

LEVERAGING WATERSHED WETLANDS TO OPTIMIZE PHOSPHORUS MANAGEMENT STRATEGIES IN LAKE ERIE BASIN

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Leveraging Wetlands To Meet BMP Goals

Problem:

Harmful algal blooms (HABs) have been linked to excess Phosphorus loading, with increasing occurrence across the Great Lakes.

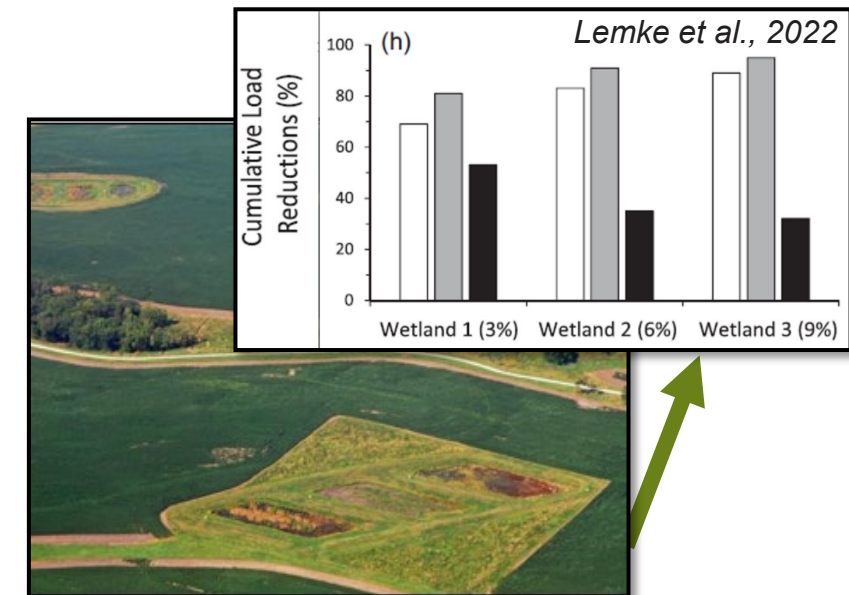
Opportunity:

Wetlands for nutrient retention provide dynamic P reduction BMP, capturing/retaining P in soil.

Current Status:

>150 wetlands completed/in-development in region

a) *P reduction BMPs have not yet met regional targets for watersheds*



Challenges → Scaled R&D

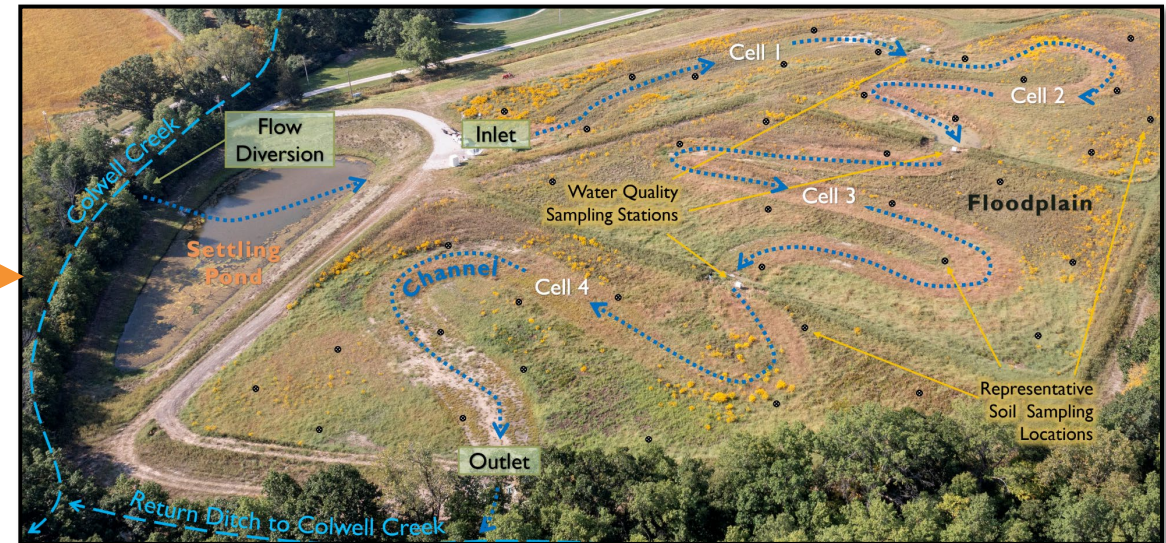
Challenges:

1. *Legacy P / P storage capacity @ sites*
2. *Limited lifecycle analysis*
3. *Few BMPs on managing watershed wetland*
4. *Scalability to watershed*

We need:

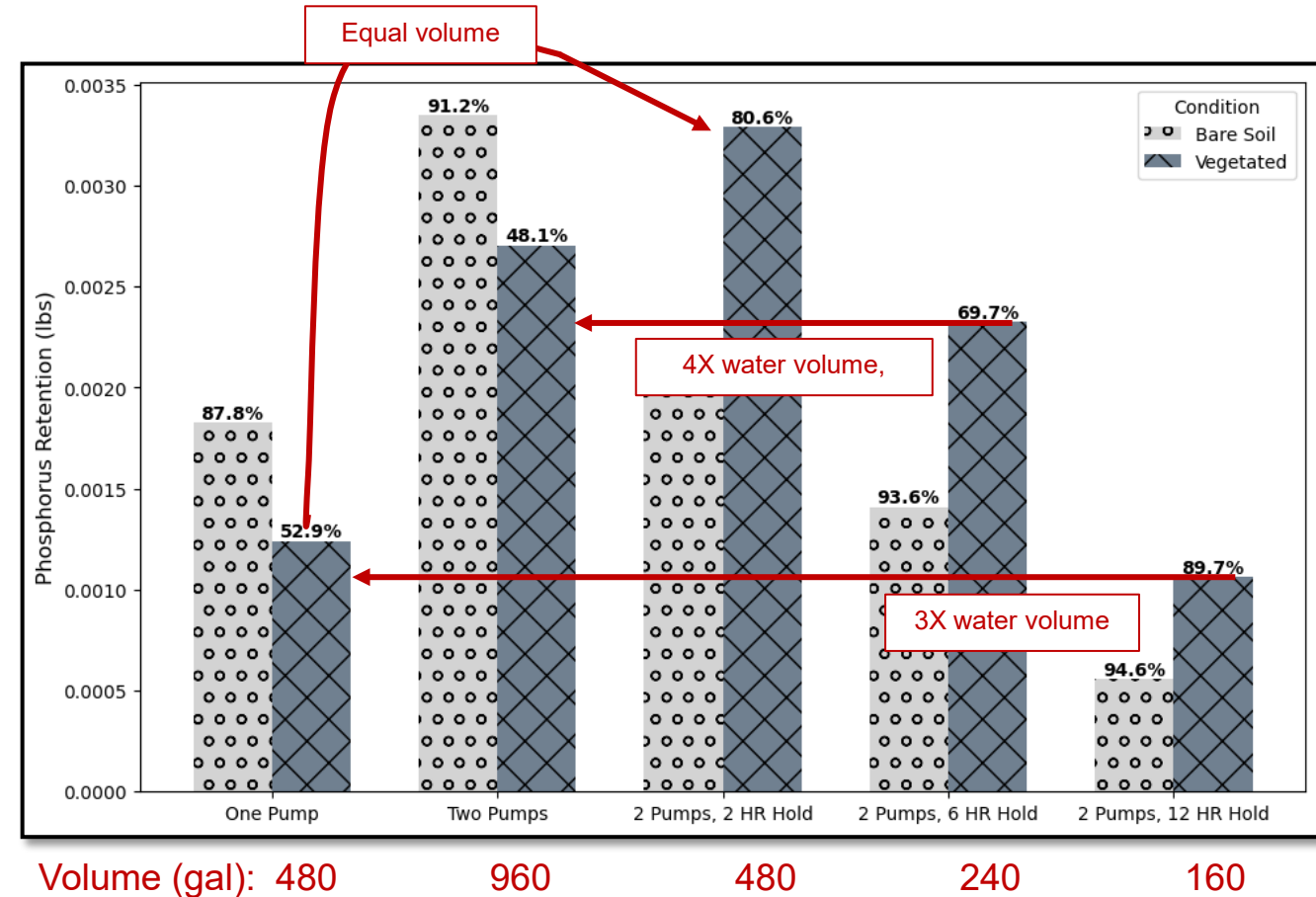
- Optimized Operations
- Long-Term Monitoring
- Adaptive Management Guidance

Operational R&D at multiple scales addresses these needs.



Optimizing Operations With Mesocosms

Mesocosm experiments test efficacy of operational scenarios before utilized at wetland demonstration site.



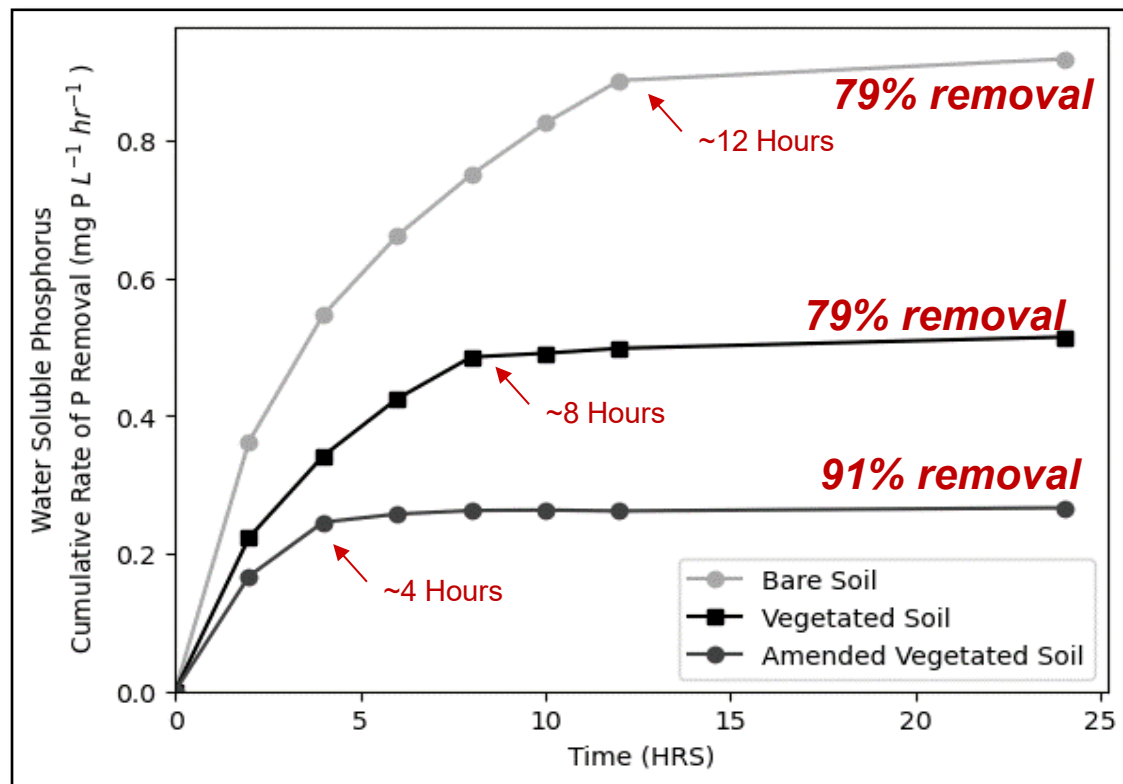
Scenario 1: Over 24 hours, varying hydropatterns can result in greater mass P retained (vegetated soils) with fraction of water volume.

Bare Soil P is highly efficient until saturation occurs.

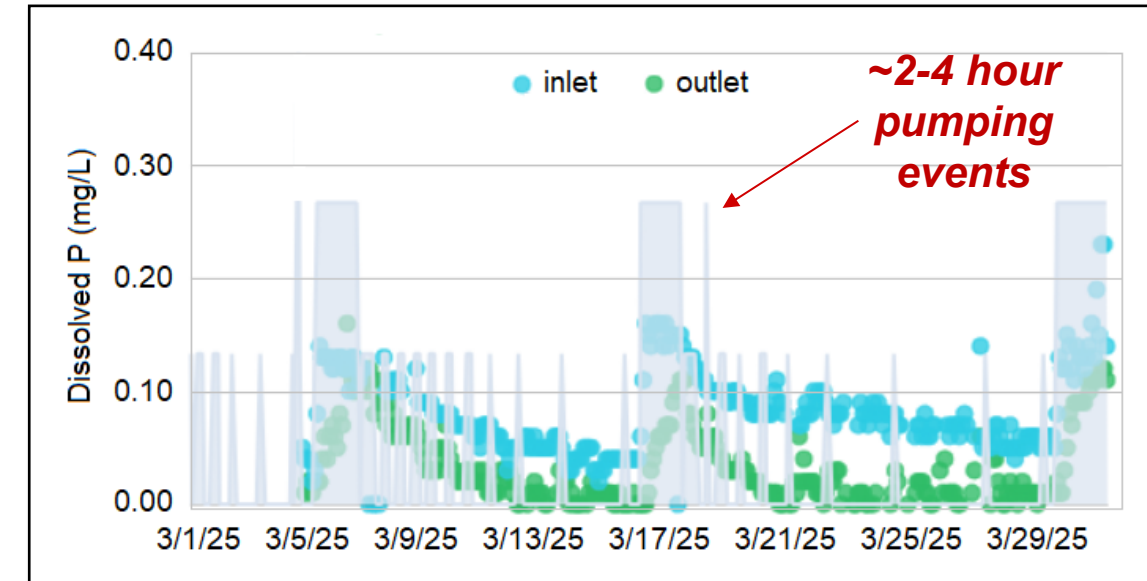
Mesocosms Results Translate To Field Scale!

Scenario 2: Hydraulic Residence Time (HRT)
provides opportunity for P to interact with soil/sediment,
limited by P conc & available soil sorption sites.

→ Vegetation/amendments can optimize P removal.



Dissolved P Time Series Plot (March 2025) via Limnotech

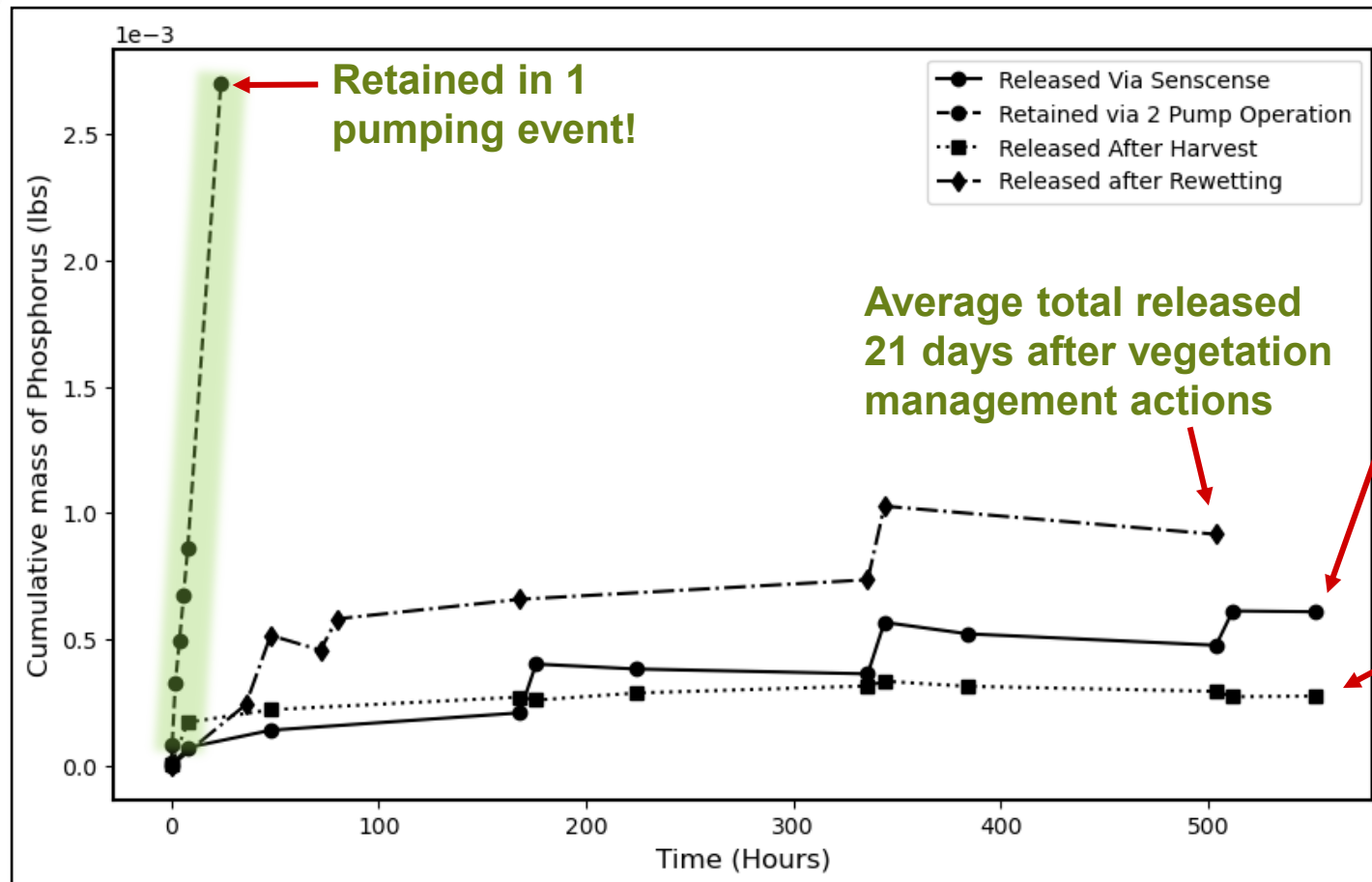


Verified by Wetland Demonstration (above):

- Dissolved P conc. reduced between wetland inlet and outlet by >50% most of the time.
- Greater reductions occur when hydraulic residence time is longer (i.e., for shorter duration pumping events).

Testing Management Actions First →

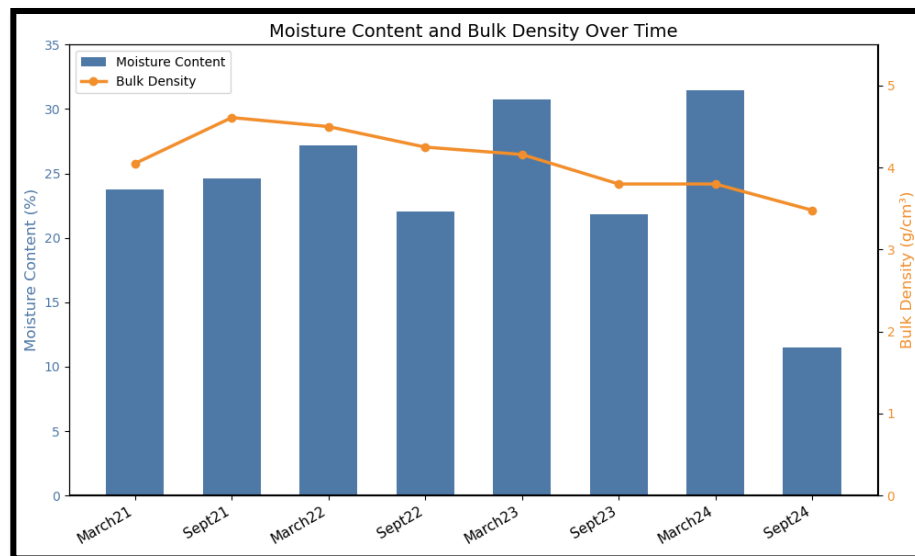
Scenario 3: Senescence & vegetation harvest release relatively low mass of P, ~ 5-7x less P than the amount retained in one 24-hour pumping event.



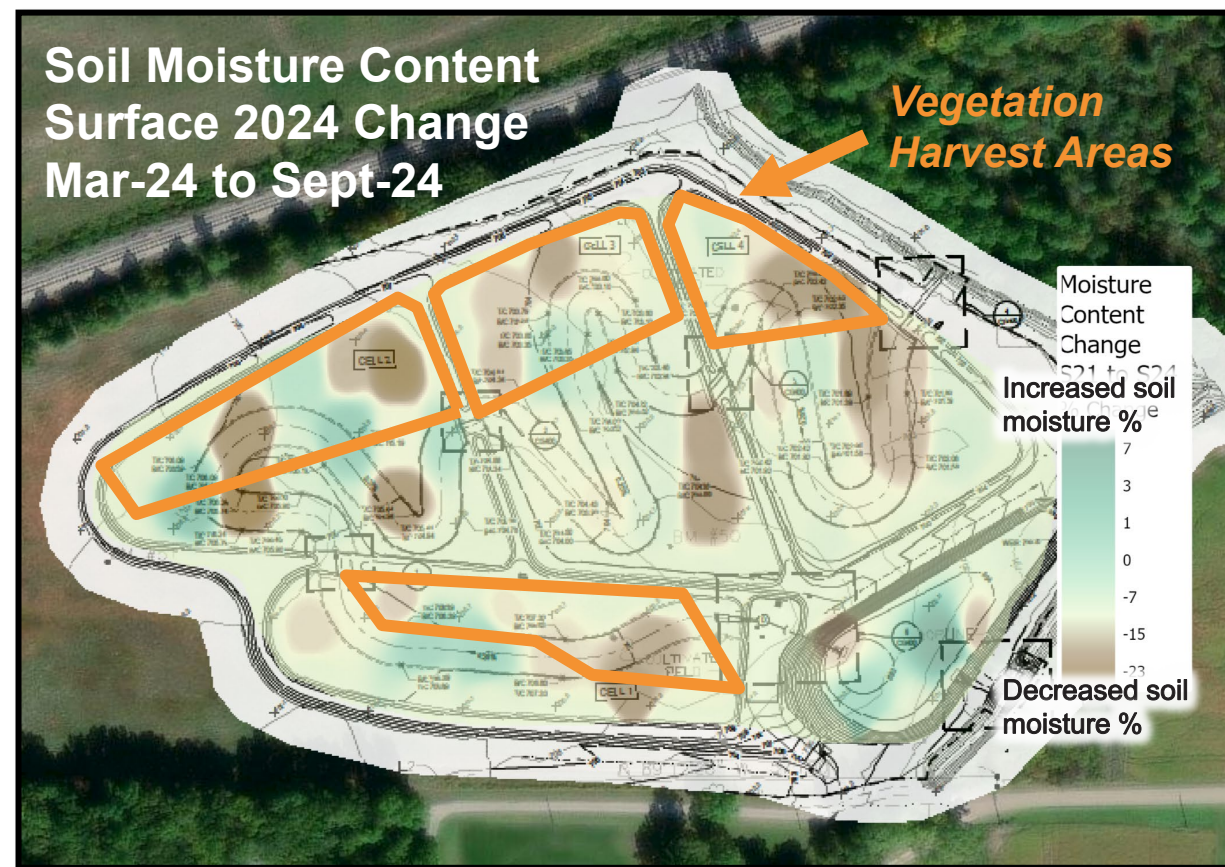
Provides Information For Field Demonstration!

Field-scale **vegetation harvest** demonstration
results in changes in bulk density & moisture
content.

~ 30% lower bulk density compared to previous
Mar → Sept 2023!

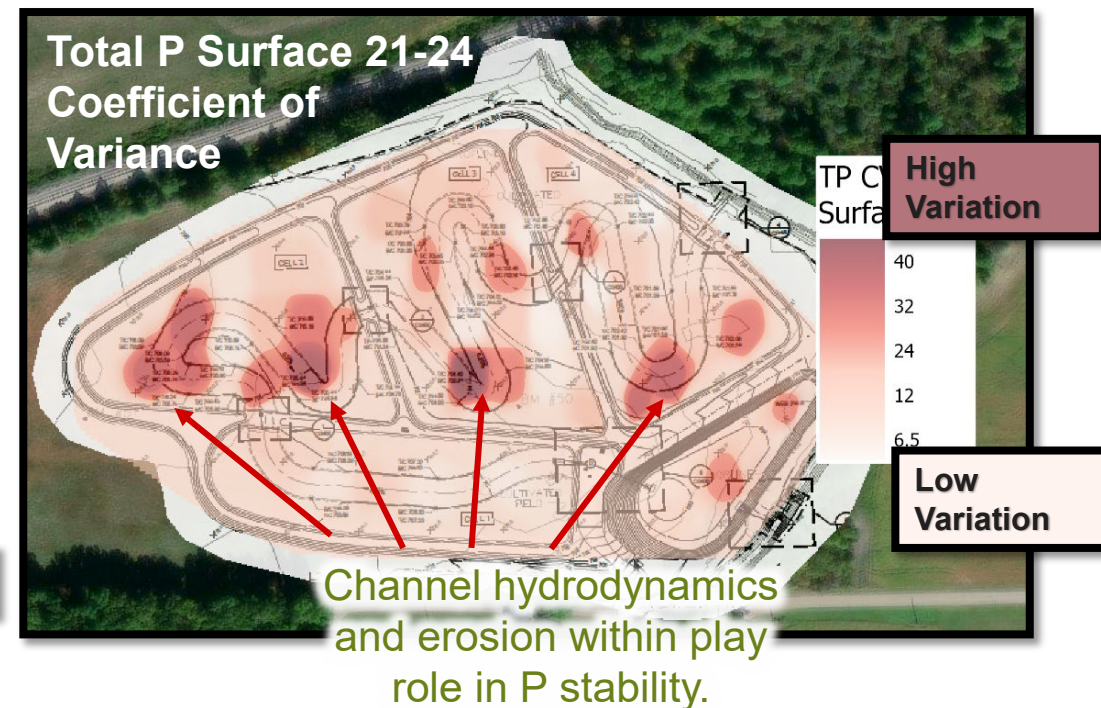
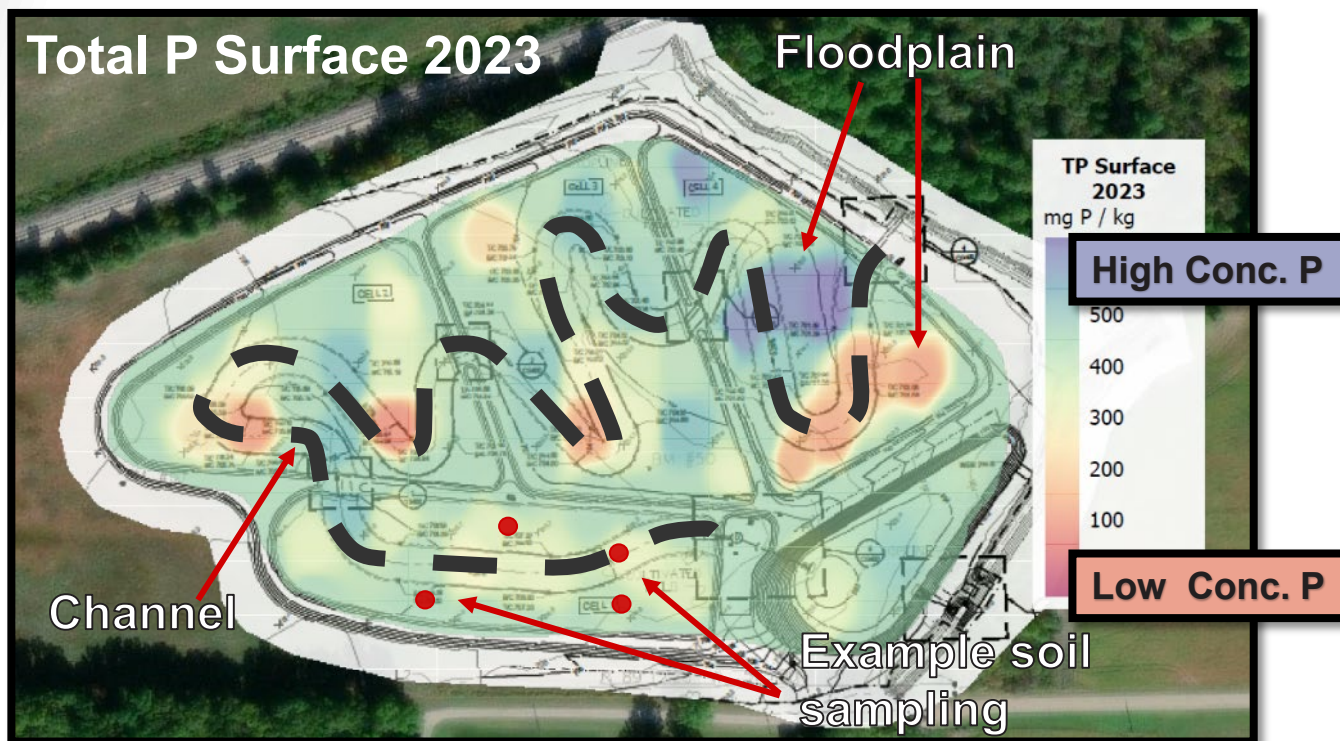


Cell 1 Spatial Average



Overall Performance Soil P Performance

Soil total P influenced by landscape and ecological gradients, (i.e., soil characteristics, inundation, and vegetation composition.)

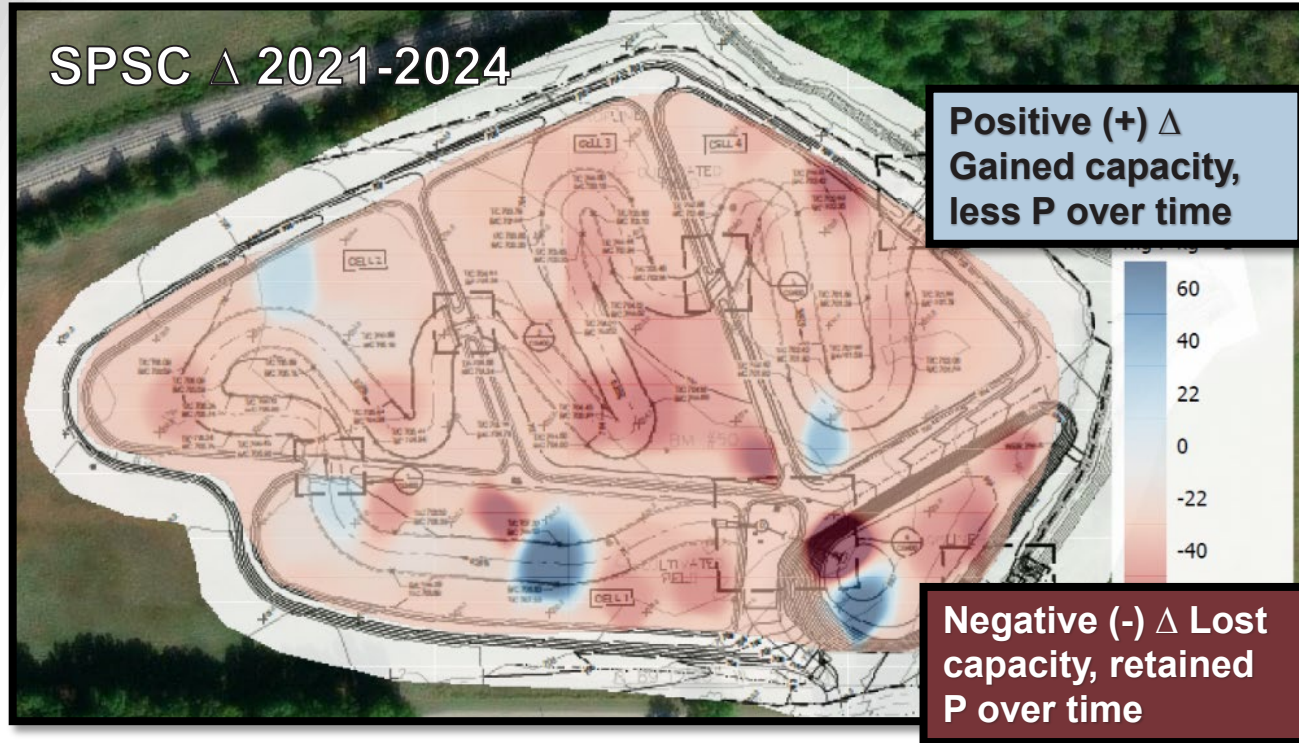


P varying & migrating within wetland does not mean it's leaving the system!

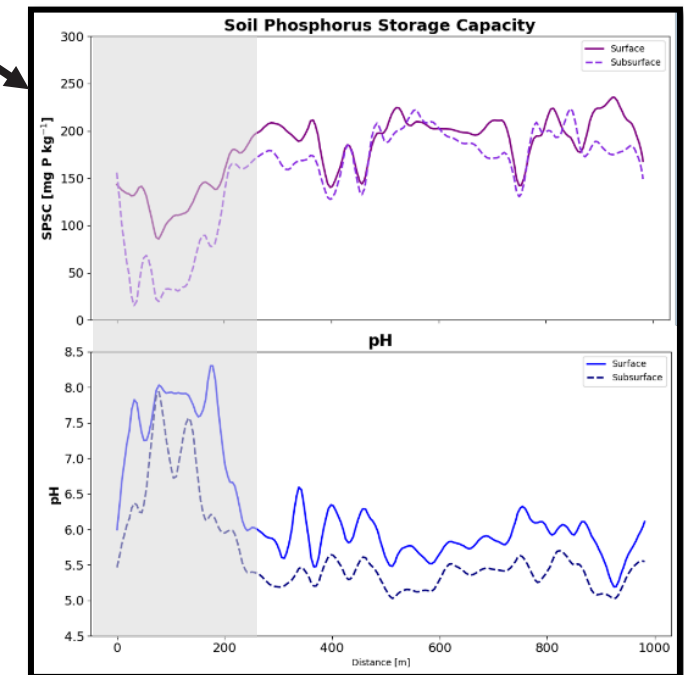


Spatial Changes In P Storage Capacity

Wetland soils have remained a SINK of P each year!



Example: Soil pH
& SPSC in Sept
2024 along
channel profile

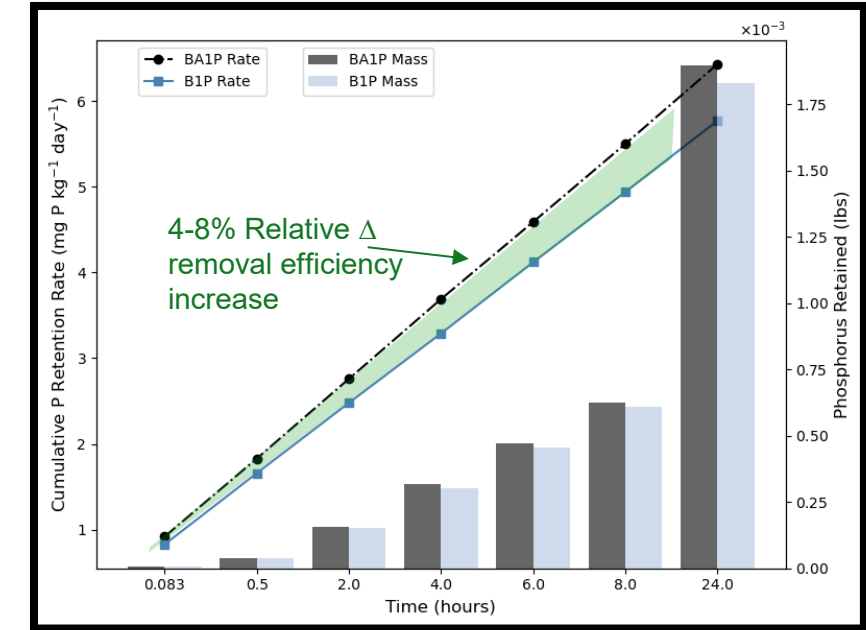


Soil properties strongly influence retention and capacity!
Fluctuating pH effects P solubility and metal oxide availability.

Future Directions & Opportunities:

1) Demonstrating emerging technologies:

- La doped Fe particles trap P permanently for physical removal from system.
- Short-term deployment during highest P concentration flows, increase retention by 20-30% in over 2 - 4 hours.



In-Prep, 2024

2) Phase 2 at Defiance P-Optimal Wetland coming in FY26

- Implementing structural changes and lessons learned.
- We would love to hear from you about opportunities to increase collaboration and leverage site for further research!



QUESTIONS AND CONNECTIONS

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Scan QR code to send us an email
or receive a copy of our nutrient
retention wetland guidance!



Practical Considerations for Wetland Design

Defiance P-Optimal:
Optimizing wetland
phosphorus retention in
the Lake Erie basin



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