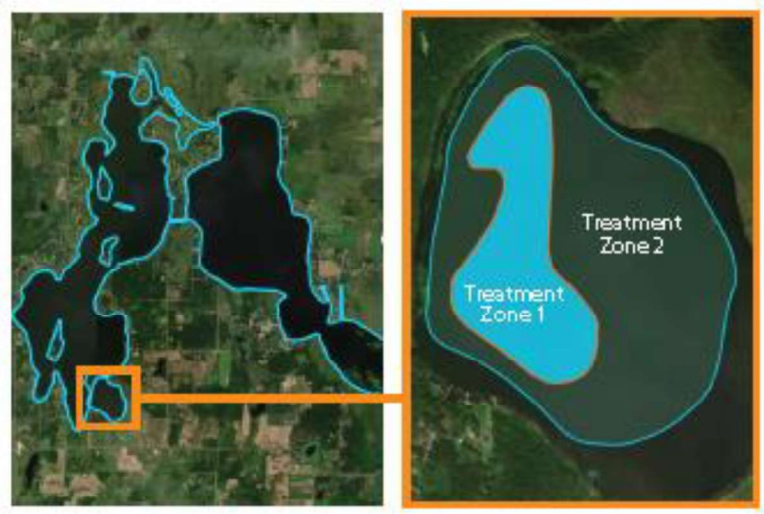
RUSH LAKE EUTROSORB DEMONSTRATION PROJECT

Patrick Selter, James Johnson

PLM LAKE & LAND MANAGEMENT, FRESHWATER SCIENTIFIC SERVICES

Background

East and West Rush Lakes are located in Chisago County, Minnesota. In 2008, West Rush Lake was listed as impaired for excessive nutrients by the Minnesota Pollution Control Agency. As a result, the Rush Lake Improvement Association (RLIA) has been seeking a way to reduce nutrients in the lakes. In 2023, the RLIA proposed using Lanthanum Modified Bentonite (LMB) to safely and permanently bind phosphorus. EutroSORB G utilizes (LMB) to address eutrophication in water bodies. Lanthanum, well-known for its strong attraction to phosphorus, enhances the adsorption of phosphorus upon introduction into water bodies. This process selectively reduces phosphorus levels, diminishing the risk of eutrophication. As a rare earth element, lanthanum's selective adsorption of phosphorus renders it invaluable for mitigating excess phosphorus and enhancing water quality restoration efforts. “Little West Rush Lake” is a small 77-acre basin connected to West Rush Lake that was selected as a demonstration site to evaluate the effects of LMB (EutroSORB G) on the water quality. This innovative project represents a collaborative effort between environmental agencies, local stakeholders, and scientific experts to implement sustainable solutions for lake restoration. On June 25, 2024, 30,000 lbs of Eutrosorb G was applied via boat to approximately 48 acres of Little Rush Lake.



Water Sampling

We collected water samples and vertical profile data (temperature, dissolved oxygen, pH, conductivity) on June 20th (pretreatment), June 25th (during treatment), June27th (2 days posttreatment), July 25th , September 5th, and October 2nd 2024. Profile data was collected using a YSI water quality probe at the deepest location in the water body. The data collected came from one site on the lake at the greatest depth. Water samples were collected at the surface and just off of the bottom on each date. These water samples were analyzed for total phosphorus (TP), chlorophyll-a (Chl-a), alkalinity, with additional analyses for soluble reactive phosphorus (SRP) and total and dissolved lanthanum on select dates.

Sediment Sampling

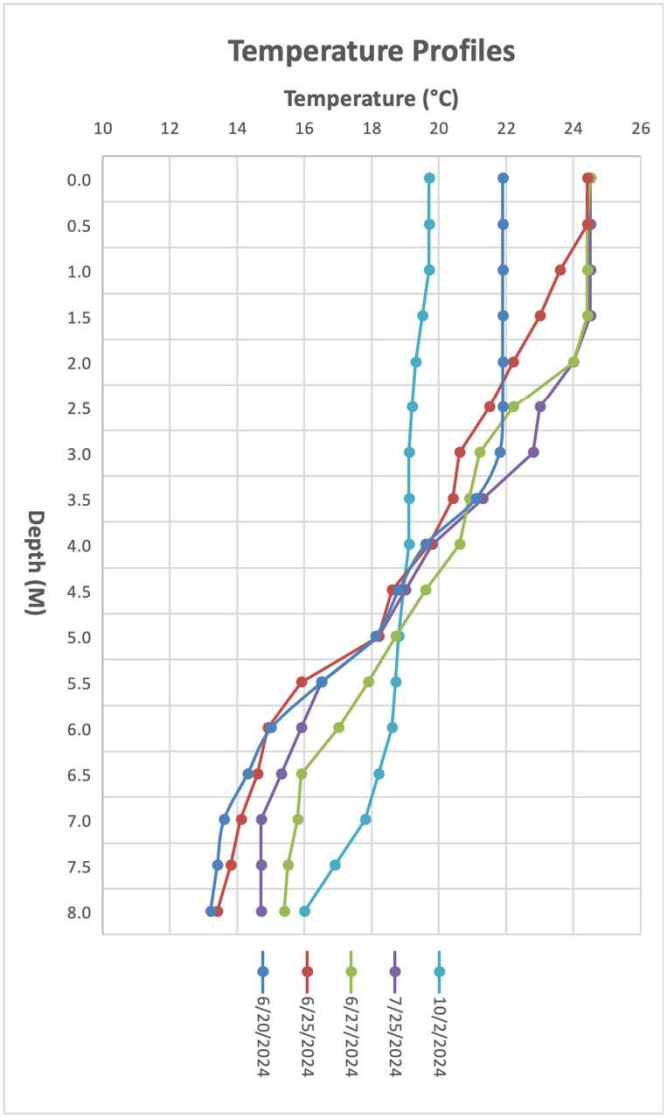
We collected sediment samples in 2023 (pretreatment) and again in October of 2024 (posttreatment) using an Eckman dredge. These sediment samples were sent to the SePRO lab for phosphorus fractionation analysis to determine the various forms of phosphorus compounds in the sediment. Continued monitoring will take place in 2025 to further evaluate the effects of EutroSORB G, and to evaluate the need for any future applications.

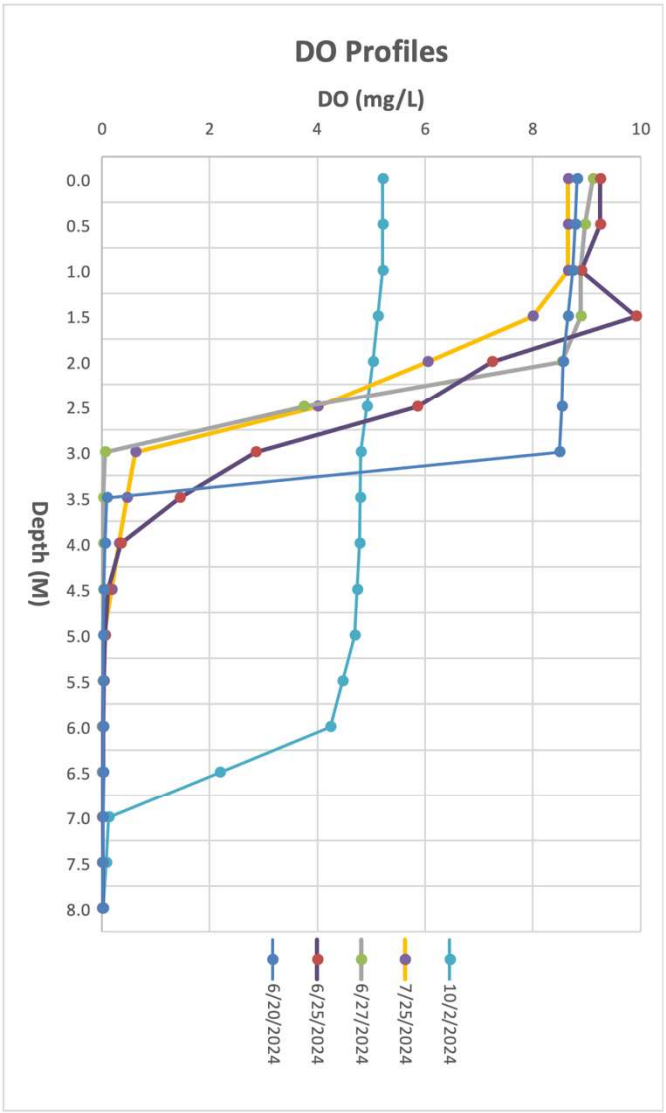
Temperature

The temperature of a lake makes a big impact on the biological life in the lakes such as the fish, insects and the plants. Temperatures that become too warm may decrease the oxygen levels in the lake making survival of fish, insects and plants more difficult. Lakes actually have a variation of temperatures depending on the depth. It is common during early to mid-summer for lakes to be stratified into three temperature levels, the epilimnion (the top level), the metalimnion (middle level), and the hypolimnion (the bottom level). This stratification can result in the depletion of oxygen in the deep portion of the lake, potentially resulting in the release of iron-bound phosphorus from lake sediment.

Dissolved Oxygen

Dissolved Oxygen (DO) measures the amount of oxygen in the water. It is produced by the plants through photosynthesis and used by nearly all aquatic organisms for survival. Because photosynthesis is dependent on sunlight, dissolved oxygen varies depending on the temperature the sunlight helps create as well. The higher the temperatures, the less gasses water can hold, which will produce less oxygen in the water. Oxygen can also be introduced to the water by the air and inflowing streams. Oxygen levels will also decrease with depth, as there is less sunlight to help generate photosynthesis. Dissolved Oxygen is measured in mg/L and must be at a level above three mg/L for aquatic organisms to survive. When DO drops below ~1 mg/L in the deep portion of the lake, iron-bound phosphorus can be released from the lake sediment.


Temperature Profiles
Temperature (°C)
10
12
14
16
18
20
22
24
26
Depth (M)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
6/20/2024
6/25/2024
6/27/2024
7/25/2024
10/2/2024

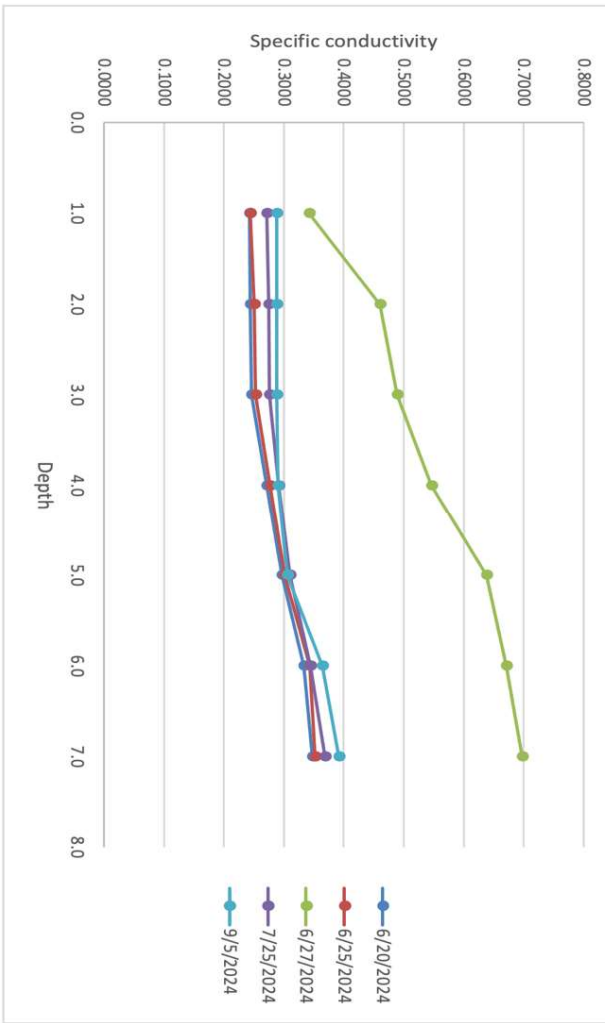

DO Profiles
DO (mg/L)
0
2
4
6
8
10
Depth (M)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
6/20/2024
6/25/2024
6/27/2024
7/25/2024
10/2/2024

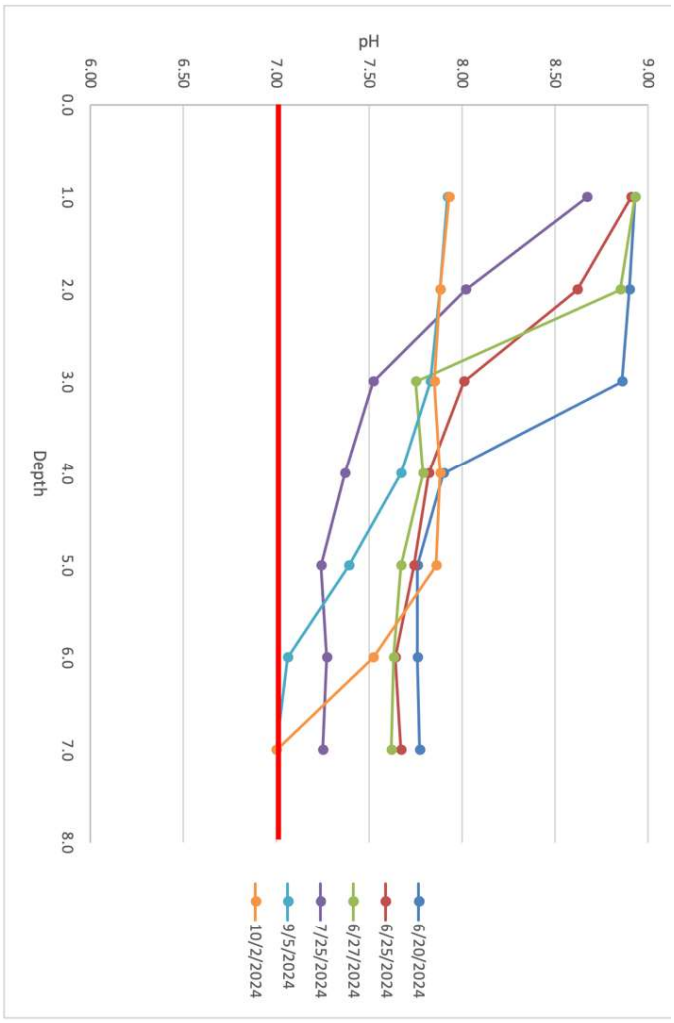
Conductivity

Electrical conductivity estimates the total amount of dissolved ions in the water and is controlled by things such as the size of the watershed relative to the area of the lake, the geology and soil type in the drainage area, wastewater and road salt runoff, and other in-lake processes.

pH

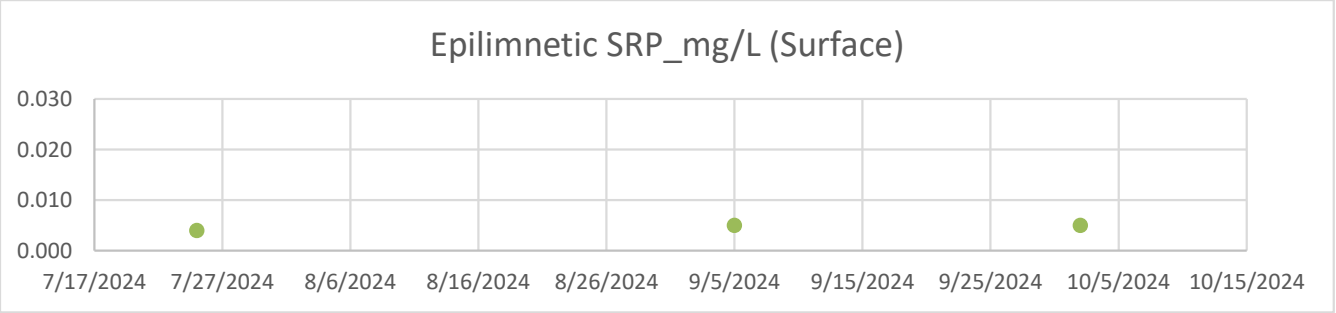
The measurement of pH indicates a lake's acid level. Neutral pH for water is 7. Lower pH levels, usually below six, indicate more acidic waters. Levels above nine indicate alkaline waters. Very acidic waters can affect fish and fish spawning, possibly leading to a fish kill. The pH levels shown in the graph below show a range between 7 and 8.93, mostly in the slightly alkaline range.

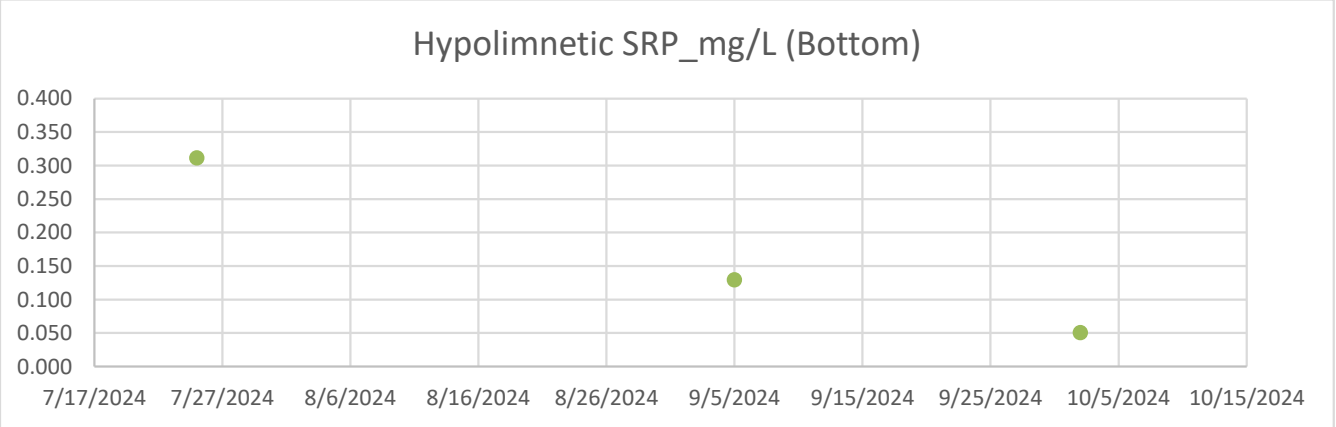


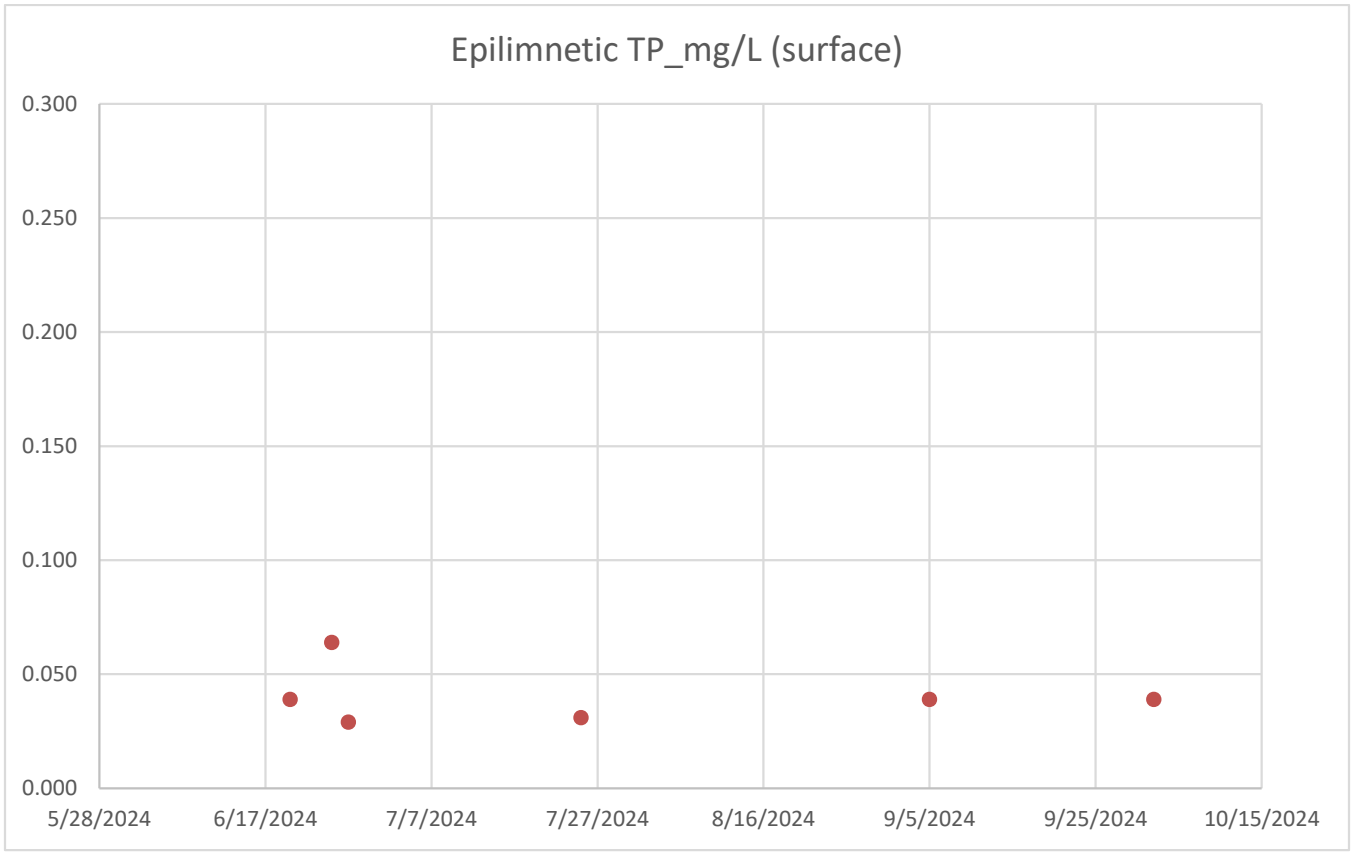


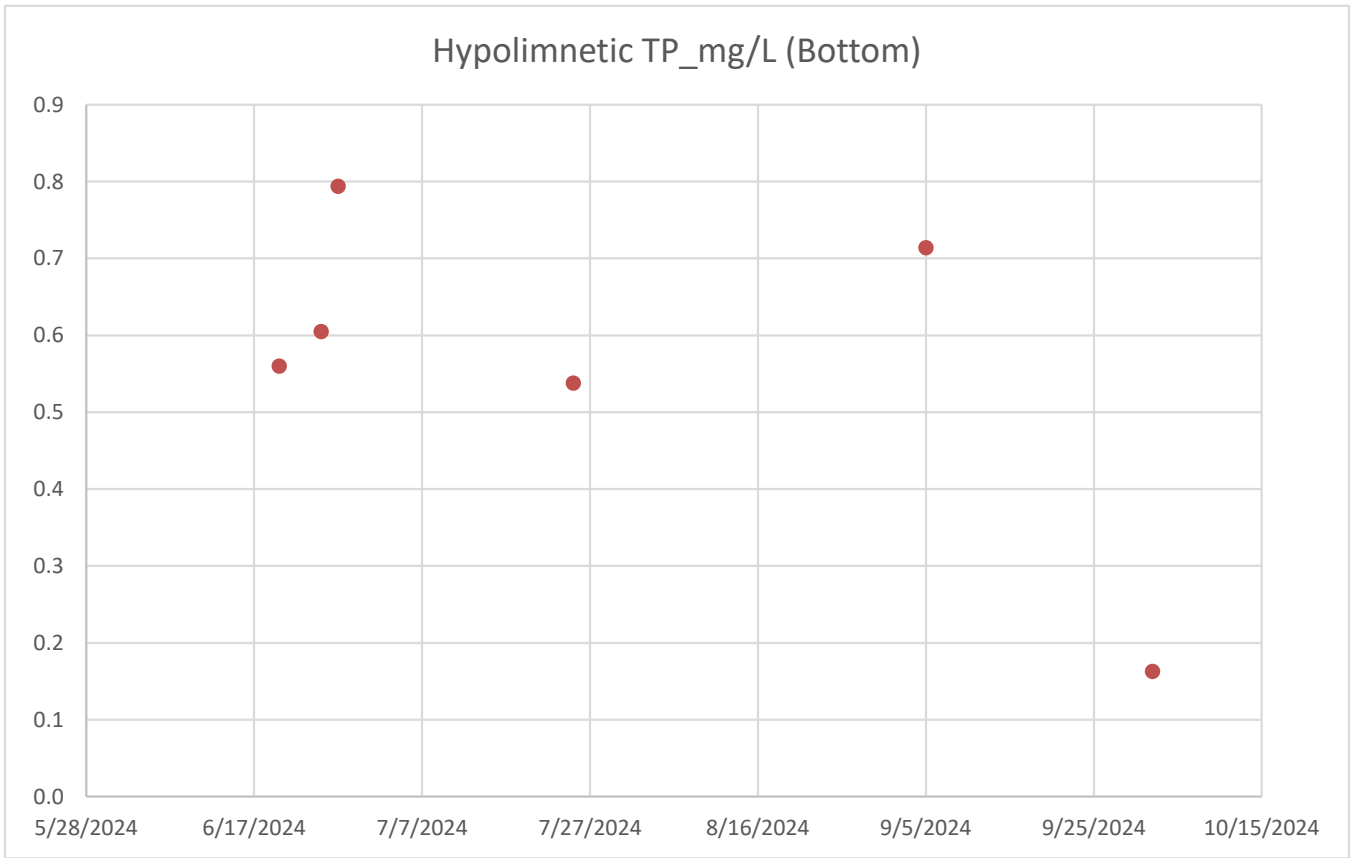
Phosphorus

A modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events including accelerated plant growth, algae blooms, and low dissolved oxygen. There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations. Total phosphorus (TP) is a measurement of all the forms of phosphorus in the sample. This includes dissolved phosphorus (orthophosphate) and any phosphorus that has been incorporated into bacteria, algae, or zooplankton in the water, or bound to suspended particulates. Soluble reactive phosphorus (SRP) is filtered before being analyzed, so it is a measure of only the dissolved phosphorus (orthophosphate) that is directly available to be taken up by plants and algae.



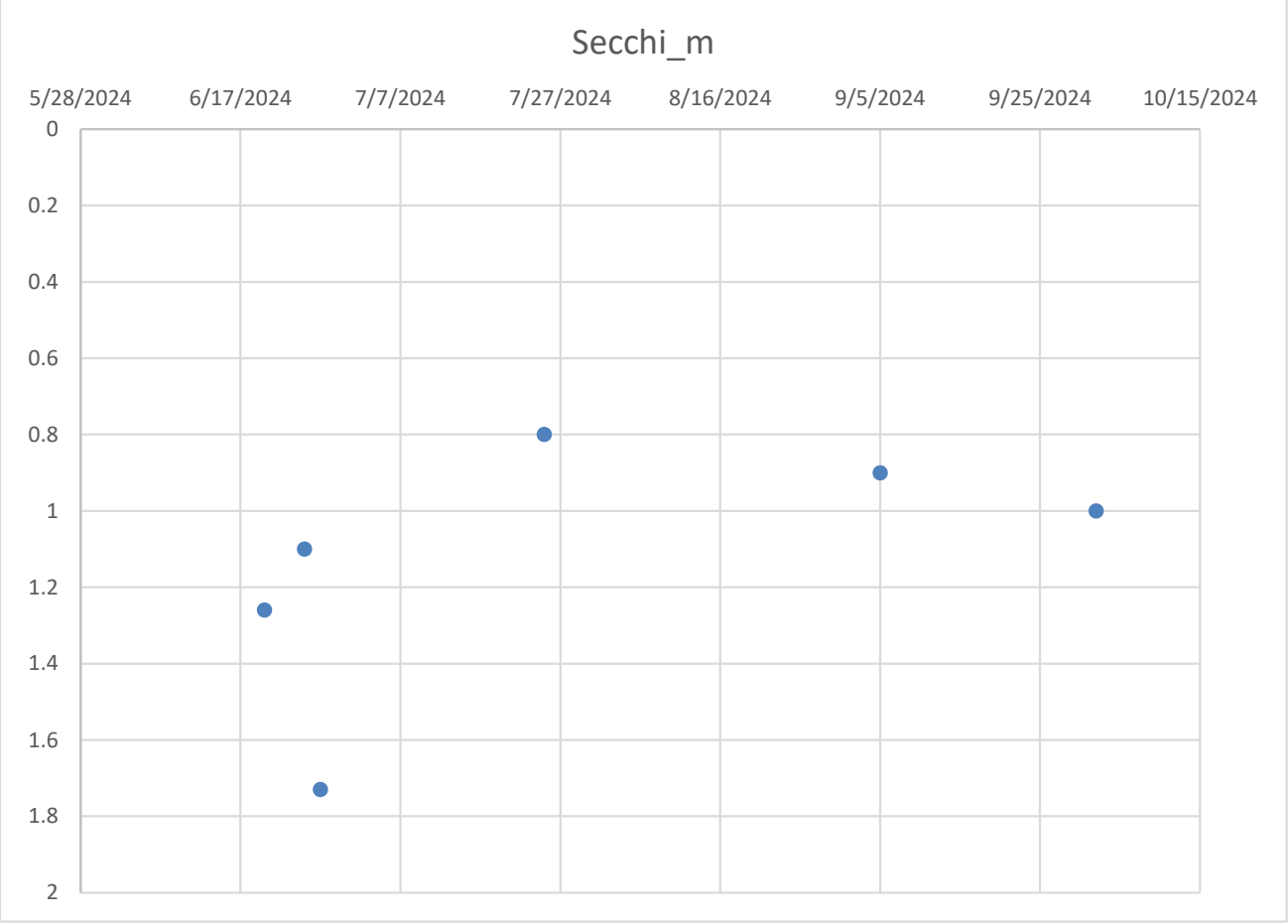



Epilimnetic TP_mg/L (surface)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
5/28/2024
6/17/2024
7/7/2024
7/27/2024
8/16/2024
9/5/2024
9/25/2024
10/15/2024


Hypolimnetic TP_mg/L (Bottom)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5/28/2024
6/17/2024
7/7/2024
7/27/2024
8/16/2024
9/5/2024
9/25/2024
10/15/2024

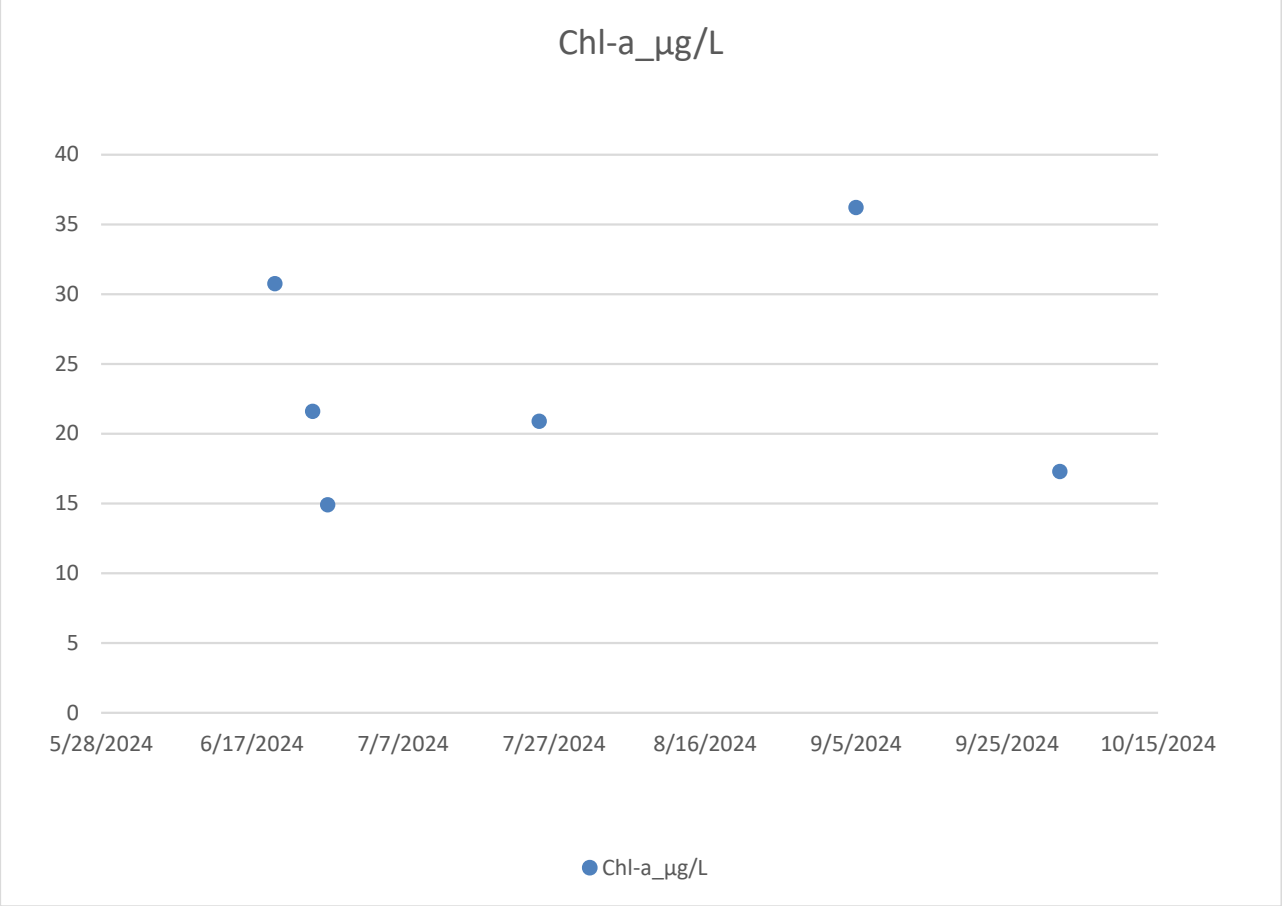
Water Clarity

Water clarity is measured based upon the depth at which a Secchi disk lowered into the water can no longer be seen from the surface. Clarity is a rough estimate of algae, and can be used to calculate the trophic status (fertility) of a lake. The Trophic Status Index also uses total pohosphorus and chlorophyll-a. This is explained in greater detail in the TSI section of this report.



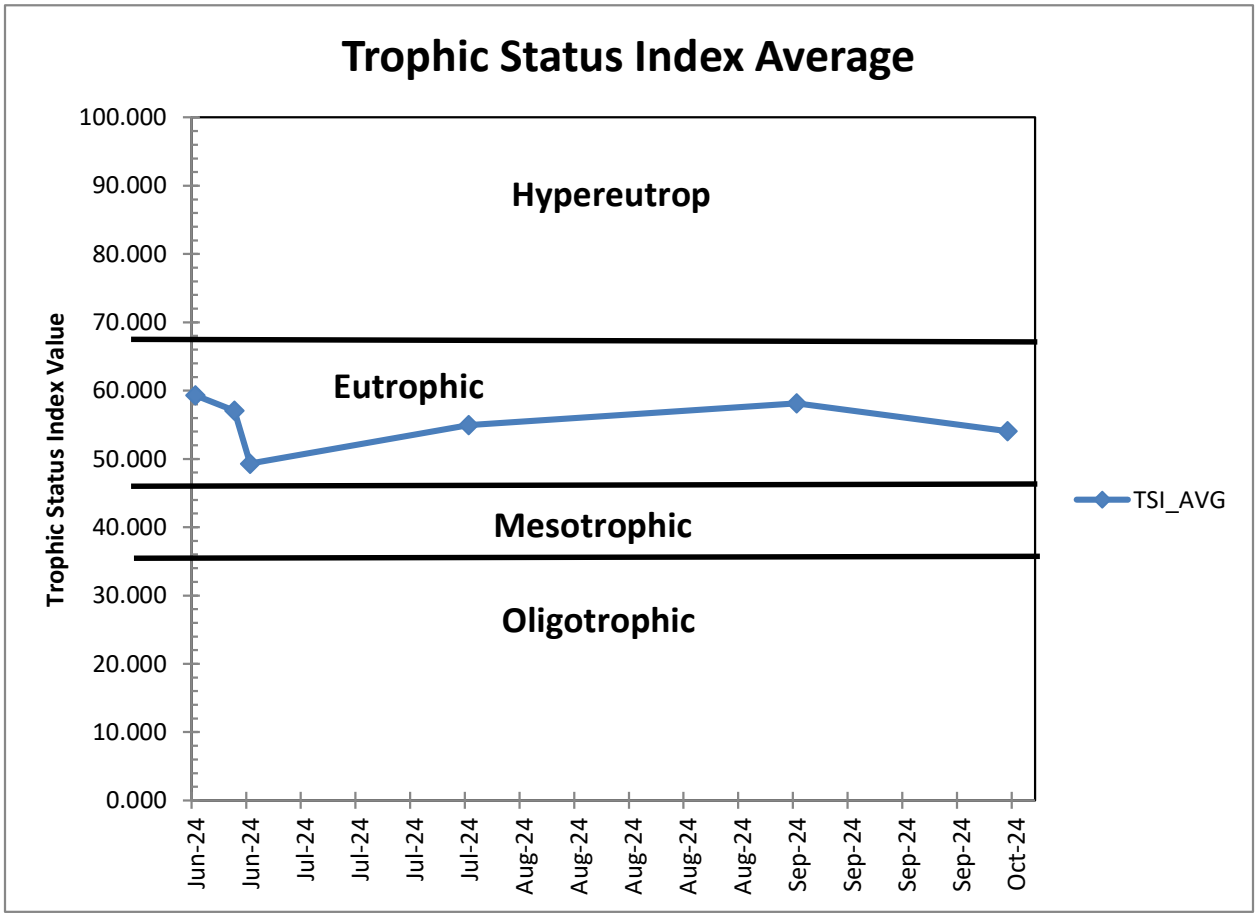
Chlorophyll-a

Chlorophyll-a is the green pigment that is responsible for the conversion of sunlight into chemical energy during photosynthesis. The measurement of chlorophyll-a is best used for indicating the amount of algae in lakes. Higher readings of chlorophyll-a indicate more algae, which can indicate unhealthy waters.



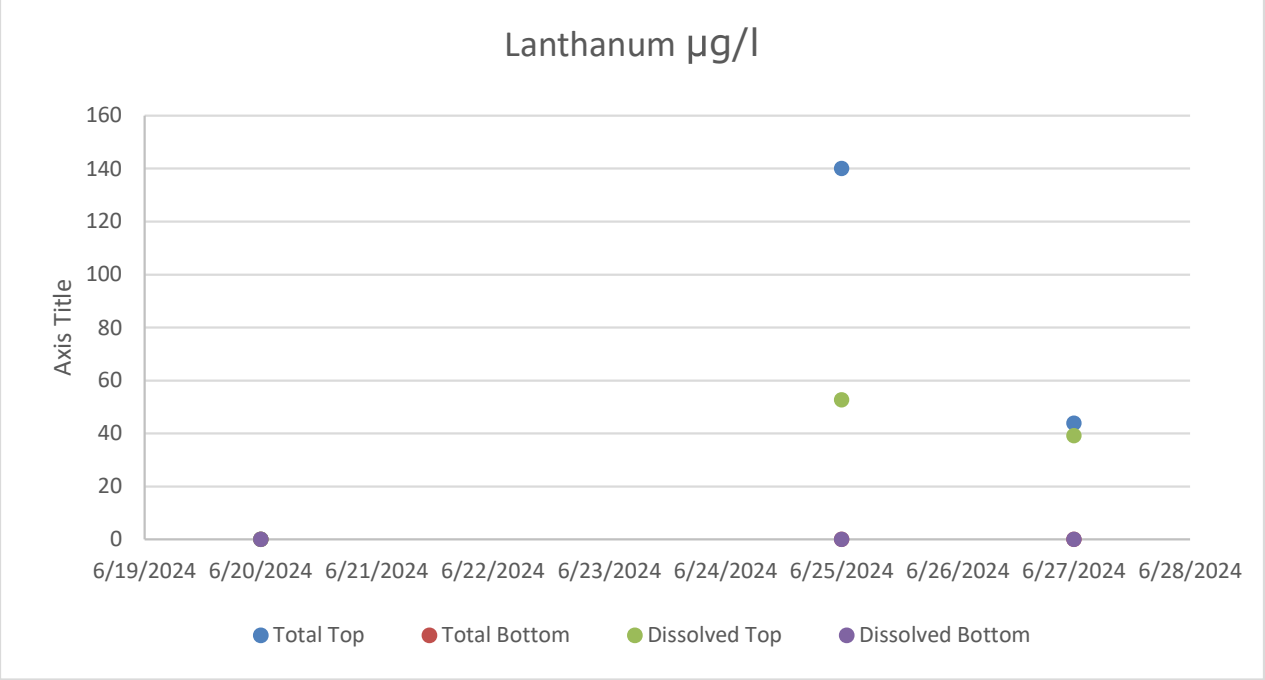
Trophic Status Index

There are four general trophic states: hypereutrophic, eutrophic, mesotrophic, and oligotrophic. Hypereutrophic lakes are extremely high in nutrients and generally considered to be unhealthy. Eutrophic lakes are high in nutrients and support a large amount of plants and algae and can be susceptible to oxygen depletion that could lead to further problems. Mesotrophic lakes are lower in fertility and generally do not experience frequent algae blooms and have good water clarity. Oligotrophic lakes are very low in nutrients and generally have very high water clarity and low algae. The following graphs show the average trophic status index for Little Rush Lake in 2024 using Secchi disk readings, total phosphorus, and chlorophyll-a.



Lanthanum

Prior to, during, and following treatment, we collected samples to determine the amount of both dissolved and total lanthanum present in the water. These samples were required by the MPCA to documented the amount of lanthanum during and immediately after treatment, and its duration in the water.

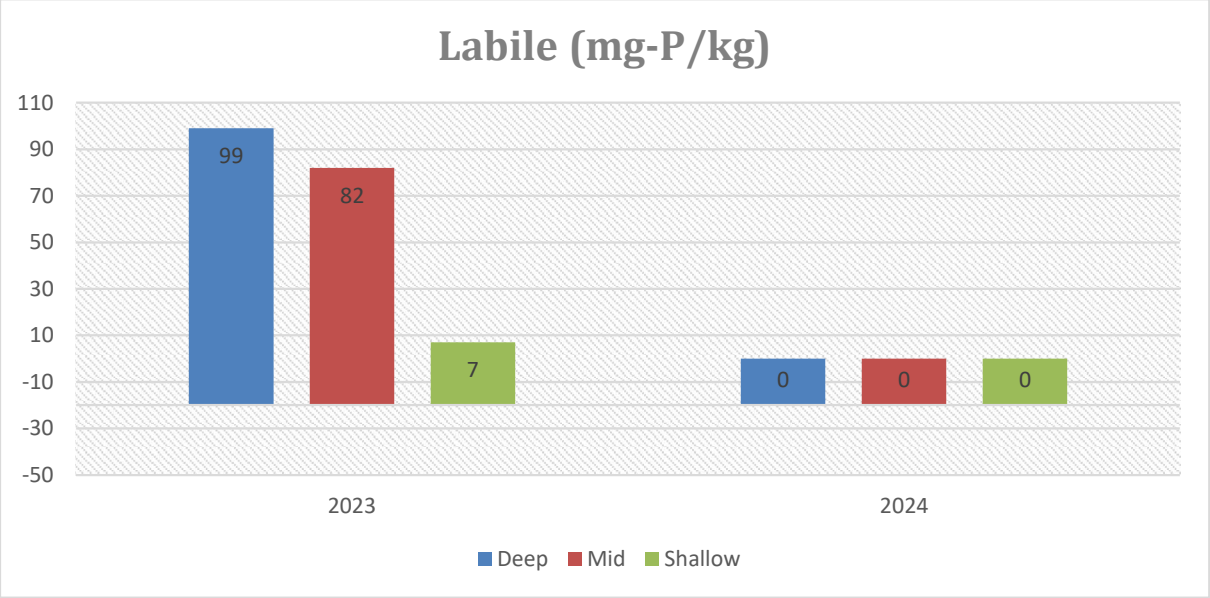


Sediment Phosphorus Fractionation

The long-term behavior of sediment Phosphorus in promoting eutrophication of lakes can be more efficiently evaluated by determining the different phosphorus compounds in the sediment that have different propensities for release into the lake. Each of these forms of phosphorus represent a “fraction” of the total phosphorus in the sample. The fractionation analysis determines the amount of labile Phosphorus, reductant Phosphorus, metal-bound Phosphorus, apatite and residual Phosphorus and organic Phosphorus by using various chemical extractants. The following is a description of each fraction, along with results from our Little Rush Lake sediment samples collected 1-year prior to treatment and four months after treatment with Eutrosorb G.

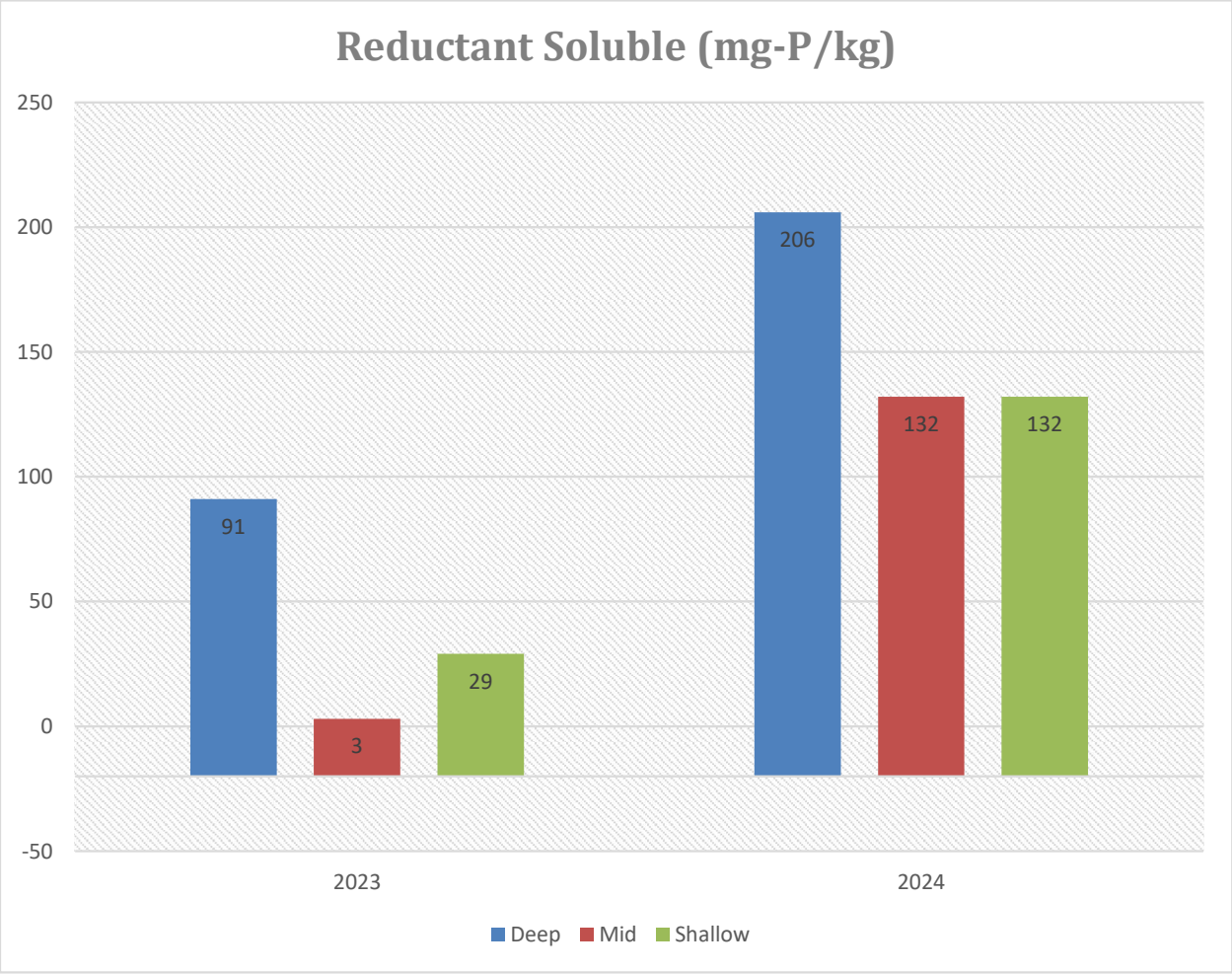
Labile Phosphorus

Labile phosphorus is a type of sediment phosphorus that is less tightly bound than stable phosphorus and is not strongly adsorbed in the soil. Labile phosphorus is less available to plants than other forms of phosphorus, but it can undergo rapid chemical or biological changes to replenish the sediment phosphorus.



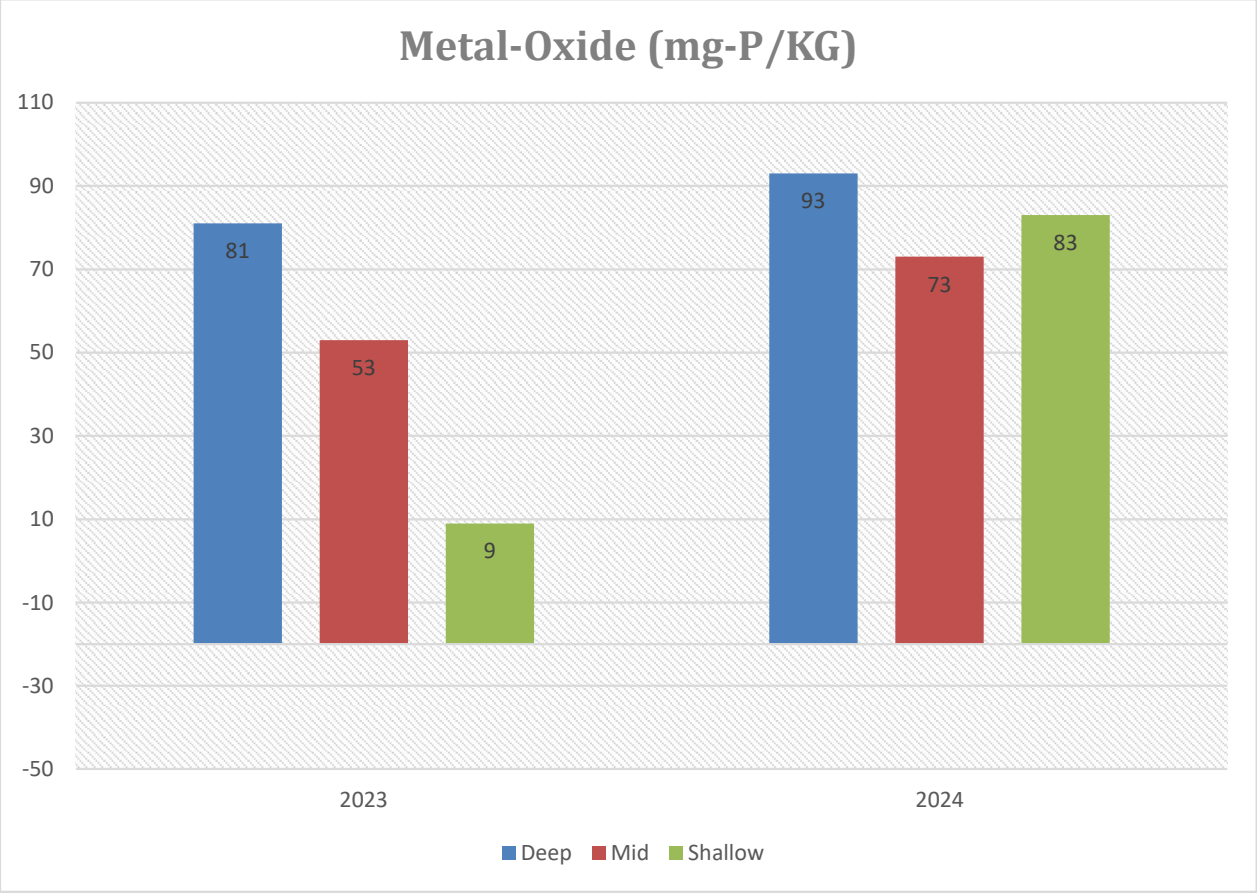
Reductant Soluble Phosphorus

Reductant soluble phosphorus is a form of phosphorus in the sediment that is only released into solution when a reducing agent (like sodium dithionite) is added, indicating that it is tightly bound to iron and aluminum oxides in the sediment, making it largely unavailable to plants unless specific chemical conditions are present; essentially, it's a measure of the "occluded" phosphorus that is not readily accessible to plants under normal conditions.



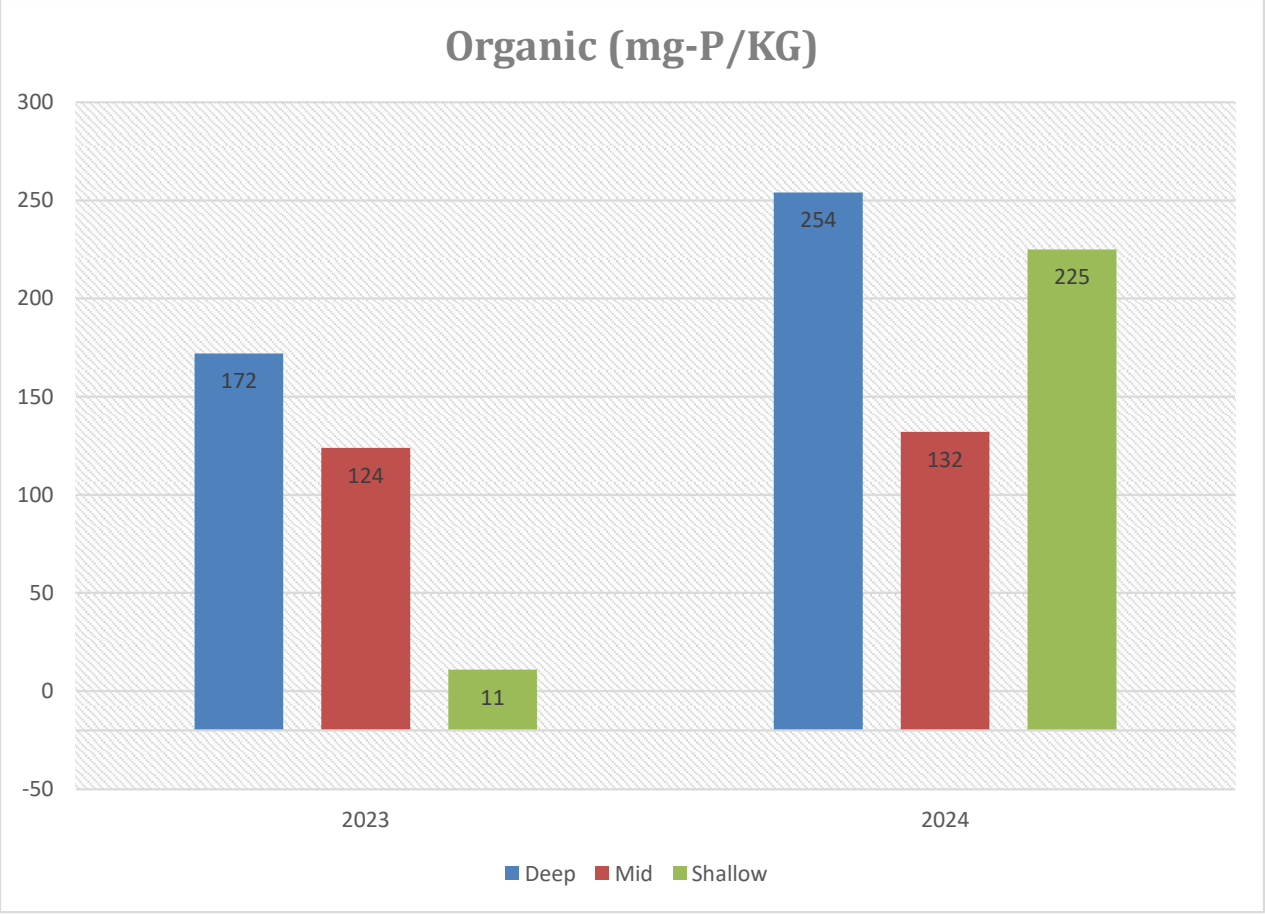
Metal Oxide Phosphorus

Metal oxide phosphorus in sediment refers to the form of phosphorus that is bound to metal oxides, primarily iron (Fe) and aluminum (Al) oxides, essentially acting as a "trap" that holds phosphorus in the sediment, making it less readily available to plants, this binding process happens due to the negative charge of phosphate ions being attracted to the positive charges on the metal oxide surfaces, limiting phosphorus mobility within the sediment.



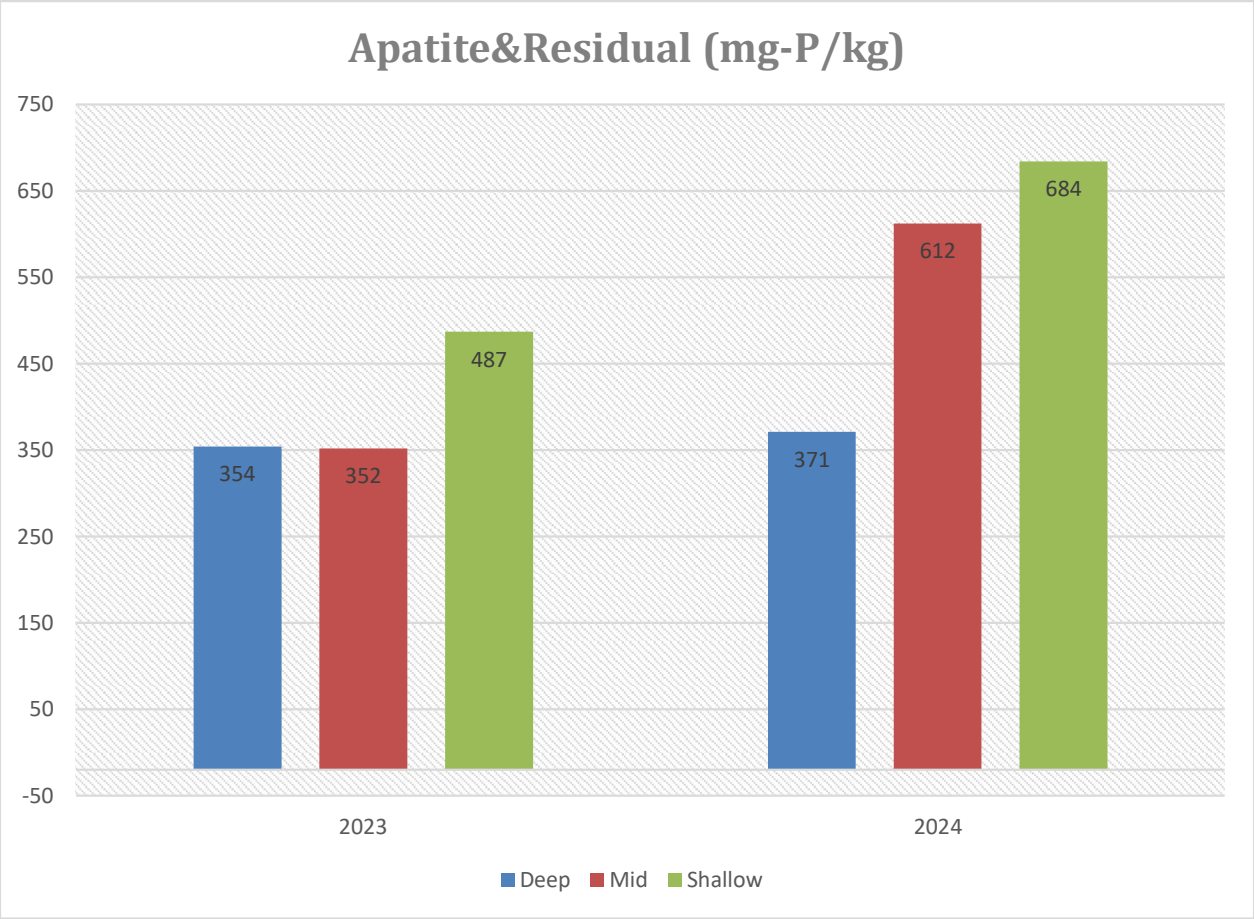
Organic Phosphorus

Organic forms of phosphorus include dead plant/animal residues and soil micro-organisms. Organic phosphate consists of phosphate associated with a carbon-based compound, such as plant or animal tissue. Phosphate that is not associated with organic material is inorganic.



Apatite Phosphorus

Apatite is a naturally occurring mineral that contains tightly-bound phosphorus, and serves as a primary source of phosphorus in soils for plants. Apatite phosphorus is very stable and requires substantial chemical or biological processing to become available for plants and algae.



Discussion

The application of Lanthanum Modified Bentonite (Eutrosorb G) has not been performed on larger scales in Minnesota lakes. The Little Rush Lake Project was performed to determine its impacts on water quality and measure shifts in sediment phosphorus to reduce plant and algae available phosphorus with the end goal of improving water quality. As demonstrated thru this project, no significant negative impacts to the measured water quality were observed. Lanthanum Levels within the water column, particularly at the top were elevated, however significantly decreased following the application and bottom levels remained low both during and following the application. Although the project didn't show significant improvements to water-based phosphorus, there was a significant shift in the types of sediment-based phosphorus types. This shift indicates that much of the bio-available phosphorus may no longer be released from the sediment immediately. After treatment, lanthanum levels were somewhat elevated at the lake surface, but these elevated levels decreased quickly following the application, lanthanum levels in bottom samples remained low both during and after the application.

Further plans for the Little Rush Lake are yet to be developed with the exception of collecting additional data through 2025. We currently plan to collect monthly water samples from May-September of 2025. This continued sampling would allow us to evaluate the longer-term effect of the LMB on the amount of phosphorus released from Little Rush Lake sediments in 2025, and to better plan for future treatments with LMB in Minnesota.

Testing Methods

Lab	Analysis	Method
IRI	Chl-a	SM 10200 H
IRI	Total P	SM 4500-P B.5.E
IRI	Total Hardness	SM 2340 Hard C.
IRI	DOC	SM 5310 C.
IRI	Tot Sus Solids	SM 2540 D.
SePRO	Total Lanthanum	FAST 13
SePRO	Dissolved Lanthanum	FAST 13
SEDIMENT		
SePRO	Labile P	based on Bostom et al. (1988), Hupfer et al. (1995), Spears et al. (2007)
SePRO	Reductant-soluable P	Based on Psenner et al. (1984, 1988), Bostrom et al. (1988), Hupfer et al. (1995), Lukkari et al. (2007), Spears et al. (2007)
SePRO	Metal Oxide adsorved P	Based on Psenner et al. (1984, 1988), Bostrom et al. (1988), Hupfer et al. (1995), Spears et al. (2007)
SePRO	Organic	calculated
SePRO	Apatite and Residual P	Based on Psenner et al. (1984, 1988), Bostrom et al. (1988), Hupfer et al. (1995)