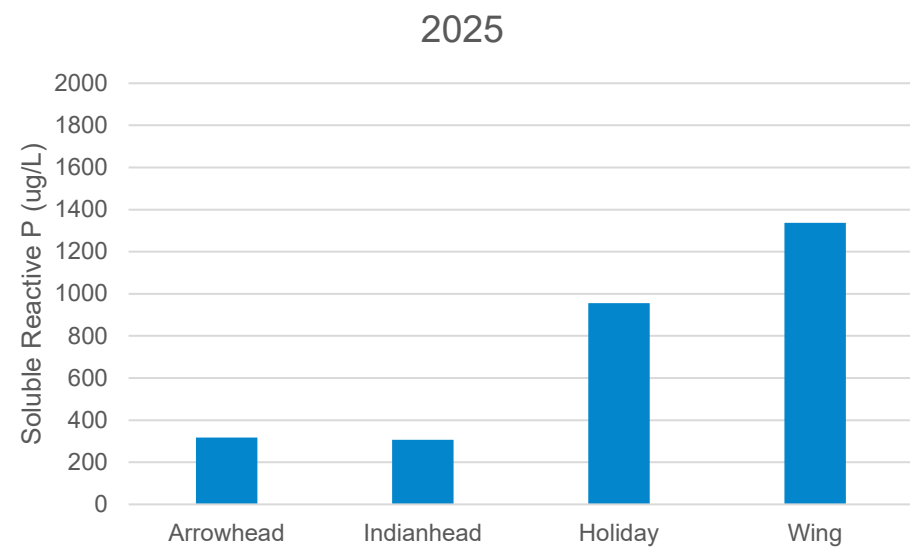
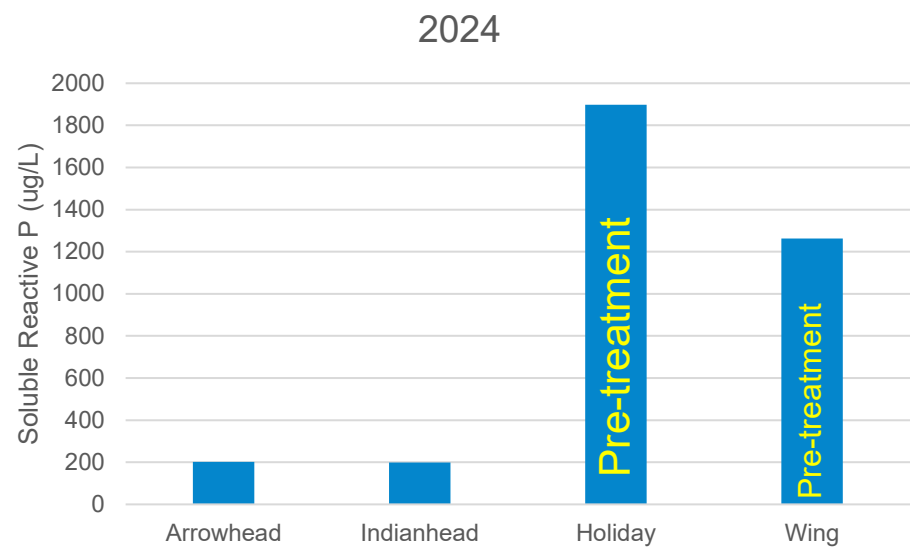
Wing Lake Continuous DO & Temperature



Monitoring Direct Porewater Sampling



Monitoring Direct Porewater Sampling



Conclusion



Definitive evidence provided that iron + aeration for shallow lakes can significantly reduce internal loading from organic P

Cornelia

High Org-P, bound all Fe-P w/-aluminum treatment, significant internal loading remains

Wing

High Org-P, aluminum alone could not prevent internal load / Fe not effective

Indianhead vs Arrowhead

Iron dose proportionate to lake response

Holiday

Sediment anaerobic despite aeration

Questions and Acknowledgements

Many Thanks to the Team!

Kevin Menken

Katie Turpin Nagle

Erica Sniegowski

Jordan Wein

Mark Origer

Janna Keifer

Michael Welch

Keith Pilgrim

kmp@barr.com

612-229-8092



EDINA
MINNESOTA



