June 6, 2024 | 3:30 p.m.
Battelle Chlorinated Conference

Remediating

HARMFUL ALGAL BLOOMS

Evaluation of Aluminum Sulfate (“Alum”) Dosing to Remediate Harmful Algal Blooms in Reservoirs

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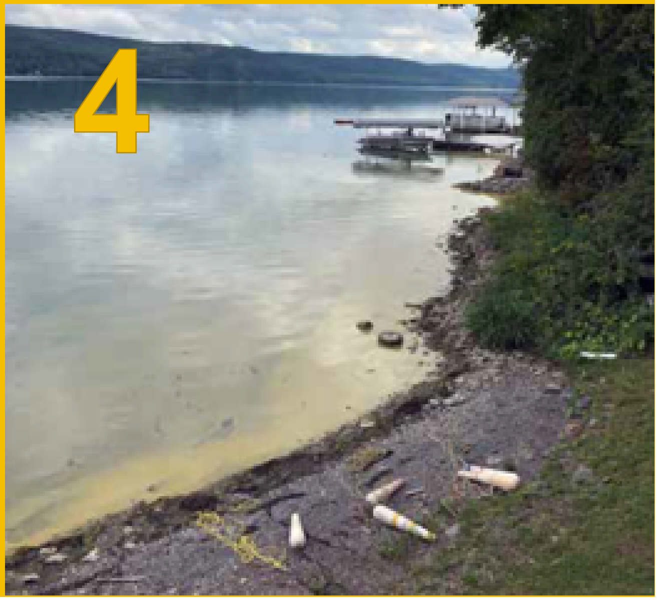
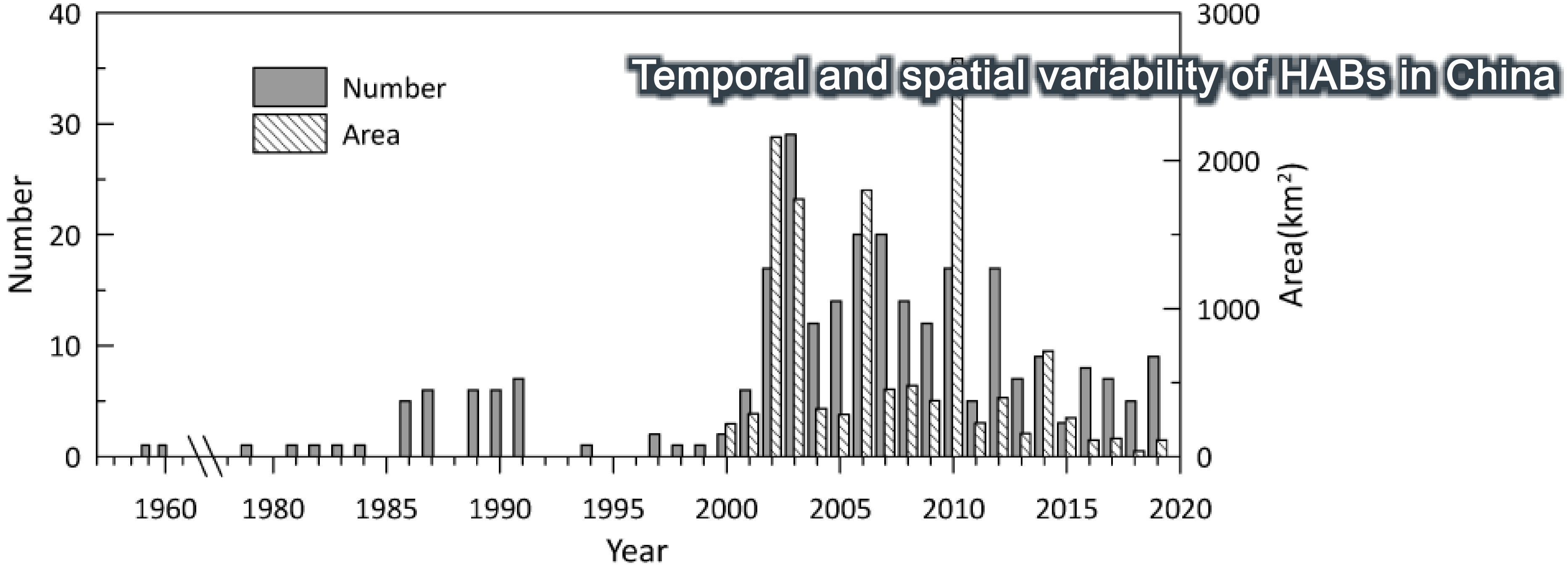
AGENDA

1. Background
2. Overview
3. Approach
4. Implementation
5. Results
6. Lessons Learned
7. Future Work

CAN YOU SPOT

THE HARMFUL ALGAL BLOOM?





Background

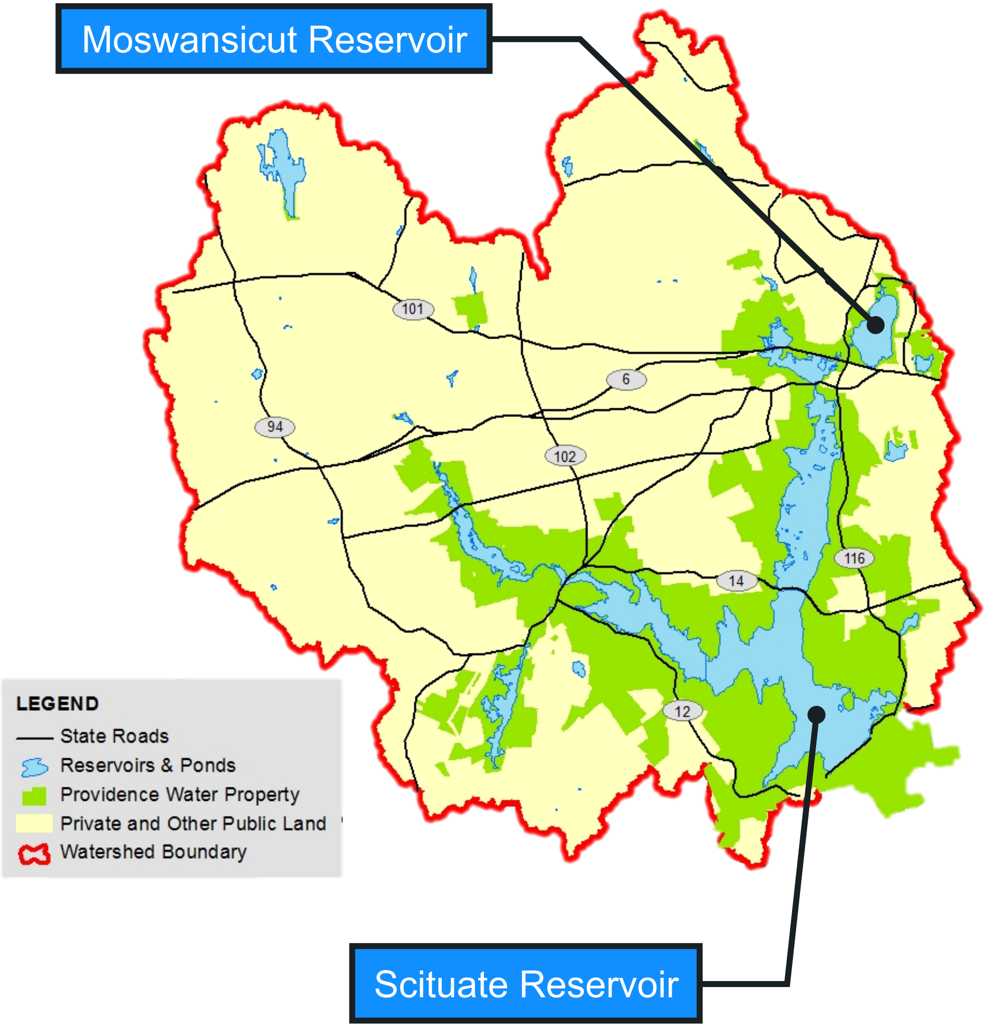
- **What are Harmful Algal Blooms (HABs)?**
  - Large, dense overgrowths of algae (“blooms")
  - Occur in fresh, marine, or brackish waters
  - Planktonic and benthic
  - Caused by excessive nutrients (“eutrophication”)
  - Nitrogen and phosphorus

- **Why are HABs a problem?**
  - Release toxins harmful to humans and wildlife
  - Oxygen depletion (“fish kills”, “dead zones”)
  - Pose challenges for drinking water treatment
  - Economic losses (fisheries, tourism, recreation)
  - Increasing frequency and intensity of HABs

Project Overview

Site Description, Scope of Work, and Project Objectives

- **Project Site: Moswansicut Reservoir, North Scituate, RI**
  - 286-acre natural reservoir
  - Operated by Providence Water Supply Board (PW)
  - Drains to Scituate Reservoir, PW's primary drinking water intake
- **Scope of Work: Treatment Program for recurring HABs**
  - Limnological assessment and data analysis
  - Treatment Program recommendation and application
  - Quantification of long-term treatment effectiveness
- **Objectives: Inhibit the growth and proliferation of HABs**
  - Minimize the production and release of toxins
  - Overall improvement of water quality
  - Restoration of ecological balance
  - Long-term sustainability



Project Approach

Three Phases of Project Execution

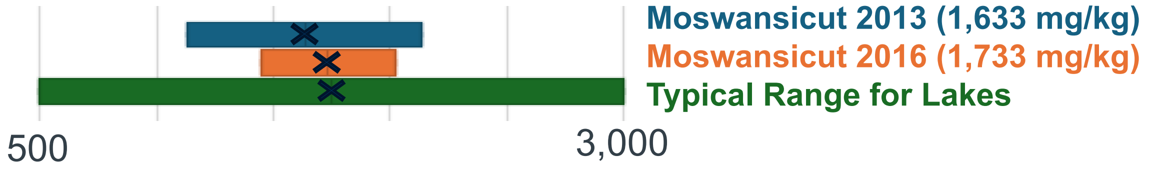
- **Limnological Assessment**
  - Baseline assessment of reservoir conditions
  - Framework to guide future watershed and in-reservoir management decisions
- **Treatment Program Development and Application**
  - Work Plan and regulatory coordination
  - Oversight of the treatment
  - Water quality monitoring before, during, and after treatment
- **Continued Water Quality Monitoring**
  - Evaluate long-term efficacy of Treatment Program
  - Warning system for future declines in water quality

Project Implementation and Results

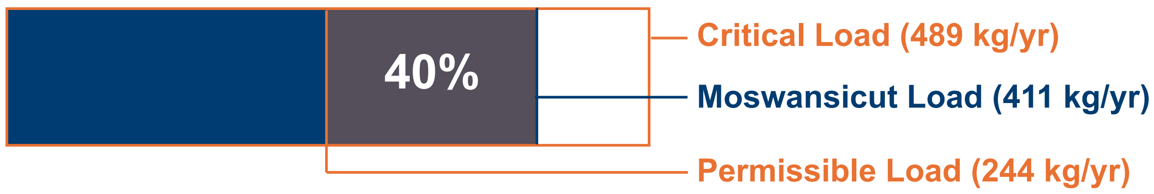
Limnological Assessment (2017 – 2018)

- **Activities**
  - **Historical Data Review:**
    - Summarize findings of previous studies
    - Identify data gaps
  - **Additional Data Collection:**
    - Reservoir water quality metrics, seasonal changes
    - Tributary water quality metrics
    - Shallow groundwater quality metrics along the shoreline
    - Biology metrics
  - **Update Recommendations for Management:**
    - Update nutrient budgets and trophic status
    - Identification of stressors on the reservoirs
    - Assessment of the potential impacts of climate change

- **Results**
  - **Trophic State: Mesotrophic, leaning eutrophic**
    - Summer HABs, prolonged period of hypolimnetic anoxia
  - **Sediments: High phosphorus concentrations**



  - **Nutrient Budget: 40% reduction in phosphorus**

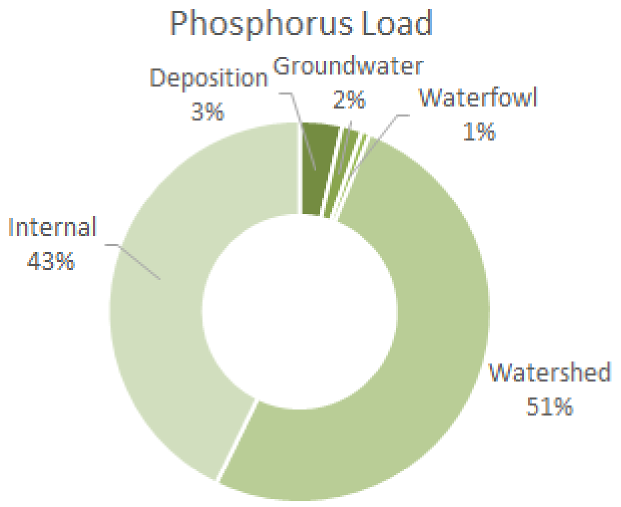


  - **Algae Speciation: Dominated by cyanobacteria**
    - Another potentially toxigenic species was also observed

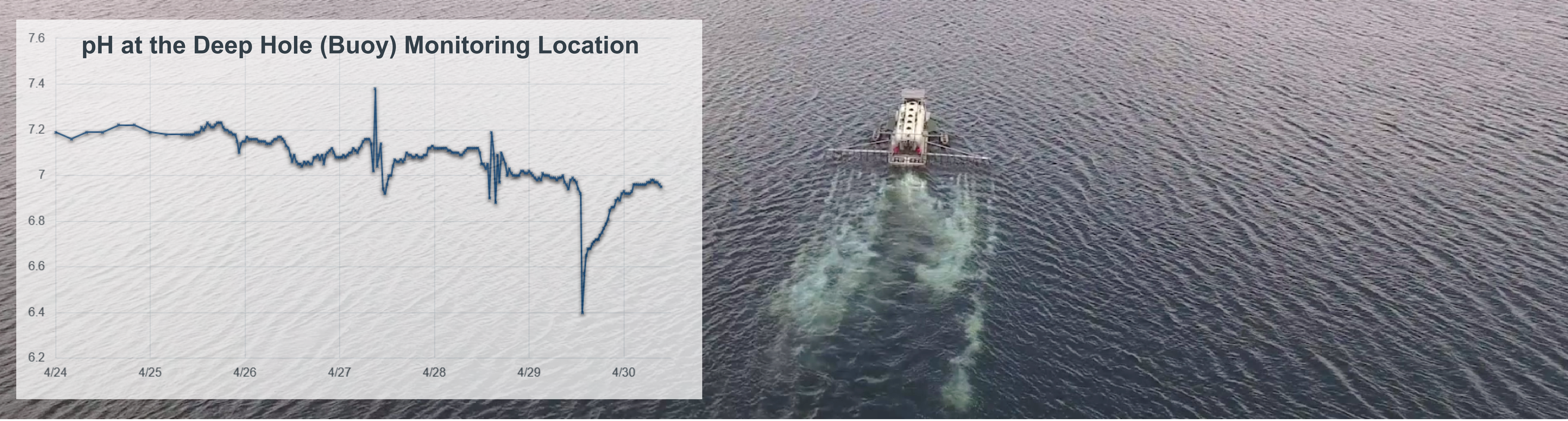
Project Implementation

Treatment Program Development and Application (2018)

- **Activities**
  - **Recommend Aluminum Sulfate (“Alum”) Treatment**
    - Flocculent strips water column of suspended sediments, algal cells, and phosphorous
    - Effective where excessive phosphorus is driving HABs
  - **February 2018: Work Plan Submission**
    - Alum delivery, storage, and application protocols
    - Water Quality Monitoring Program
    - Daily reporting protocols
  - **March 22, 2018: Regulatory Notification**
  - **April 24-29, 2018: Application to Reservoir**
    - 6 days of treatment, totaling 51.5 hours of application
    - Daily testing to verify chemical concentrations



Staging area, chemical storage tanks, and treatment vessel on April 26, 2018.



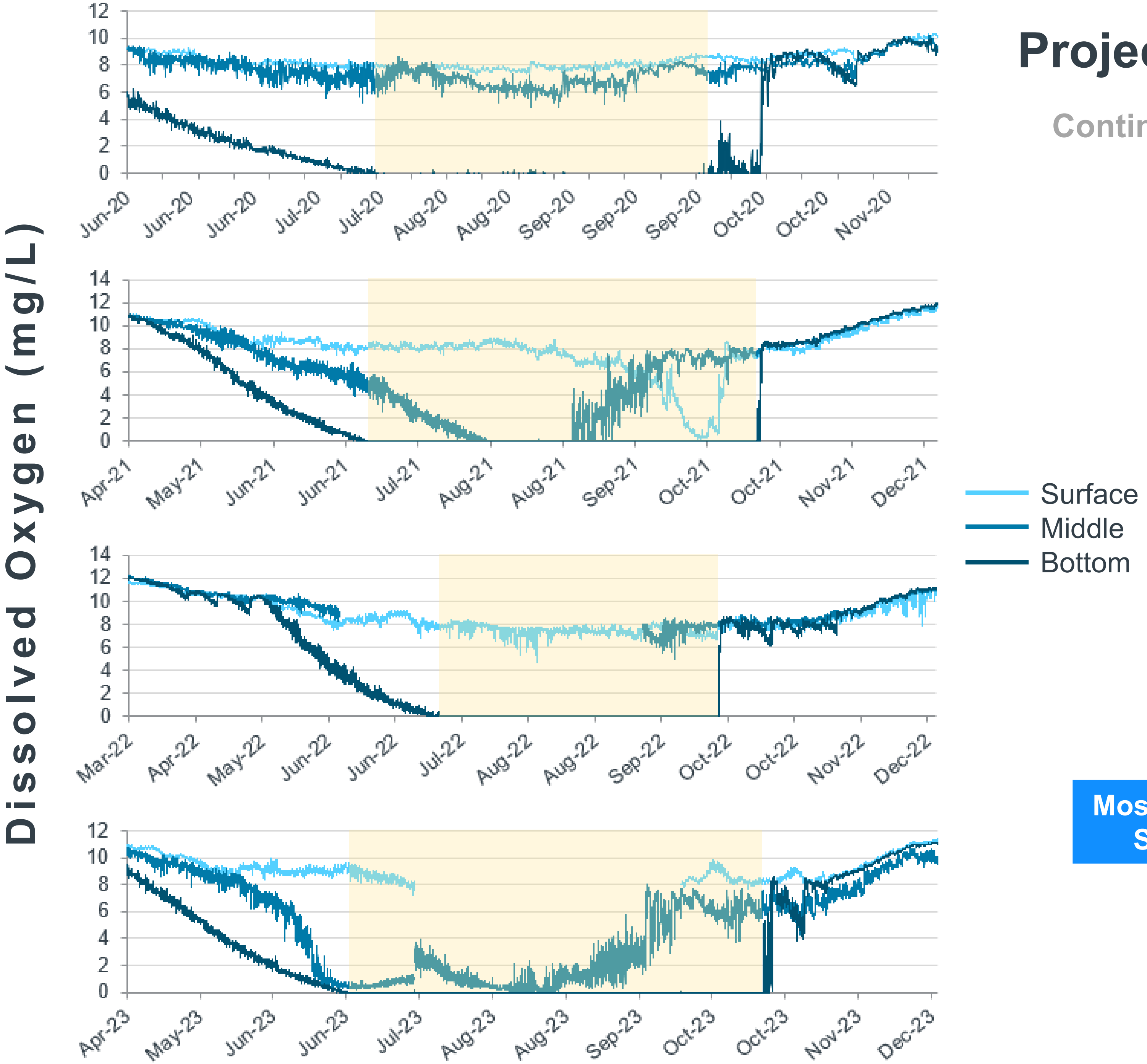
Project Implementation and Results

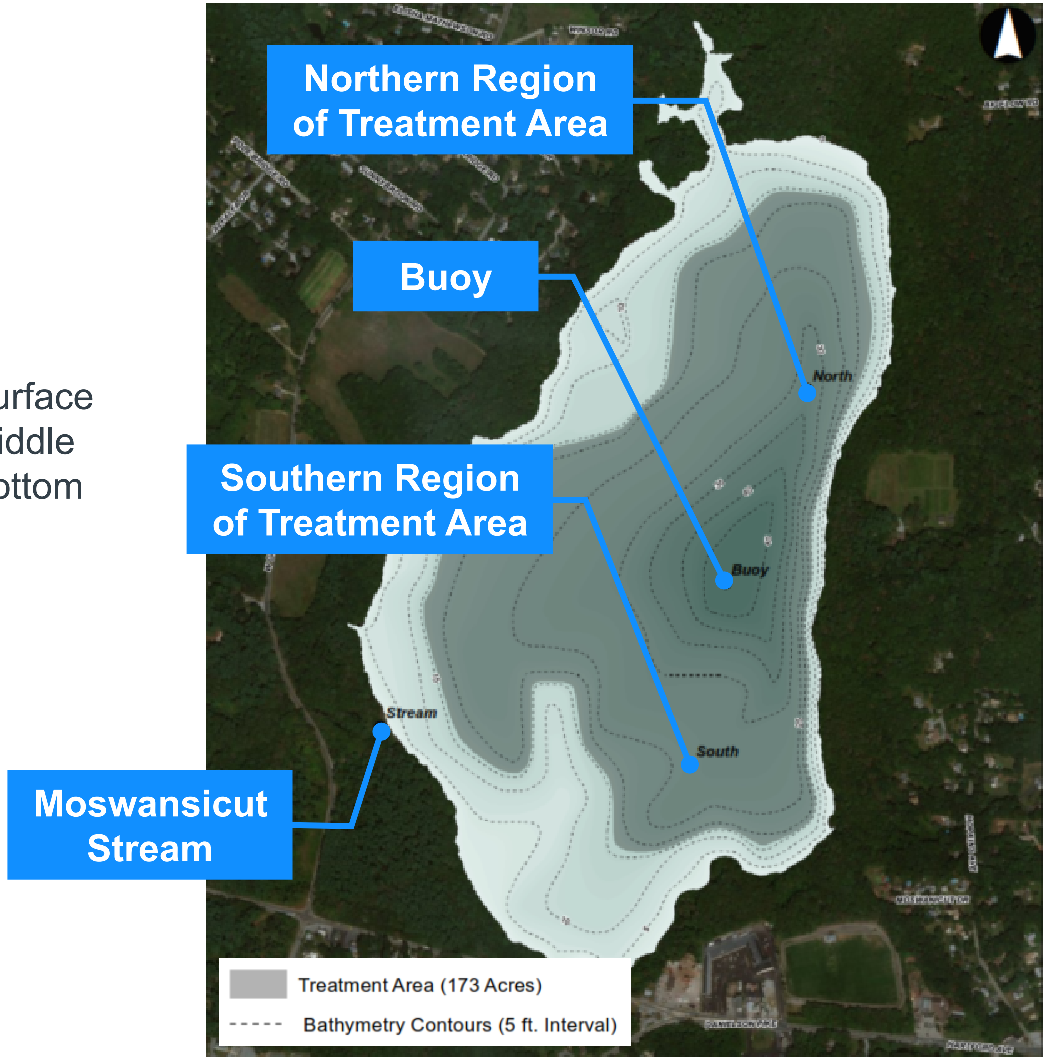
Treatment Program Development and Application (2018)

Parameter (unit)	Anticipated	Actual	Difference
Aluminum Sulfate (gallons)	70,058	70,359	301
Sodium Aluminate (gallons)	35,029	34,824	-205
Aluminum (lbs)	78,717	79,924	1,207
Treatment Area (acres)	173	173	0
Aluminum (g/m^2)	51	52	1

Project Implementation and Results

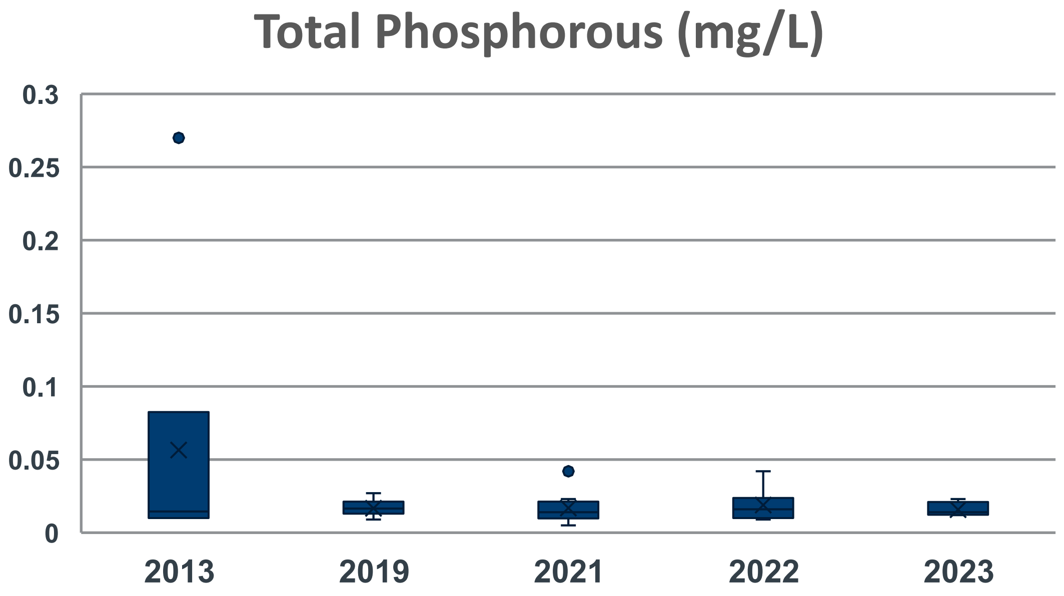
Continued Water Quality Monitoring (2018 – 2024)

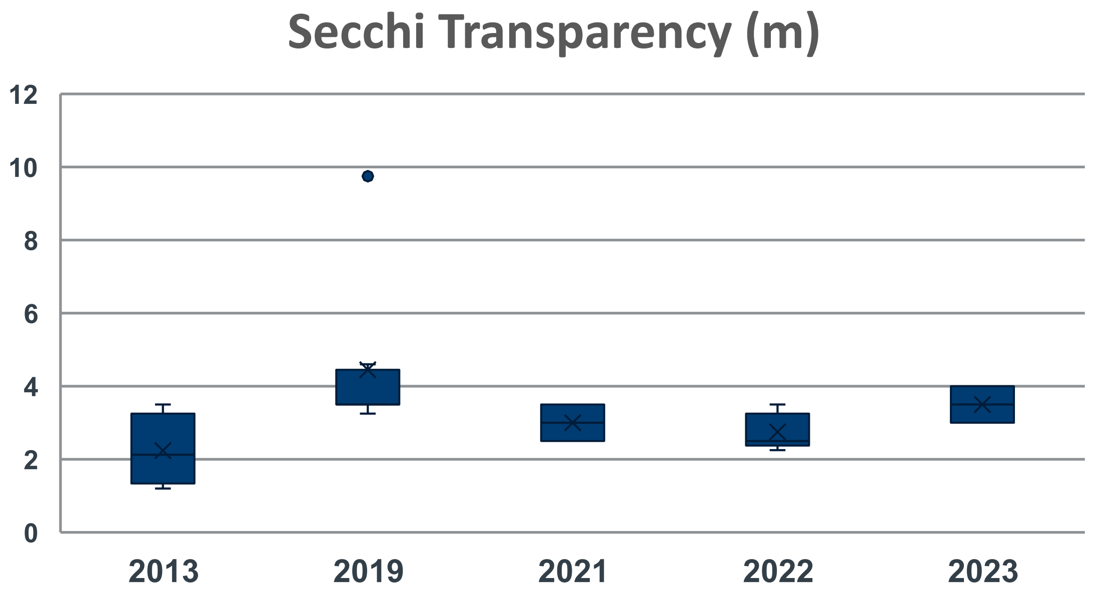


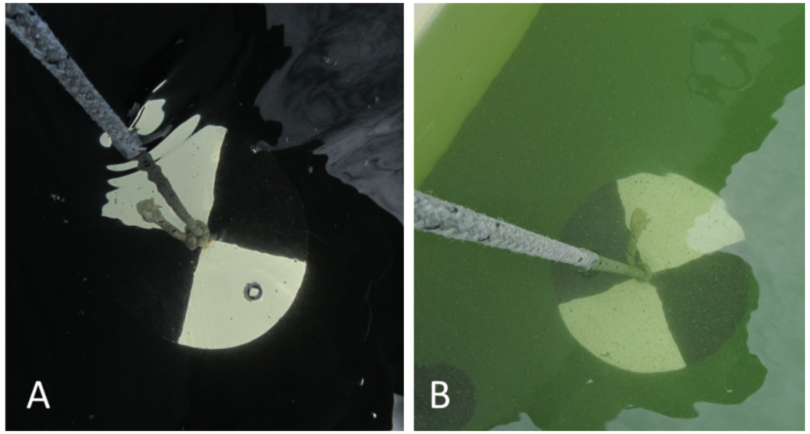


Project Results

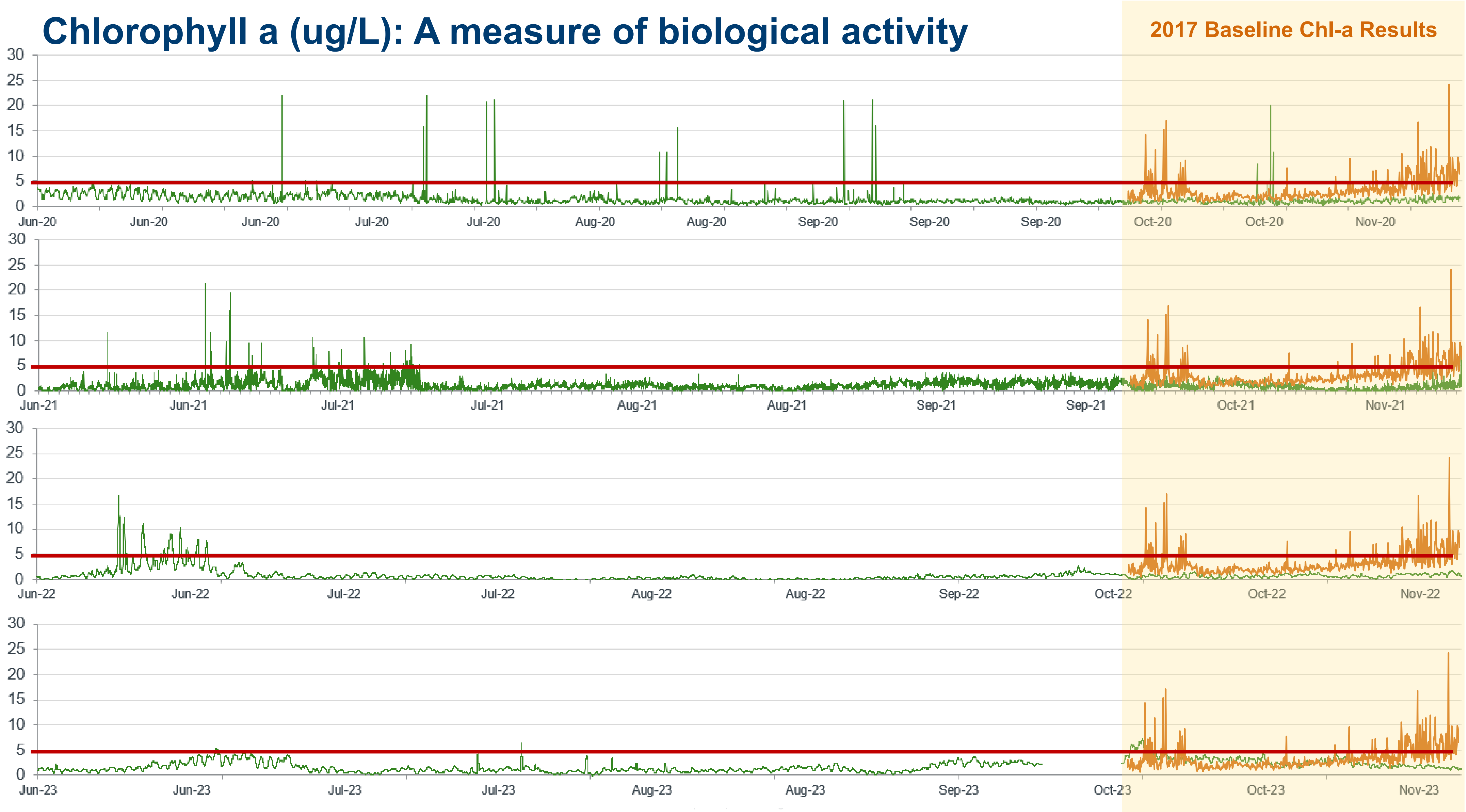
Continued Water Quality Monitoring (2018 – 2024)







Chlorophyll a (ug/L): A measure of biological activity



Conclusions and Lessons Learned

Moswansicut Reservoir Alum Treatment

- Low dissolved oxygen conditions (hypoxia) in bottom waters persist during stratification

BUT

- P concentrations throughout the water column trending lower
- Suggests that anaerobic P release from sediments is muted
- Slight improvement in water clarity based on Secchi Disk readings
- Chlorophyll a typically highest in June, however, generally remained under 5 µg/L
- Reservoir mixing in October and November slightly increases Chlorophyll a, however, values generally remain under 5 µg/L
- Most importantly, no cyanobacteria blooms have been observed since 2018 Alum Treatment

Future Work

Where is this technology headed?

- **Integration with other treatment methods**
  - Combine with other treatment methods, such as aeration or bioaugmentation
  - Achieve better outcomes and reduce costs
- **Optimization of dosing rates**
  - Optimal dosage can vary depending on specific characteristics of reservoir
  - Minimize costs while still achieving the desired outcomes
- **Development of new alum formations**
  - New formulations of alum have improved performance and reduced environmental impact
- **Assessment of long-term impacts**
  - Long-term impacts of alum treatment on reservoirs and their ecosystems are still not well understood
  - Long-term monitoring to assess the impacts of alum treatment on water quality, biodiversity, and other ecosystem variables
- **Application in developing countries**
  - Potential for improving water quality in developing countries, where access to safe drinking water is often limited
  - Development of low-cost methods for alum treatment

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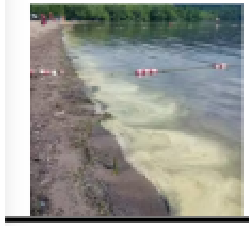
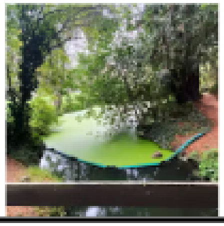
Can You Spot the HAB?



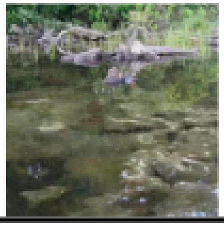
1

POLLEN



2

DUCKWEED



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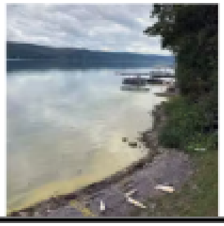
FILAMENTOUS CHAROPHYTE



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CYANOBACTERIA BLOOM

Thanks!

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