Silver Lake Water Quality Monitoring Program

Project Update

Central Plymouth County Water District Commission

June 27, 2023

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Summary of Technical Findings - Data

Silver Lake Water Quality

Technical Findings – Overview

- Today's presentation to focus on results of key parameters

Temperature	**DO**	Sp. Cond.	pH
Turbidity	Secchi	Alkalinity	**Phosphorus**
Nitrogen	**Chlorophyll a**	E. coli	**Microcystins**
Phyoplankton	**Macrophytes**	Macroinvertebrates	Water Depth
Sediment Moisture	Sediment Density	Loss on Ignition	**Discharge**

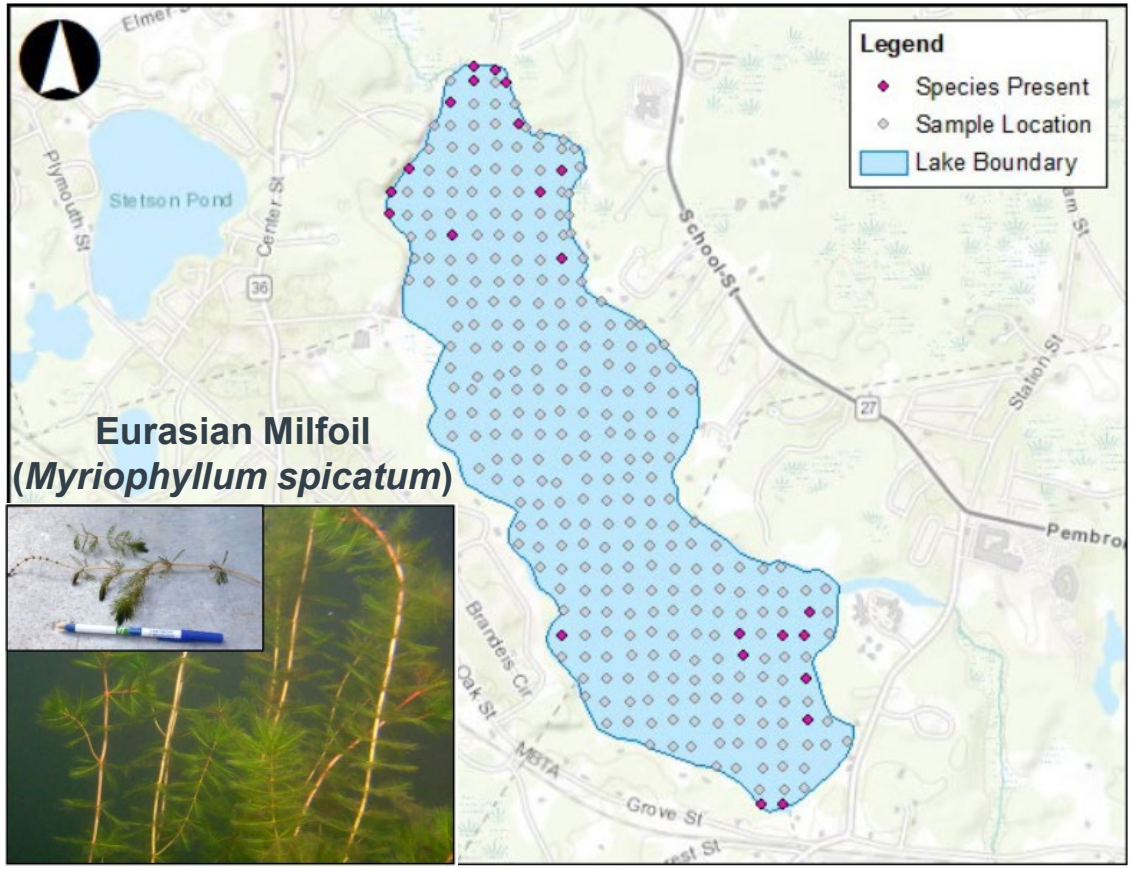
Technical Findings – Overview

Key findings from the 2021-2022 study period:

- Aquatic invasive plants present and widely distributed in Silver Lake
- Cyanobacteria common to dominant much of the year
- Cyanotoxins present at detectable concentrations each visit from November 2021 to June 2022
- Sediments rich in phosphorus, including forms that readily release into the water column
- Dissolved oxygen low or absent from bottom waters for several months of the year
- Nutrient levels elevated in water column
- Outlet ceases to flow at times

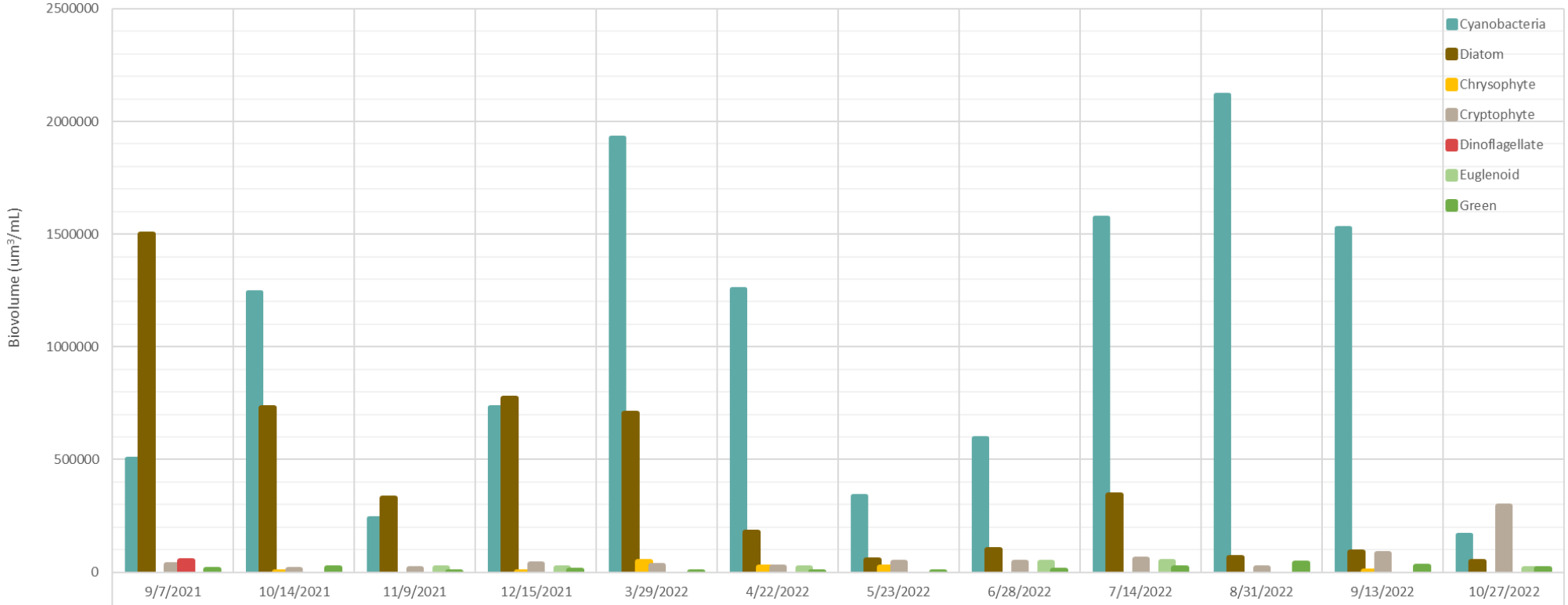
Technical Findings – Key Results: Plants

- Three aquatic invasive plants present
  - Fanwort – scattered beds to about 15’ deep
  - Eurasian milfoil – widespread to about 20’ deep
  - Variable-leaf milfoil – only detected at far northern end
- Why are these an issue?
  - Large plants that outcompete native species and spread easily via fragmentation
  - Impact habitat for aquatic life
  - Contribute to eutrophication (nutrient enrichment)
  - May alter other water quality (e.g., dissolved oxygen) when abundant enough



Technical Findings – Key Results: Cyanobacteria and Cyanotoxins

- Cyanobacteria common to dominant much of the year
  - *Aphanizomenon flos-aquae, Dolichospermum planctonicum,* and *D. flos-aquae* among most common
  - All are potential cyanotoxin producers
- Microcystins detectable from November 2021 to June 2022
  - Ranged from 0.7 µg/L to 12.55 µg/L
  - Federal drinking water Health Advisory level is 0.3 µg/L and recreational Health Advisory level is 8 µg/L

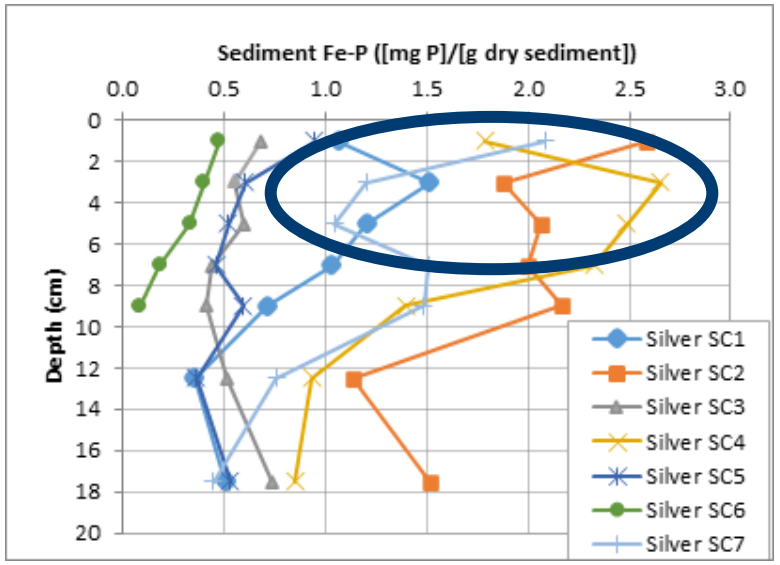


Technical Findings – Key Results: Sediment Phosphorus

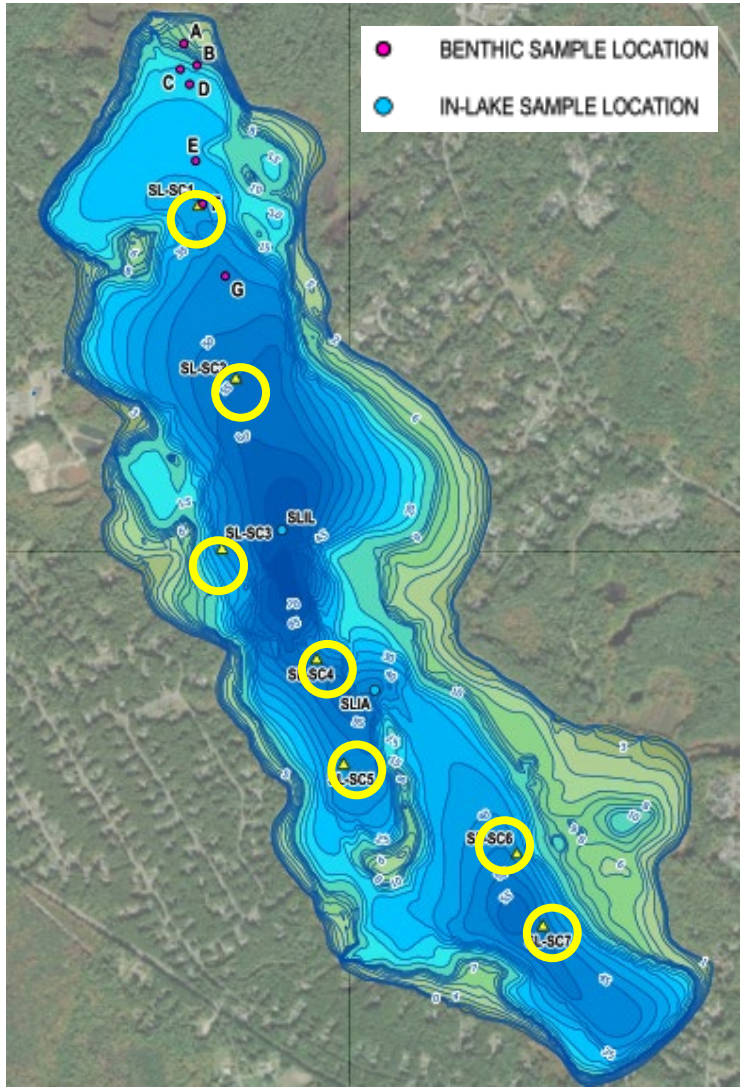
- Primary phosphorus fraction was iron-bound (releases under low DO)
- No noticeable gradient north to south
- Highest concentrations in surface sediments of deepest waters

Iron-bound P

More Recent Sediments

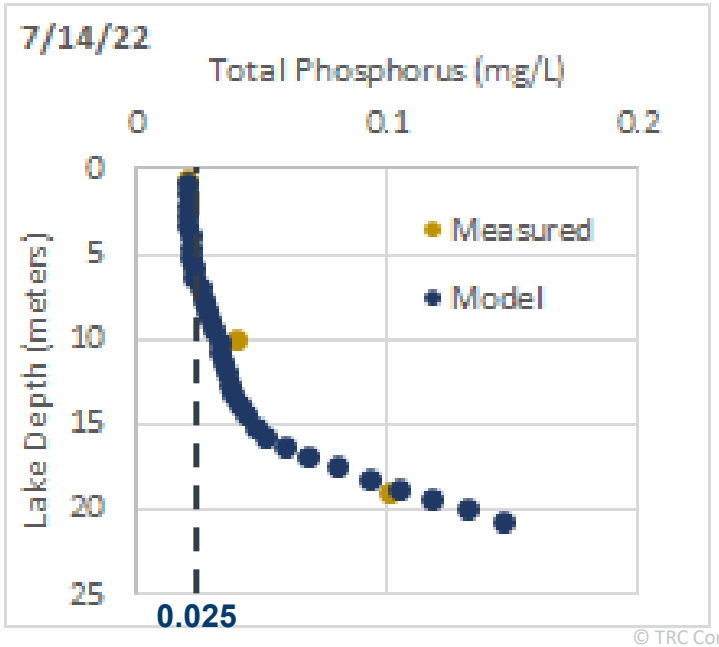


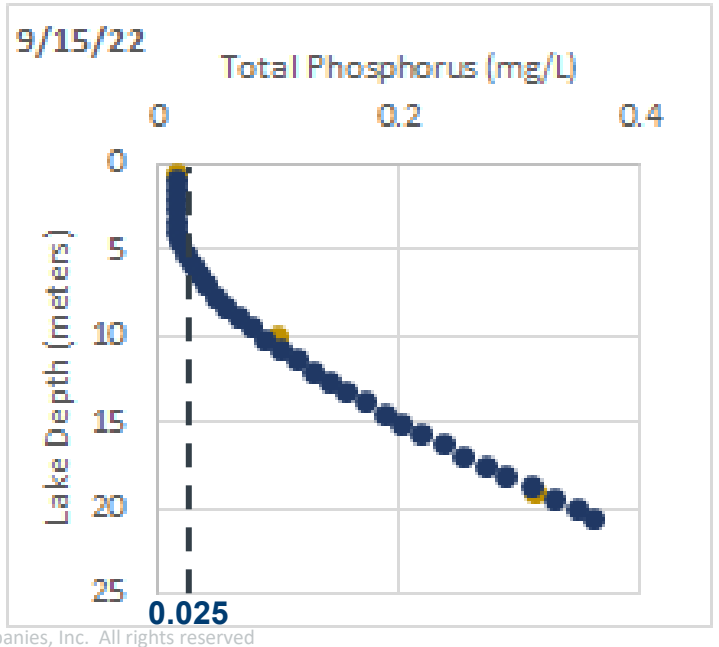
Older Sediments



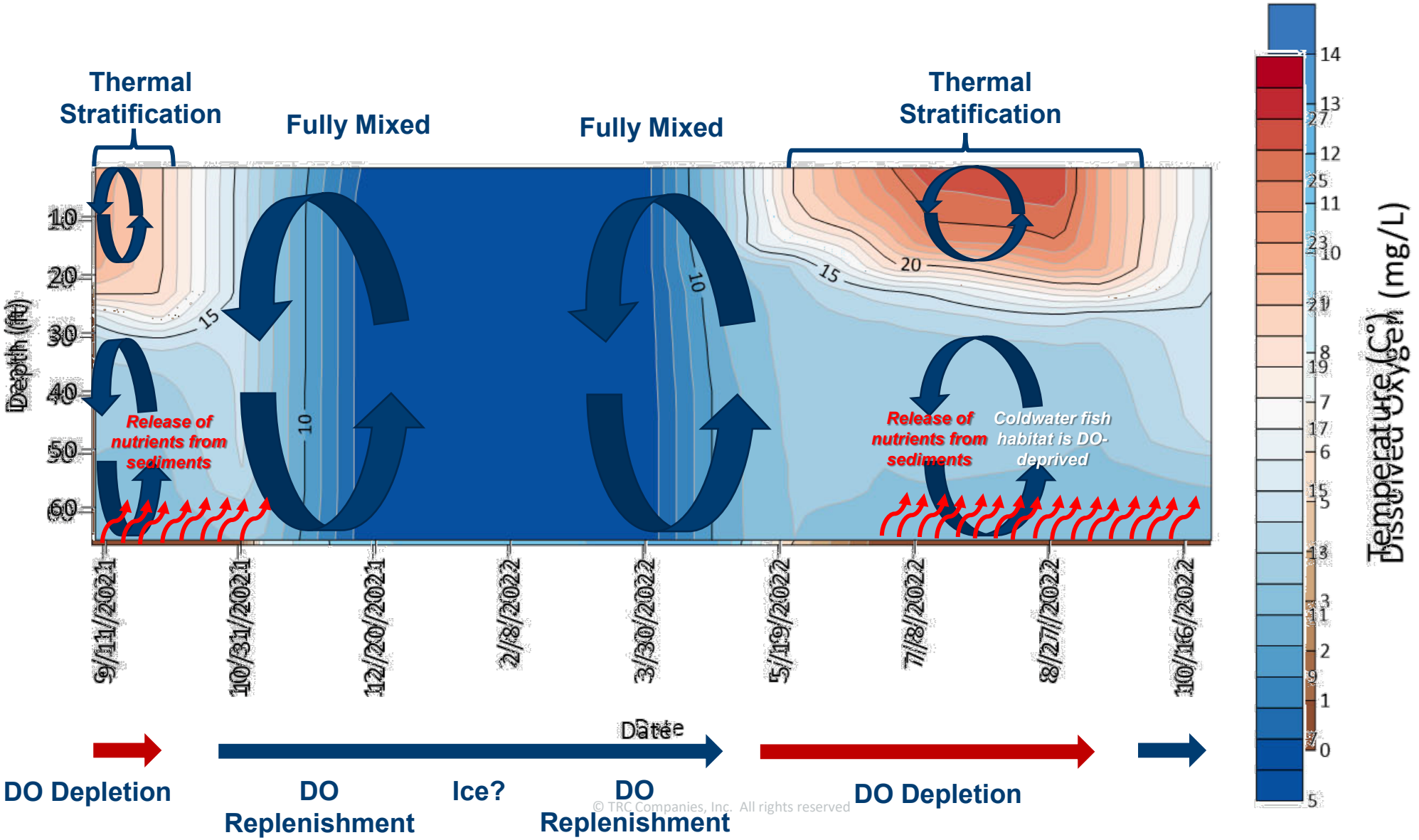
Technical Findings – Key Results: Nutrients and DO

- Total phosphorus exceeds EPA's "Gold Book" standard of 0.025 mg/L (25 ppb), most frequently in mid- and deep waters
- Bloom risk characterized as high at these levels (MassDEP 2021 Guidance on Cyanobacteria and Public Water Systems)
- Characteristic of a mesotrophic lake – more subject to recurring algae blooms, depletion of DO from deep waters, taste & odor issues, and undesirable levels of metals (e.g., iron & manganese)



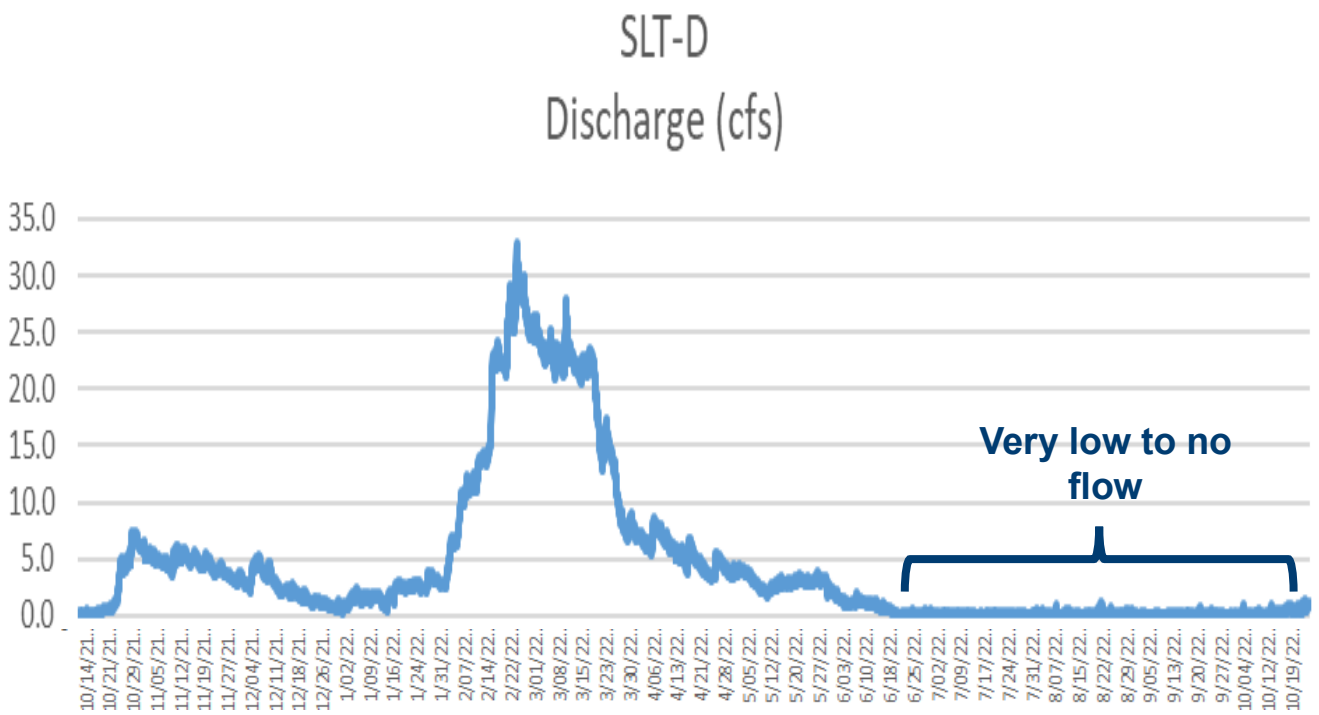


Technical Findings – Key Results: Nutrients and DO



Technical Findings – Key Results: Discharge

- Jones River flow record shows periods of low to no flow from outlet of Silver Lake (Forge Pond)
- In 2022 this period lasted more than three months (end of June to late October)
- Aquatic life impacts

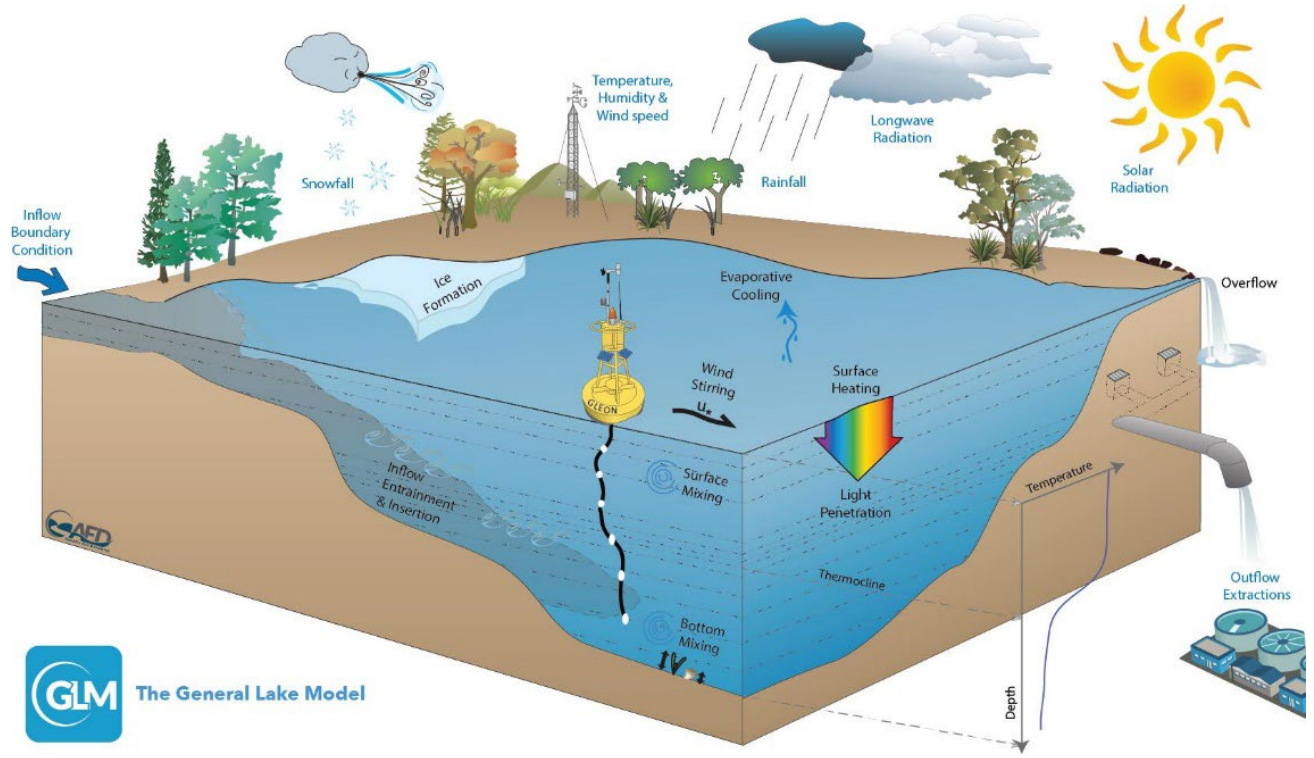


Summary of Technical Findings - Modeling

Silver Lake Water Quality

Technical Findings – Model Components

- Developed lake model that included these components:
  - Water balance
  - Lake temperature
  - External loads of N and P
  - Internal loads of N and P
  - Losses of N and P
  - N and P in-lake transformation
- Model calibrated to observed conditions
- May be used to test management scenarios going forward



Technical Findings – Selecting the Dataset for Modeling

- Used 2022 data from March-October period - best suited
  - 2021 an atypically wet year – water levels in Silver Lake high
  - 2022 a near normal precipitation year overall but very dry spring and summer - short-term drought
  - More comprehensive dataset available for 2022 and better capture of thermal stratification in summer
  - Diversions from East Monponsett sampled multiple times (March, May, and October) in 2022
  - In-lake sampling data available from March-October 2022

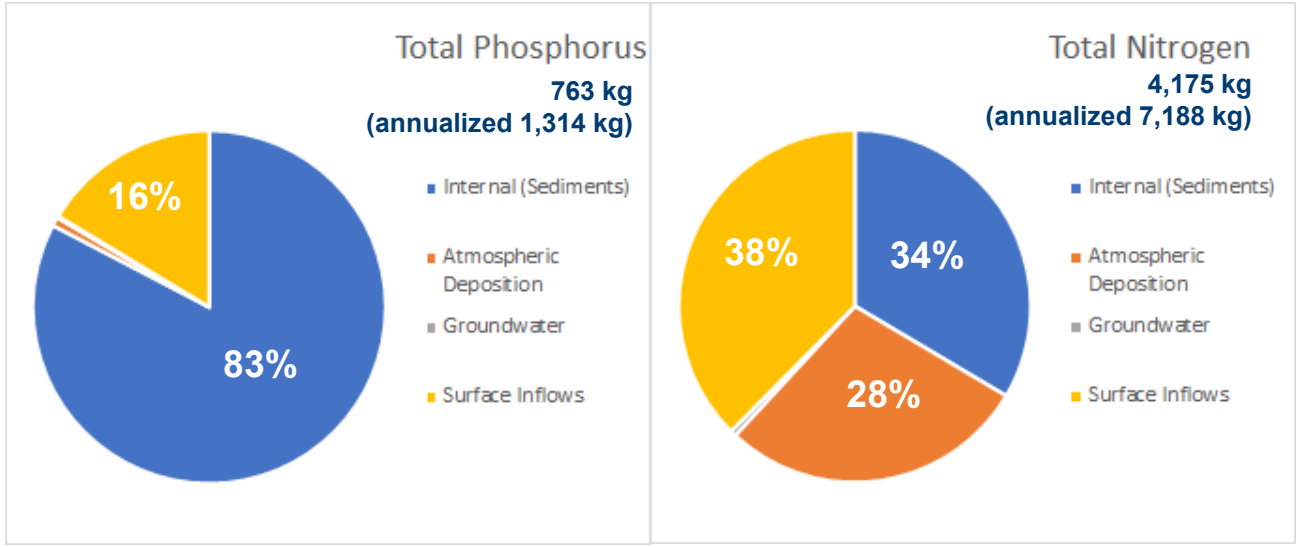
		Drought Level by Region						
Month	Year	Western	CT River Valley	Central	Northeast	Southeast	Cape Cod	Islands
2/1/2021 through 8/31/2021								
February	2021	Mild Drought	Normal	Normal	Normal	Normal	Normal	Normal
March	2021	Mild Drought	Mild Drought	Mild Drought	Mild Drought	Significant Drought	Mild Drought	Normal
April	2021	Mild Drought	Mild Drought	Mild Drought	Normal	Normal	Mild Drought	Normal
May	2021	Mild Drought	Normal	Normal	Normal	Mild Drought	Mild Drought	Normal
June	2021	Normal	Normal	Normal	Normal	Normal	Mild Drought	Normal
July	2021	Normal	Normal	Normal	Normal	Normal	Mild Drought	Normal
August	2021	Normal	Normal	Normal	Normal	Normal	Mild Drought	Normal
September	2021	Normal	Normal	Normal	Normal	Normal	Normal	Normal
4/1/2022 - 1/31/2023								
April	2022	Normal	Normal	Normal	Normal	Mild Drought	Normal	Mild Drought
May	2022	Normal	Mild Drought	Mild Drought	Significant Drought	Significant Drought	Normal	Mild Drought
June	2022	Mild Drought	Significant Drought	Significant Drought	Significant Drought	Significant Drought	Normal	Mild Drought
July (through mid-month)	2022	Mild Drought	Significant Drought	Critical Drought	Critical Drought	Significant Drought	Mild Drought	Mild Drought
July	2022	Mild Drought	Critical Drought	Critical Drought	Critical Drought	Critical Drought	Significant Drought	Mild Drought
August (through mid-month)	2022	Significant Drought	Critical Drought	Critical Drought	Critical Drought	Critical Drought	Critical Drought	Significant Drought
August	2022	Significant Drought	Critical Drought	Critical Drought	Critical Drought	Significant Drought	Critical Drought	Significant Drought
September	2022	Normal	Mild Drought	Mild Drought	Significant Drought	Mild Drought	Significant Drought	Significant Drought
October	2022	Normal	Mild Drought	Normal	Mild Drought	Normal	Mild Drought	Significant Drought

Technical Findings – Model Outputs: Nutrient Loading

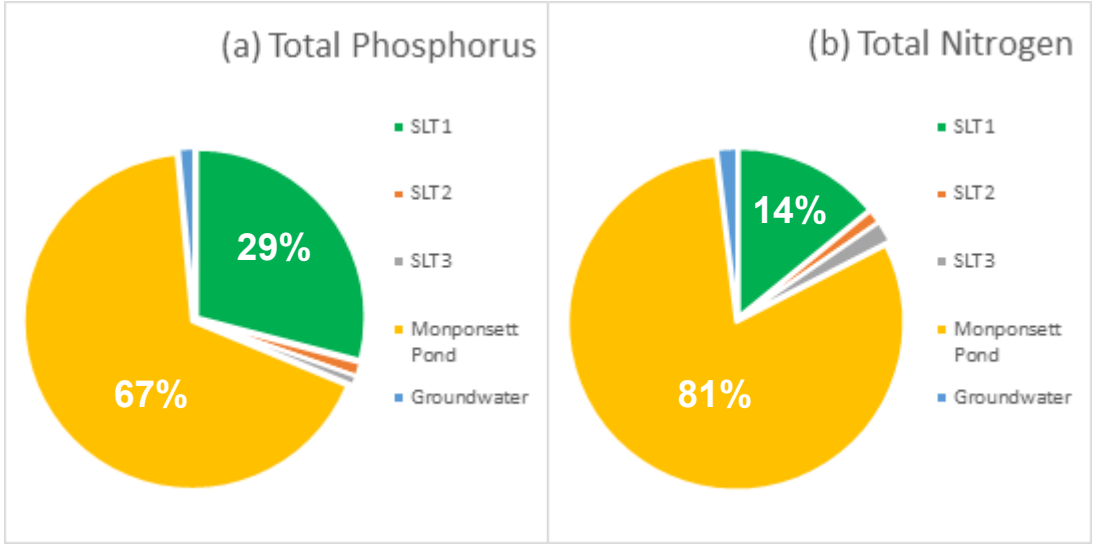
- Internal loading from sediments was largest source of phosphorus to Silver Lake (>80%)
- External loading accounted for a larger share of nitrogen loading, mostly through surface inflows and atmospheric deposition

- Diversion from E Monponsett Pond was the largest source of external phosphorus and nitrogen loading

All Loading

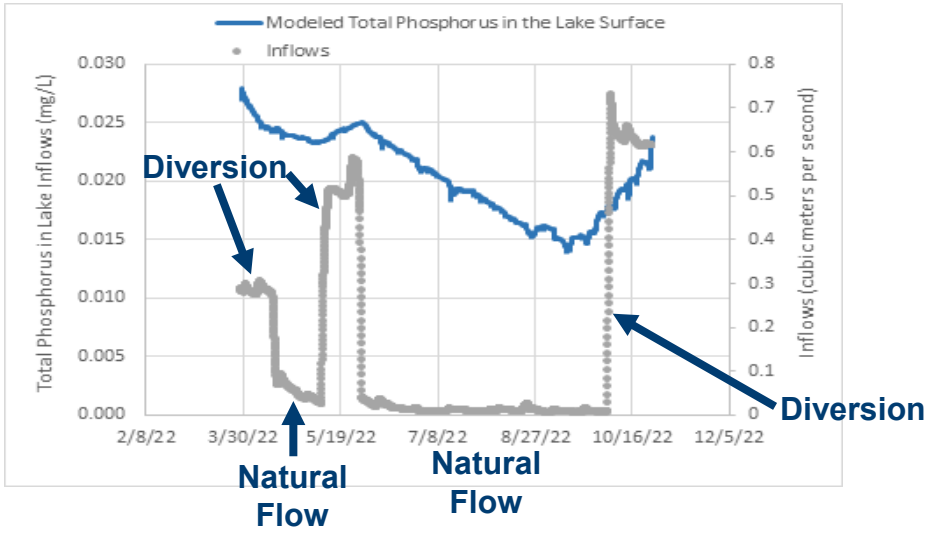


Surface and Groundwater Loading Only

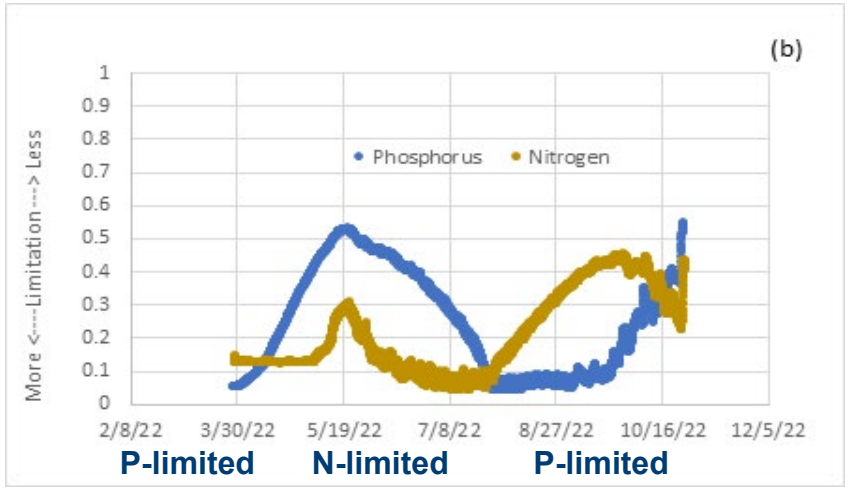


Technical Findings – Model Outputs: Selected Insights

- Outputs include generation of continuous phosphorus, nitrogen, and chlorophyll a in Silver Lake
- Allows comparison of model outputs to various inputs
  - Inflows plotted against phosphorus concentration in Silver Lake



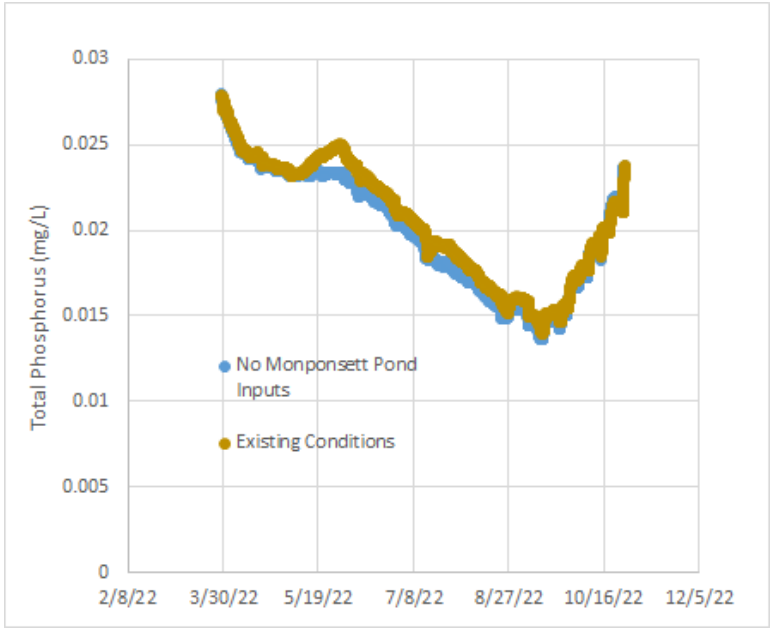
- Provides insights into nutrient limitation
  - Silver Lake appears to experience both phosphorus and nitrogen limitation
  - Certain cyanobacteria may be favored by nitrogen limitation because they can fix their own
- Can also use to test different “what if?” scenarios…



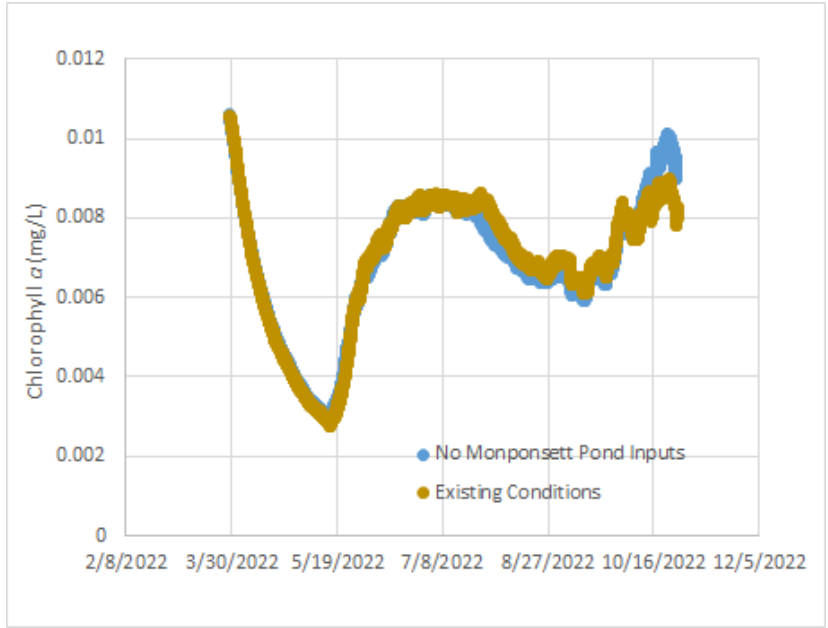
Technical Findings – Model Load Reduction Scenarios

- For instance, what would have happened if E. Monponsett diversions had been eliminated in 2022?
- On its own, elimination of diversions in 2022 (blue lines below) would have had minimal impact on nutrient levels or chlorophyll a in Silver Lake
- But this does not take into account any change in withdrawals

Diversion Loading Reduction – Surface P



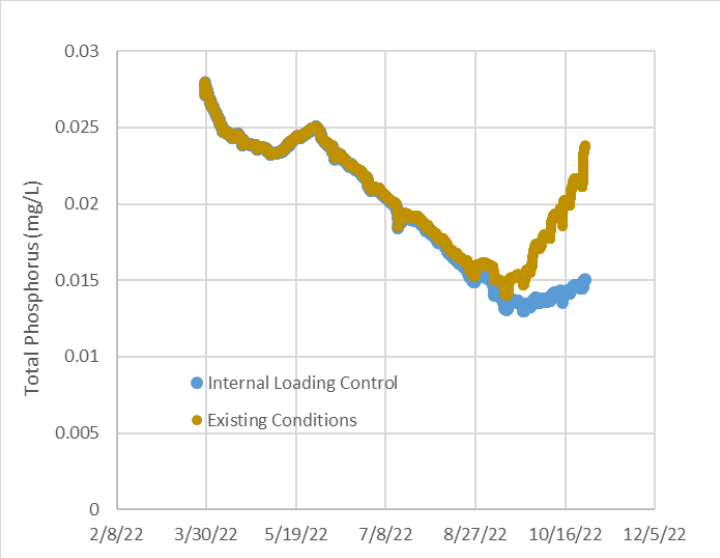
Diversion Loading Reduction – Chlorophyll a



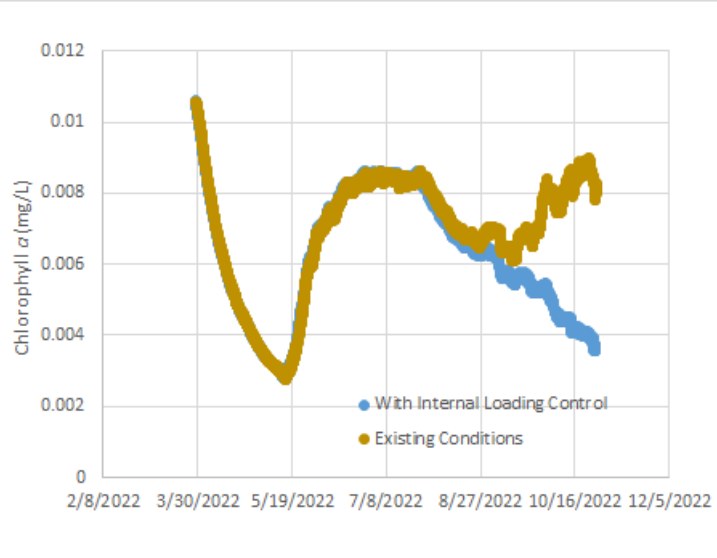
Technical Findings – Model Load Reduction Scenarios

- Alternatively, what if internal loading had been eliminated?
- Internal loading controls would decrease total phosphorus contributions during late summer/autumn
- This also results in a decrease in chlorophyll a over the same period
- Cumulative improvements may be realized the following year

Internal Loading Reduction – Surface P



Internal Loading Reduction – Chlorophyll a



In Conclusion

Silver Lake Water Quality

In Conclusion – Overall Assessment of Silver Lake

Applying MassDEP CALM approach, results of 2021-2022 monitoring program indicate Silver Lake is:

- Not supportive of Aquatic Life
  - Non-native plants
  - Dissolved oxygen
  - Total phosphorus
  - Other impairments also possible (e.g., nutrients)
- Supportive of Aesthetics
- Not supportive of Primary Contact Recreation (although swimming is prohibited)
  - Harmful algal blooms
- Supportive of Secondary Contact Recreation (also prohibited)

In Conclusion – Effects of Water Diversions

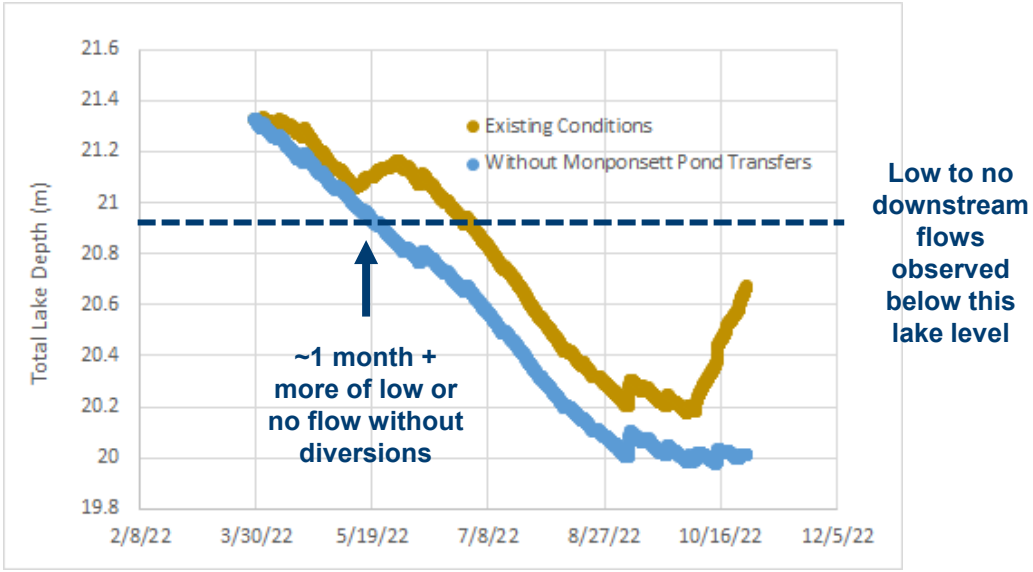
How have water diversions likely impacted the following?

- Aquatic plants
  - Species now in Silver Lake are also found in Furnace Pond and Tubbs Meadow Brook
  - Prior Furnace Pond diversions (pre-2020) could have been a source
- Cyanobacteria
  - None detected in either of the diversion sources
  - Unlikely to have been direct contributor of substantial cyanobacteria during the study period
- Cyanotoxins (Microcystins)
  - None detected in either of the diversion sources
  - Unlikely to have been direct contributor of cyanotoxins during the study period
- Dissolved oxygen
  - Levels mostly adequate in diversion sources under the observed conditions
  - DO levels likely to change in transit from diversions sources to Silver Lake

In Conclusion – Effects of Water Diversions

How have water diversions likely impacted the following?

- Nutrients
  - Phosphorus and nitrogen external loading to Silver Lake is much higher due to water diversions (67% and 81% of external loading, respectively)
  - Likely to have long-term effect, although diversions did not appear to have a major impact during the study period
- Outlet flow issues
  - If diversions were not used but water withdrawals and outlet configuration remained the same, outlet flow issues could worsen due to lower lake levels



In Conclusion – Key Takeaways

- Silver Lake appears to be facing multiple management issues, several of which rise to the level of water quality impairments.
- These impairments impact aquatic life and present a challenge to future use of Silver Lake as a public water supply.
- Excessive nutrients are associated with many of these impairments, particularly phosphorus.
- Modeling suggests that internal loading from the sediments is now the primary source of phosphorus to Silver Lake.
- Diversions were the primary external source of nutrients but the relationship with in-lake water quality may be complex.

In Conclusion – What to Do

- An appropriate management response needs to be developed and implemented to address current impairments and future risks.
- Localized actions may help to ensure the quality of raw and finished water from the point of the potable water intake to the distribution system but a large-scale approach will be needed to fully address the observed issues on a broader basis.
- Ongoing monitoring is recommended to track water quality, water quantity, and ecological trends.
- Additional modeling could be used to evaluate the effectiveness of alternative management scenarios.
- Ultimately, need to develop a comprehensive management plan for Silver Lake that:
  - Identifies a target condition
  - Assesses feasibility of management options for achieving that condition
  - Selects and prioritizes the preferred management options
  - Identifies funding needs and sources
  - Lays out a schedule for implementation
  - Provides a mechanism for evaluating success

Thanks!

Questions?

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