



PROACTIVE MITIGATION OF HARMFUL ALGAE BLOOMS THROUGH REAL-TIME REMOTE MONITORING & NUTRIENT MITIGATION

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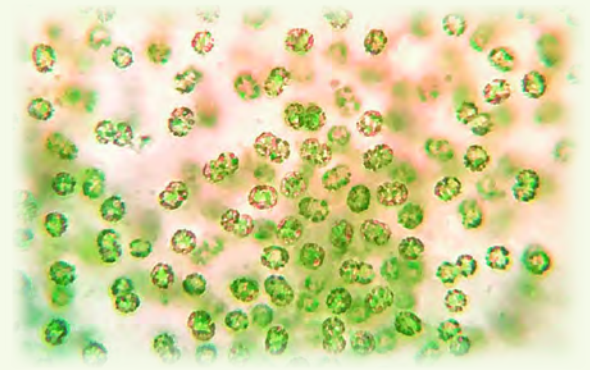
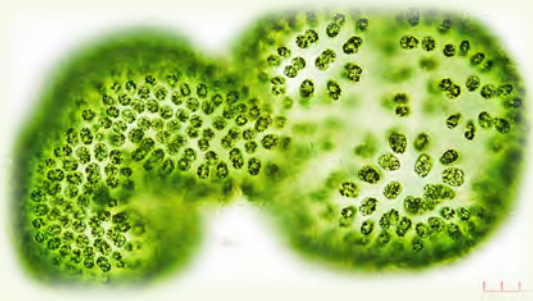
PRESIDENT

AMARÛQ ENVIRONMENTAL SERVICES & CLEARCHANNELVM

PREPARED FOR THE WESTERN AQUATIC PLANT MANAGEMENT
SOCIETY'S 43RD ANNUAL CONFERENCE
SACRAMENTO, CALIFORNIA 2025

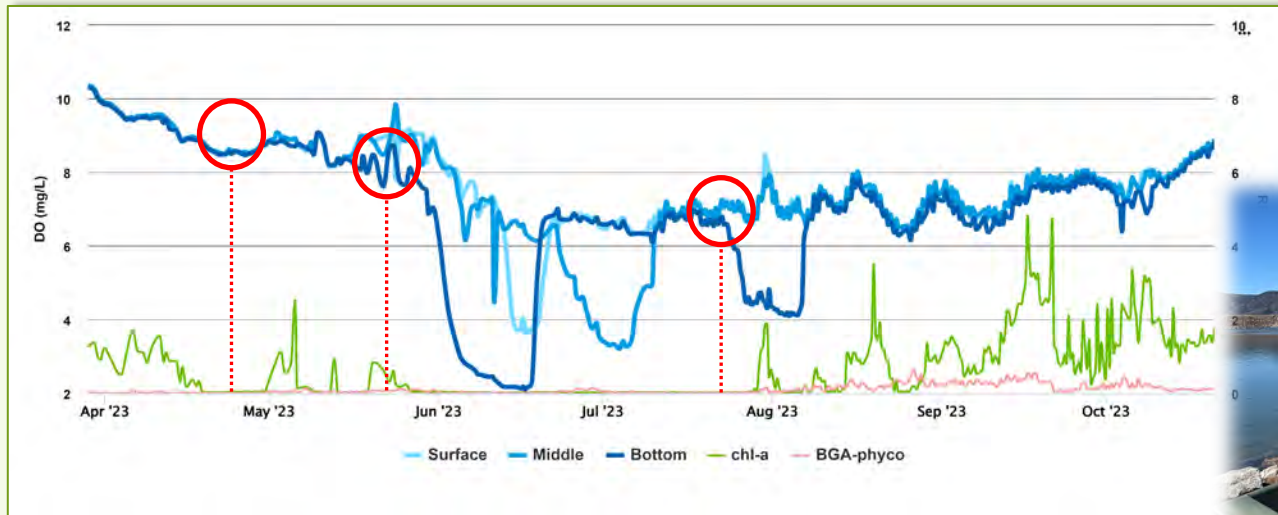
EXECUTIVE SUMMARY

- NUTRIENT MANAGEMENT BASICS
- SITE LOCATION & BACKGROUND
- TP MITIGATION PROGRAM 2024
- MANAGEMENT PLANS 2025
- Q&A



MANAGEMENT DECISION TRIGGERS – IN PRACTICE (NALMS 2023⁺)

“21st Century Management of Harmful Algae Blooms in Drinking Water Reservoirs: Advantages of Near Real-Time Remote Monitoring in Management Decision Trigger-based Programs”



PROACTIVE RESERVOIR MANAGEMENT TRIGGERS

TARGET: INTERRUPTING THE PHOSPHORUS CYCLE

1. SEASONAL TEMPERATURE INCREASE ($>12^{\circ}\text{C}$) - **MONITOR**
2. BIOLOGICAL PROCESSES DRIVE BENTHIC ANOXIA – **DRIVE AERATION SYSTEM**
3. HYPOLIMNETIC PHOSPHORUS DIAGENESIS – **MITIGATE POTENTIAL FRP**
4. CHL- α BGA-PC PRODUCTION – **MITIGATE CHLOROPHYTA & CYANOBACTERIA**
5. WWTP OPERATIONS & STAKEHOLDERS NOTE T&O ISSUES – **TOO LATE!**

SITE LOCATION & BACKGROUND

SITE SPECIFICS

PUBLIC DRINKING WATER UTILITY

SURFACE AREA: 13.3 HECTARE

DEPTH_{AVG} ≈ 4M

DEPTH_{MAX} ≈ 10.1M

VOLUME: ± 446.2K M³

SITE MANAGEMENT ISSUES

RECURRENT HARMFUL ALGAE
BLOOMS

1^o: *MICROCYSTIS*, *WORONICHINIA*
SPP.

TASTE & ODOR ISSUES LEAD TO
RELIANCE ON WELL WATER MID-
SEASON

NUTRIENT MITIGATION PROGRAM

Map & Measure – BioBase™

Shock – GreenClean® PRO

Lock – Phoslock® 5% LMB

Lab Services – SePRO Corp

Monitor – in-Situ™ & LakeTech™

 LakeTech BioSafe Systems PET

SITE LOCATION & BACKGROUND



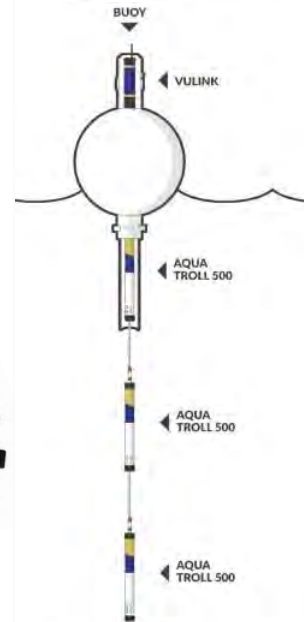
SITE MONITORING ARRAY

**3X IN-SITU ENVIRONMENTAL AQUA
TROLL 700's MPS + VULINK
TELEMETRY**

MONITORING DEPTHS: -3', -12', -20'

**READINGS TAKEN HOURLY, UPLOADED
DAILY**

**PH
DISSOLVED OXYGEN / TEMP
CONDUCTIVITY
CHLOROPHYLL- α
PHYCOCYANIN**



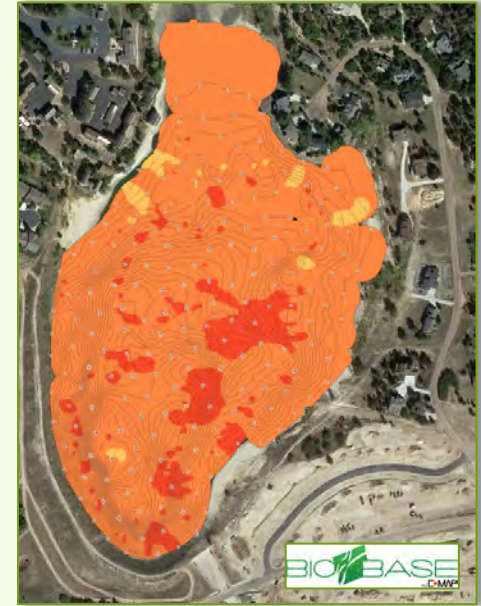
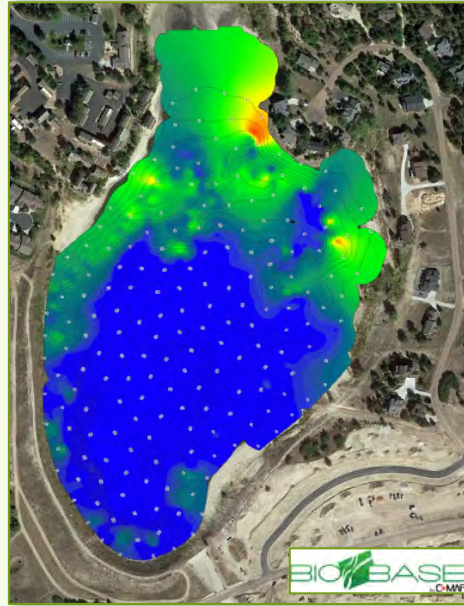
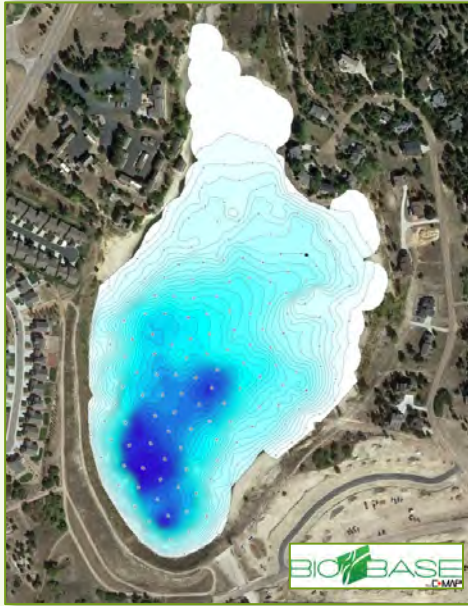
SITE WET CHEMISTRY

QUARTERLY SAMPLING DEPTHS: -3', -12', -20'

**TURBIDITY
CONDUCTIVITY
FRP/ TP
CHL-A
ALKALINITY
HARDNESS
NITRATE/ NITRITE / TKN / TN
pH**



NUTRIENT MITIGATION PROGRAM DEVELOPMENT - 2023



Test	Method	Results	Sampling Date / Time
Turbidity (NTU)	EPA 180.1	3.6	01/10/2023
Conductivity (uS/cm)	EPA 120.1	446.0	
Free Reactive Phosphorus (ug/L)	EPA 365.3	5.4	
Chlorophyll a (ug/L)	EPA 445	90.4	
Total Phosphorus (ug/L)	EPA 365.3	58.8	
Alkalinity (mg/L as CaCO3)	EPA 510.2	97.1	
Total Hardness (mg/L as CaCO3)	EPA 130.2	162.8	
Total Nitrate (mg/L) and Nitrite (mg/L)	Campbell et al 2004	0.1	
Nitrite (mg/L)	Campbell et al 2004	<0.02	
Nitrate (mg/L)	calculated	0.1	
Total Kjeldahl Nitrogen (mg/L)	EPA 351.2	1.3	
Total Nitrogen (mg/L)	calculated	1.4	
pH	EPA 150.1	8.8	

NUTRIENT (P) MITIGATION CALCS

- TARGETED REDUCTION OF 163KG TP FROM SEDIMENTS
- 2024: 18.12MKG PHOSLOCK®
- 2025: 18.12MKG PHOSLOCK®
- PRE-DOSE WATER COLUMN P RELEASE
 - 2.7MKG GREENCLEAN® PRO APPLIED 24 PRIOR TO EACH APPLICATION (204.5KG/HA)

Mobile Phosphorus† Fraction (mg P/kg)	Apatite and Residual (mg P/kg)	Sum of Phosphorus Fractions (mg P/kg)	% Solids (% Dry Wt.)
20.6	346.2	366.8	68.5

NUTRIENT MITIGATION “PRE” TREATMENT – PEROXIDE SHOCK



2024 “**SHOCK** & **LOCK**” PROGRAM

- DORMANT *MICROCYSTIS*,
WORONICHINIA SPP. COLONIES 1°
SPECIES OF CONCERN
- EXTENSIVE DATASET FOR SITE LEGACY
NUTRIENT LOAD (WATER & SEDIMENT)
- WATER COLUMN P RELEASE THROUGH
SHOCK TREATMENT OF GREENCLEAN®
PRO
- 24-HOUR REST THEN NUTRIENT (P)
LOCK TREATMENT

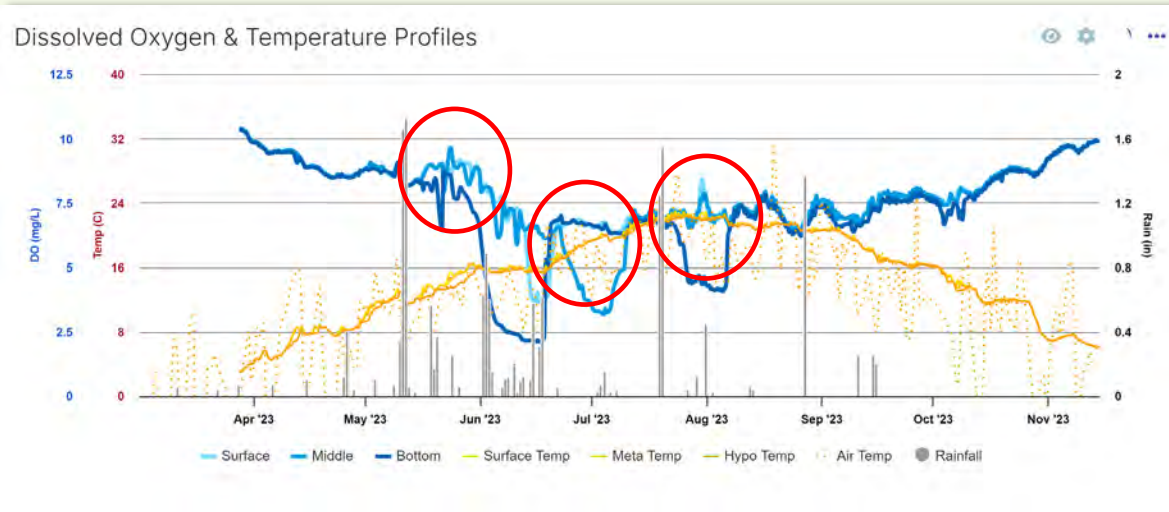


**HOW DO YOU APPLY GREENCLEAN® PRO
AND/ OR
PHOSLOCK® LANTHANUM-MODIFIED
BENTONITE?**



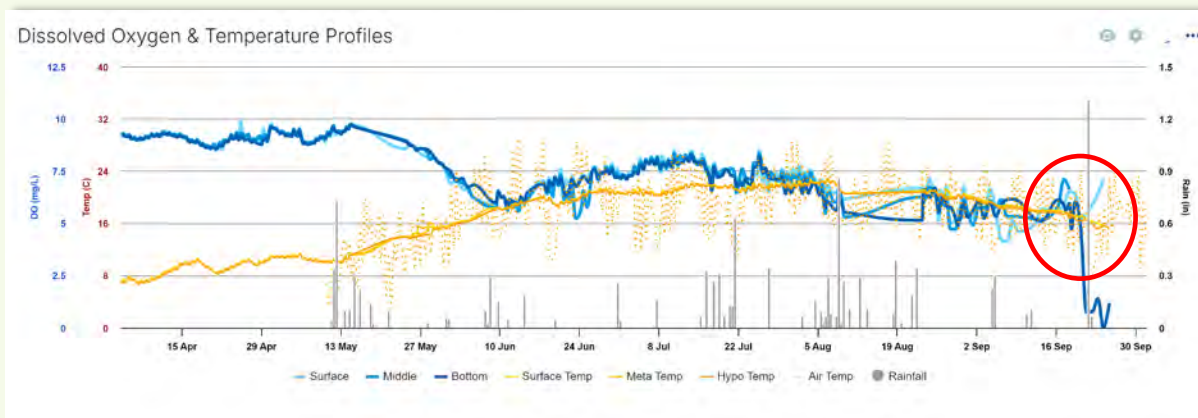
ENVIRONMENTAL DRIVERS - 2023 V. 2024

2023



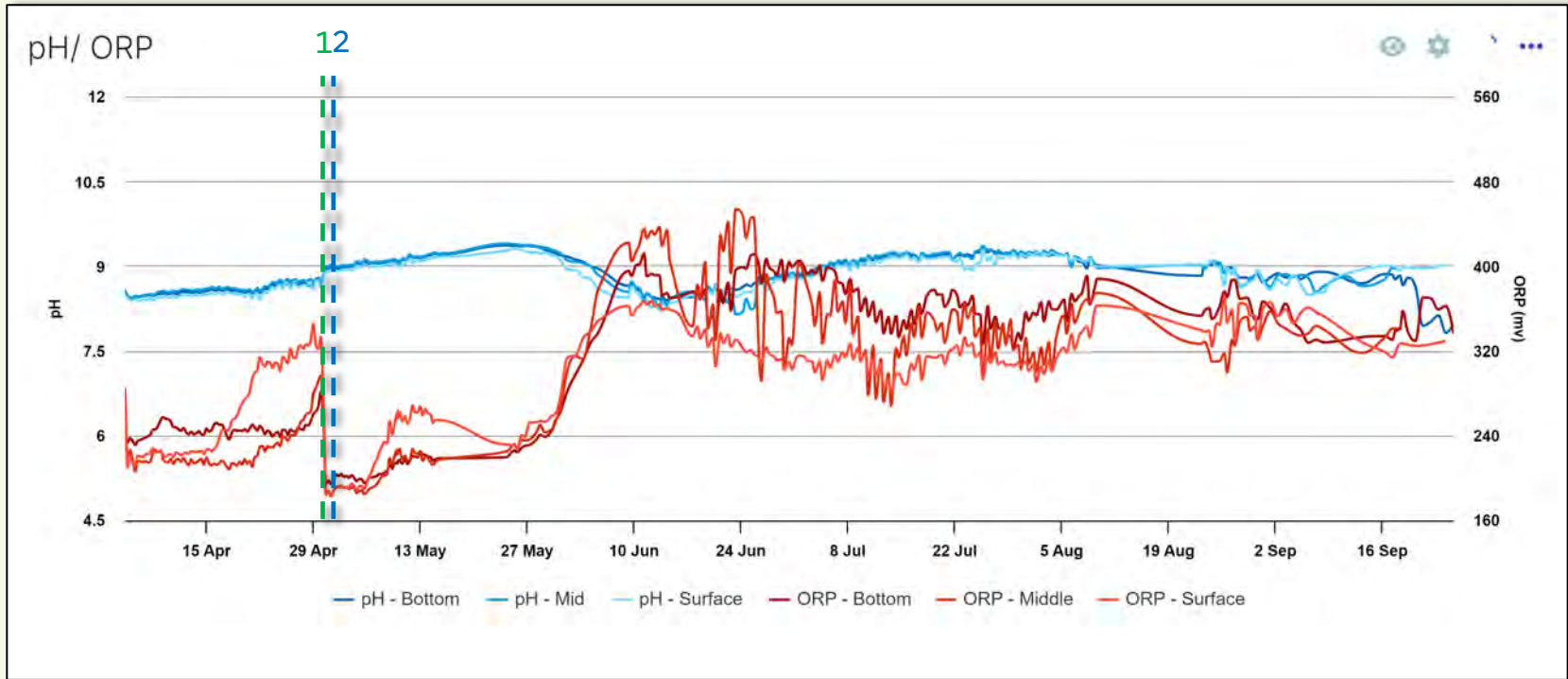
- **SEVERAL AERATION SYSTEM OUTAGES**
- SHORTER SPRING WEATHER WITH ONSET OF $>12^{\circ}\text{C}$ TEMPS BY 01MAY
- LARGER, LESS FREQUENT PRECIPITATION EVENTS

2024



- AERATION SYSTEM **MOSTLY** OPERATIONAL
- LONGER SPRING WEATHER WITH ONSET OF $>12^{\circ}\text{C}$ TEMPS BY 01JUNE
- SMALLER, MORE FREQUENT PRECIPITATION EVENTS

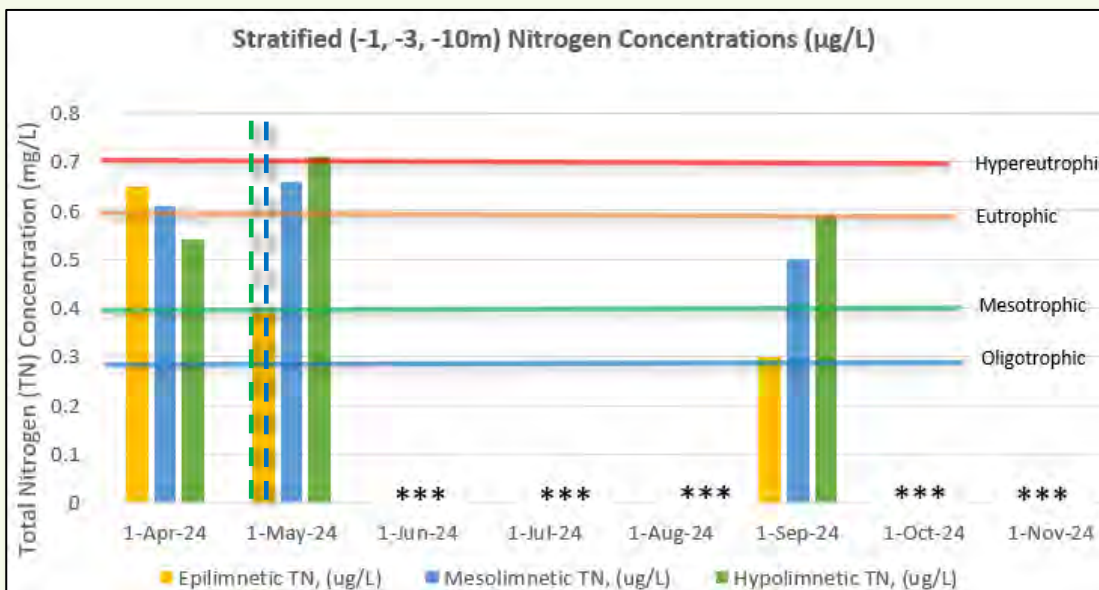
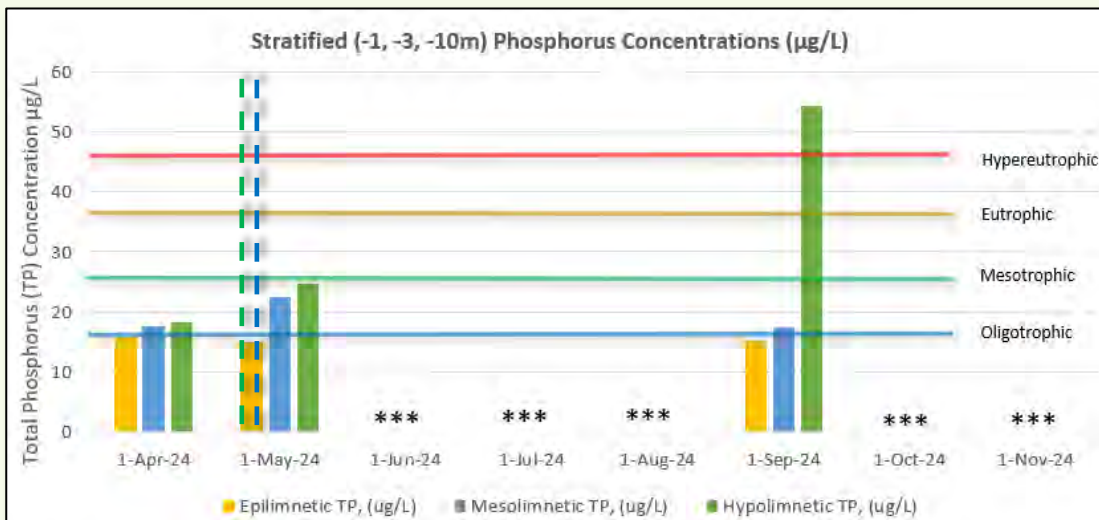
MONITORING PROGRAM – INCORPORATED pH/ORP SENSORS 2024 SEASON



2024 NUTRIENT MITIGATION “SHOCK & LOCK” PROGRAM

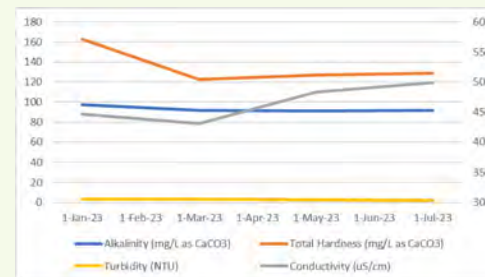
- 1: 30APR24 204.5KG/HA GREENCLEAN® PRO APPLIED
- 2: 1-3MAY 18.12MKG PHOSLOCK® 5% LANTHANUM-MODIFIED BENTONITE (LMB) APPLIED
- pH UNAFFECTED. NO NEGATIVE EFFECT IN DWTP OR RISK TO NON-TARGET MACROFAUNA
- OXIDATION REDUCTION POTENTIAL (ORP) DECREASED ± 2 WAT, RETURNED TO NORMAL
- DWTP NOTED SIGNIFICANT INCREASED DEMAND FOR PAC FLOCCULANT POST-TREATMENT
LIKELY A RESULT OF BENTONITE SLURRY, LYSSED ALGAL PROTEINS

WET CHEMISTRY DATA (TP/FRP, TN) 2024

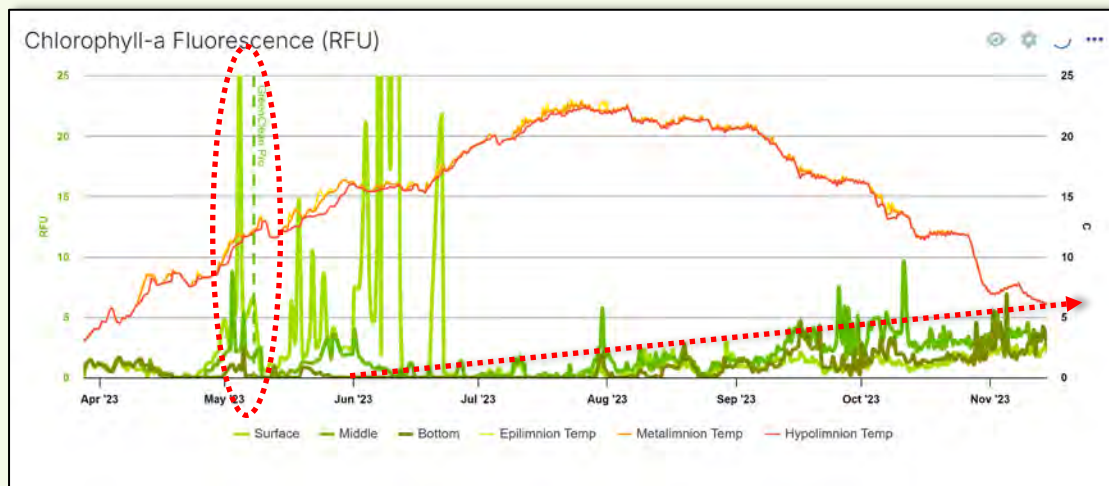


2024 MITIGATION PROGRAM

- SAMPLES SENT FOR LABORATORY ANALYSIS APR, MAY, JUL, SEP
- HYPOLIMNION TP VALUES REFLECT AERATION SYSTEM SHUTDOWN, REMAINDER OF PHOSLOCK® EXHAUSTED DUE TO LEGACY LOAD
- $\text{LaCl}_3 + \text{H}_2\text{O} \rightarrow \text{La}^{+3} + \text{Cl}^- + \text{H}_2\text{O} \rightarrow \text{LaPO}_4$
- TN VALUES EUTROPHIC THROUGHOUT SEASON, NO REAL CHANGE
- NOT DISCUSSED: TURBIDITY (NTU), CONDUCTIVITY (µS/CM), FRP (**ND**), ALKALINITY, HARDNESS, NO₃/NO₂, TKN



2024 NUTRIENT MITIGATION PROGRAM RESULTS – CHLOROPHYLL α

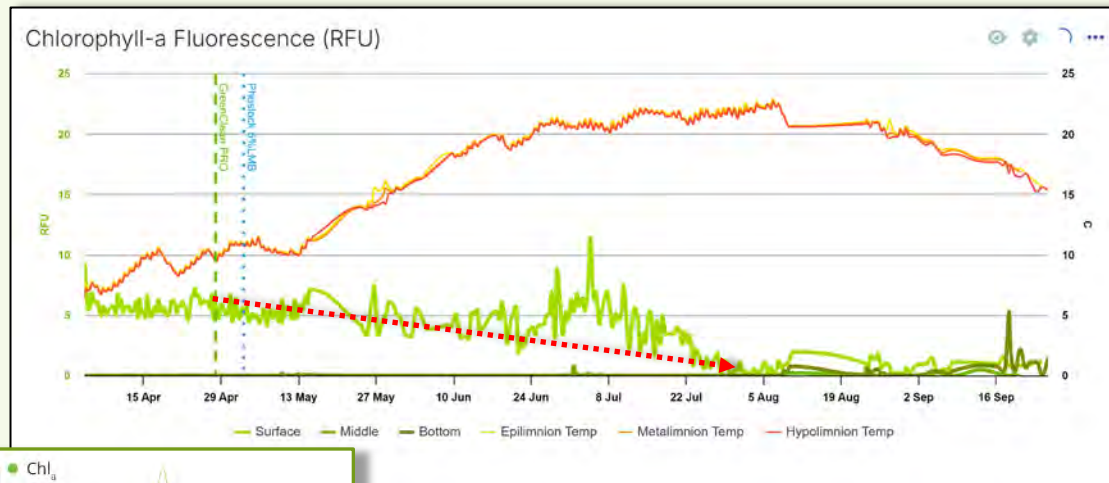


2023 **SHOCK** PROGRAM

HAB-TARGETED (MIRCROCYSTIS SPP.)

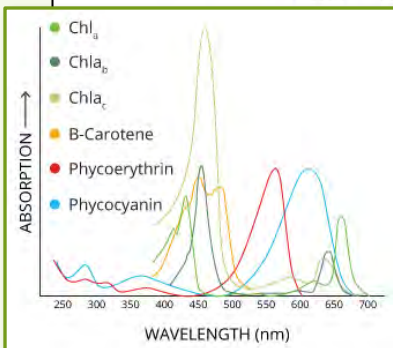
CHL α LEVELS REDUCED 6WAT THEN CLIMBED THROUGHOUT REMAINDER OF SEASON.

- EXCEEDED 2RFU 01AUG
- EXCEEDED 5RFU 15SEP



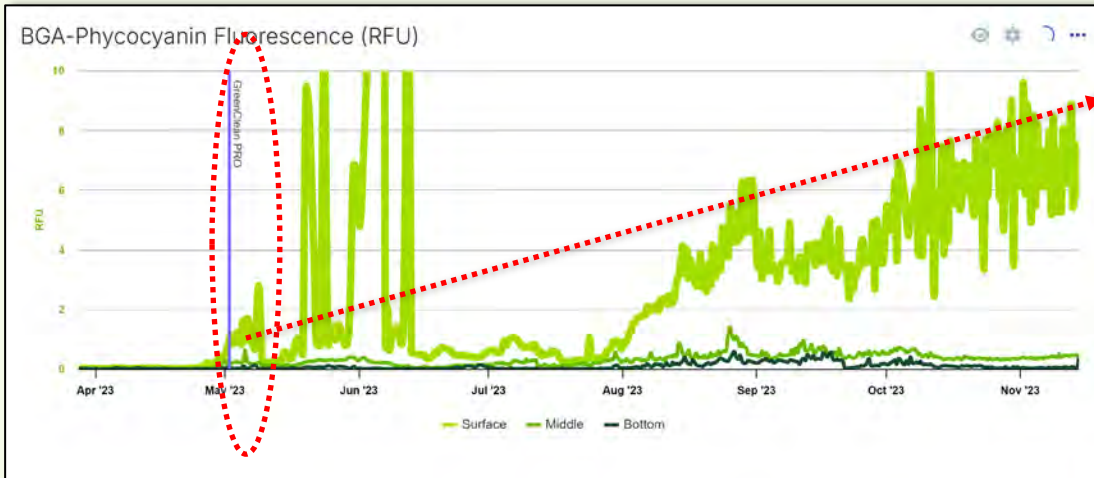
2024 **SHOCK & LOCK** PROGRAM

- HAB & NUTRIENT MITIGATION
- CHL α LEVELS ASSOCIATED W/GREEN ALGAE UNAFFECTED IN EPIILMNION
- BENTHIC CHL- α LEVELS LOW UNTIL LATE SUMMER THEN DID NOT EXCEED 5RFU
- *NOTE: ND IN ANY LAB SAMPLES*



NOTE: CHL α IS DISTINCT FROM BGA-PC IN UV FLUORESCENCE (440nm V. 642nm) WHICH ALLOWS FOR DIFFERENTIATION VIA OPTICAL SENSORS

2024 NUTRIENT MITIGATION PROGRAM RESULTS - PHYCOCYANIN



2023 **SHOCK** PROGRAM

HAB-TARGETED (MIRCROCYSTIS SPP.)

PHYCOCYANIN LEVELS REDUCED
6WAT THEN CLIMBED THROUGHOUT
REMAINDER OF SEASON.

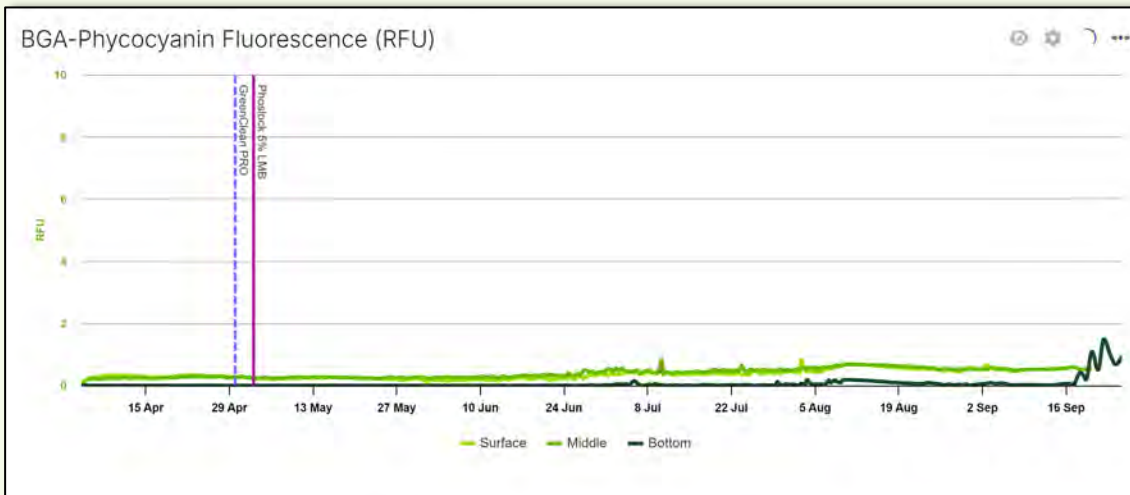
- EXCEEDED 2RFU * 01AUG
- EXCEEDED 5RFU 15SEP

*RELATIVE FLUORESCENCE UNIT (RFU; 1-1000µg/L)

PROBE RESOLUTION: ±0.001RFU

WHO* LEVEL OF CONCERN LEVEL 1: 30µg/L = 3RFU

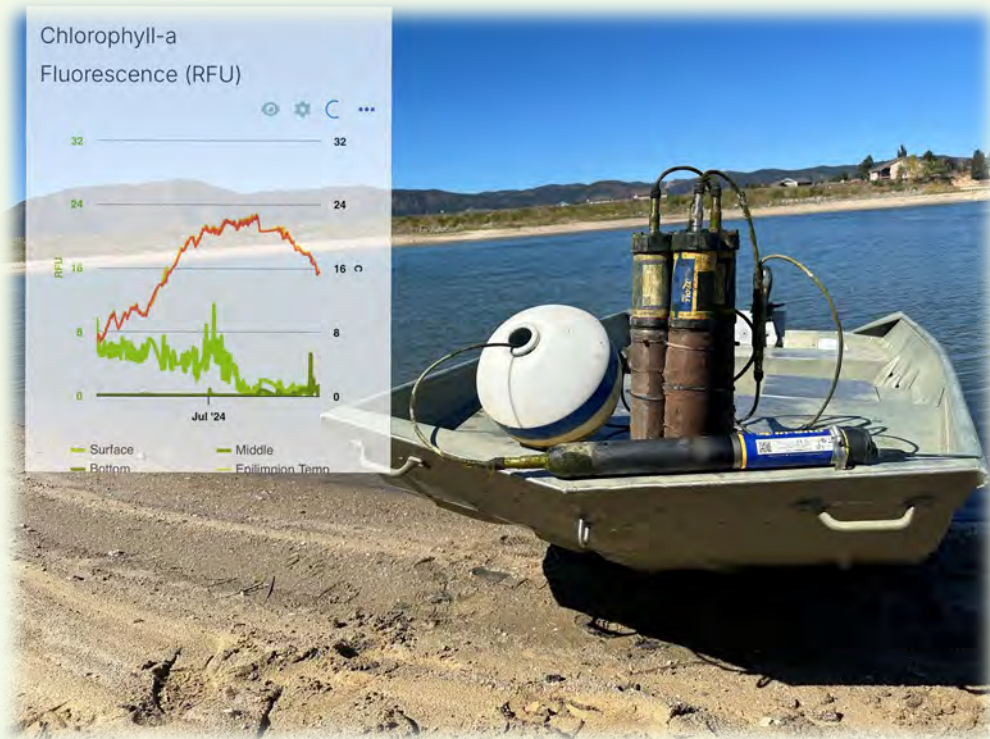
*Guidelines on Recreational Water Quality: Volume 1 Coastal and Fresh Waters
Geneva: World Health Organization; 2021.



2024 **SHOCK & LOCK** PROGRAM

- HAB & NUTRIENT MITIGATION
- BGA-PC LEVELS <1RFU UNTIL
01AUG
- BGA-PC REMAIN ≤2RFU 2024

NUTRIENT MITIGATION PROGRAM 2024 - KEY TAKEAWAYS



2024 PROGRAM RESULTS

1. CHL α & BGA-PC LEVELS WERE FAR LOWER 2024 THAN IN 2023
2. DOMINANT ALGAL SPECIES 2024
CHLOROPHYTA/ EUGLENOPHYTA → DIATOMS
3. PH/ORP & TSS MONITORING HIGHLY RELIABLE

2025 PROGRAM GOALS

GOAL: >BENTHIC REDOX POTENTIAL

VIA AERATION SYSTEM OPTIMIZATION

GOAL: 2° LMB APPLICATION

GOAL: NO HAB's, NO T&O 2025

GOAL: NO MITIGATION NEEDED 2026



PHOSLOCK[®]



 **LakeTech**



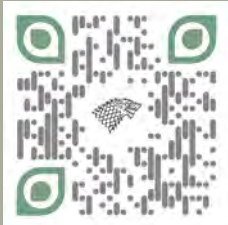
BIOBASE[™]



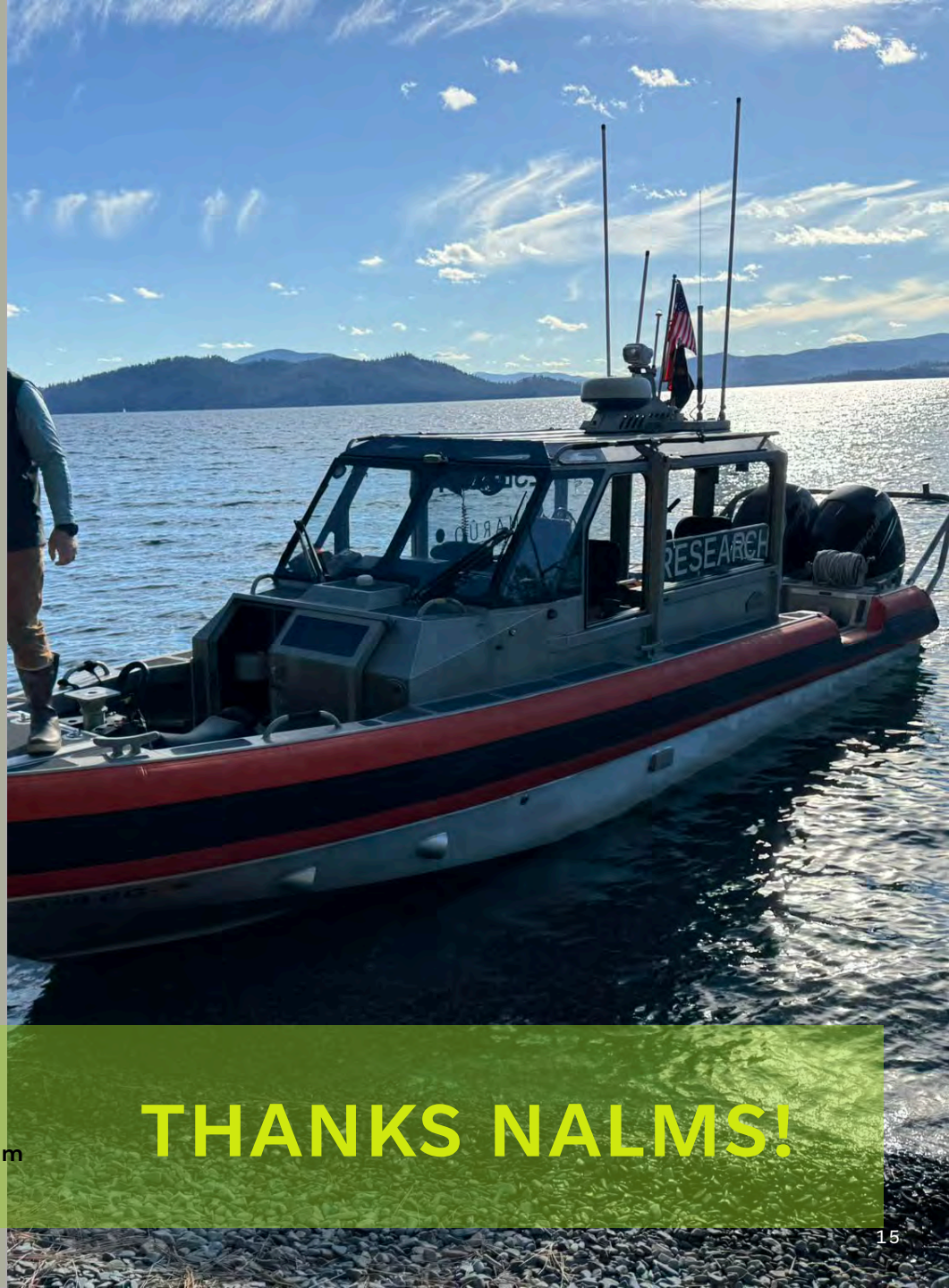
 **In-Situ**



 **BioSafe Systems**



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THANKS NALMS!