Clear Lake Watershed and Lake Remediation

Clear Lake Blue Ribbon Committee Meeting

December 16, 2024

UCDAVIS
Tahoe Environmental
Research Center

Why this project?

Filling knowledge gaps from past Clear Lake basin studies:

- *Focused on **historical** analysis, not driving **mechanisms***
- *No **predictive tools** to explore lake and watershed restoration strategies*

What did we do?

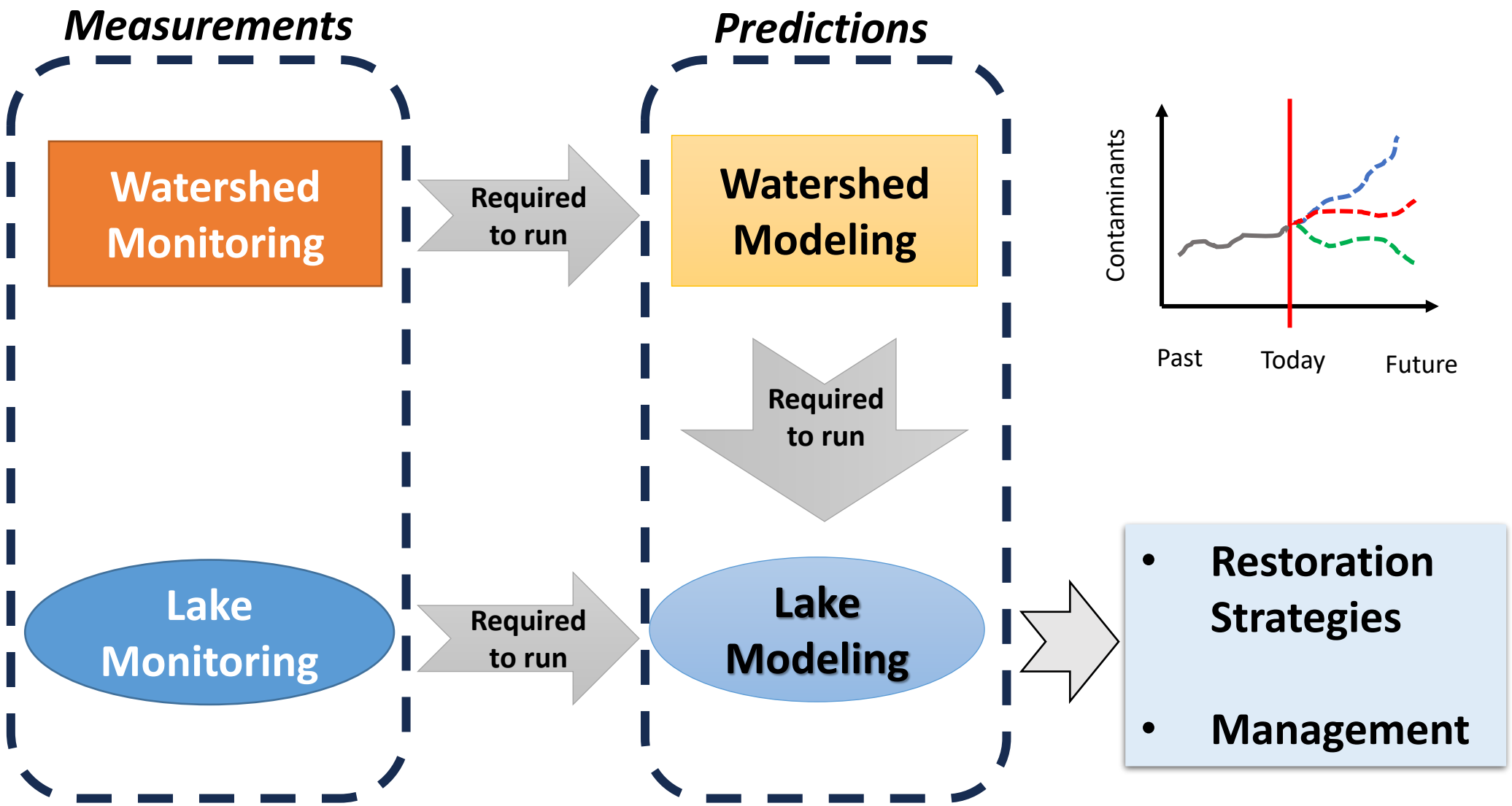
- Identify the main **cause(s) of poor water quality** in Clear Lake
- Develop **predictive tools (models)** to evaluate lake and watershed restoration strategies

How did we do it?

Monitoring (Continuous Measurements)

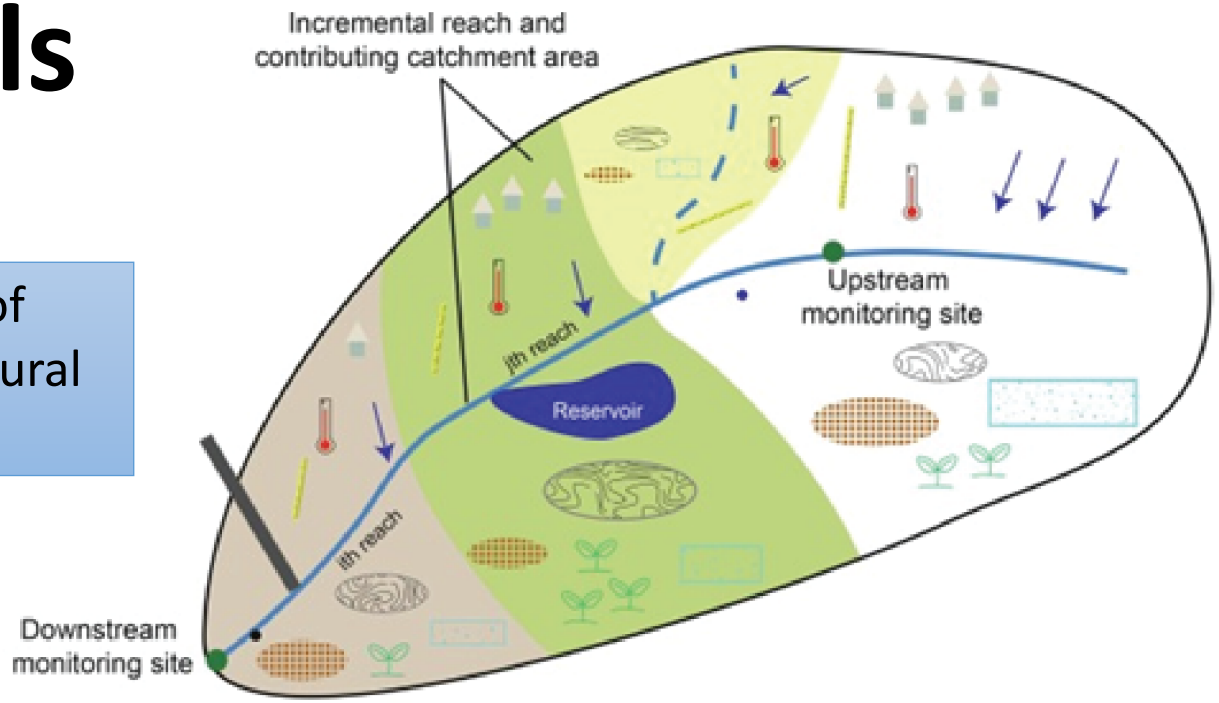
Modeling (Predictions)

Restoration Strategies & Management


Measurements
Predictions
Watershed Monitoring
Required to run
Watershed Modeling
Required to run
Lake Monitoring
Required to run
Lake Modeling
Contaminants
Past
Today
Future
Restoration Strategies
Management

Watershed Models

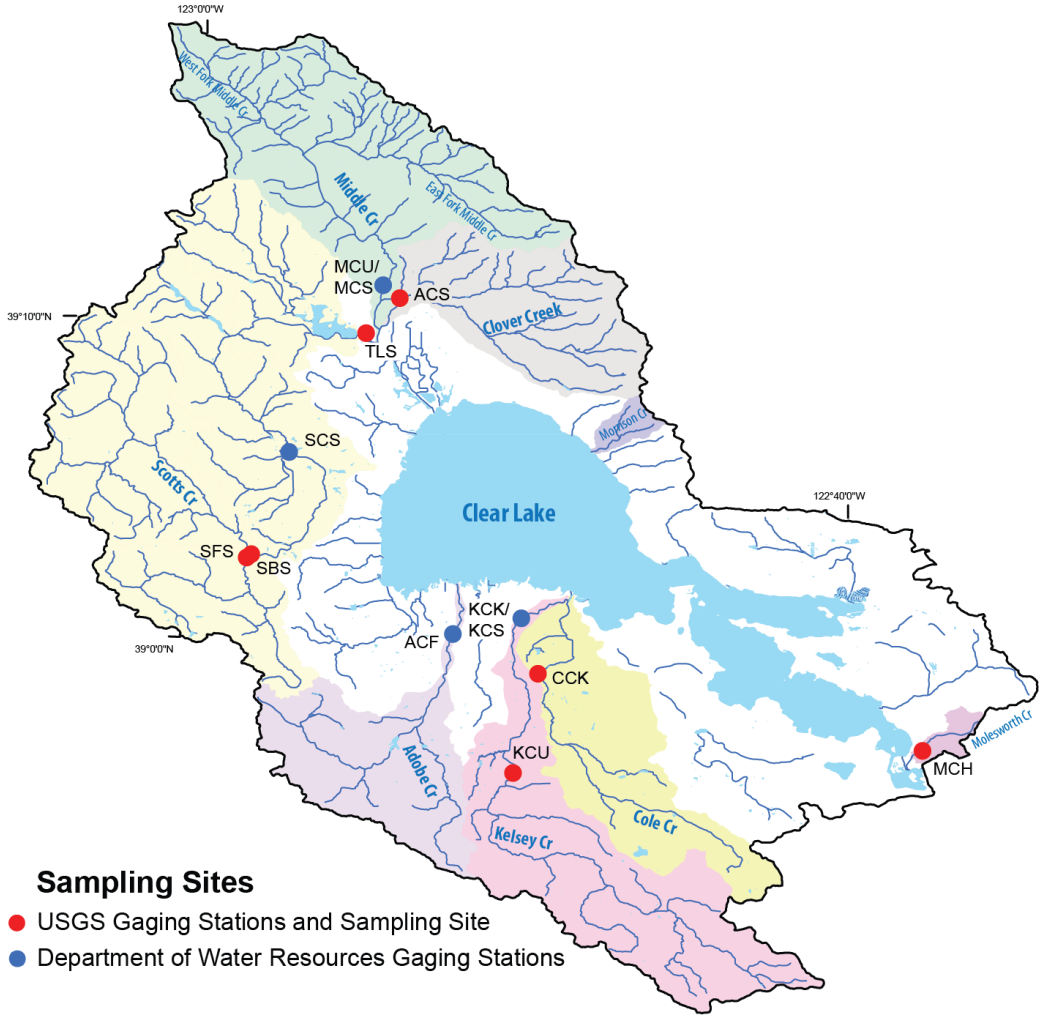
Understand and predict **sources and transport** of **nutrients and sediment** in the watershed from natural and anthropogenic processes



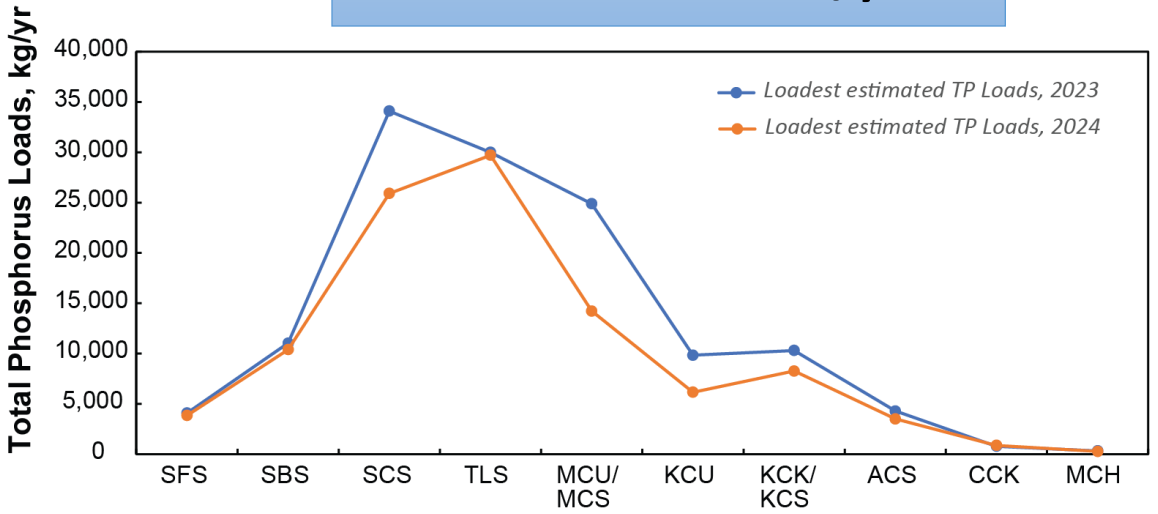
- ***LOADEST:*** Used to **estimate daily nutrient loads** at gaged monitoring sites
- ***SPARROW:*** Used to **predict sources, loads, and transport** of total N and total P
- ***HSPF and Sediment Fingerprinting:*** Used to **quantify sources of sediment** to the lake

LOADEST OUTPUT:

Total Phosphorus Loads



Wet Year
Total TP Load ~115 T/year



Station Name	Site Abbreviation
South Fork Scotts Creek near Lakeport CA	SFS
Scotts Creek below South Fork Scotts Creek near Lakeport, CA	SBS
Scotts Creek above Eickhoff Road Bridge near Lakeport CA	SCS
Scotts Creek above State Route 29 at Upper Lake, CA	TLS
Middle Creek near Upper Lake at Rancheria, CA	MCU/MCS
Kelsey Creek near Kelseyville, CA	KCU
Kelsey Creek below Kelseyville, CA	KCK/KCS
Clover Creek Bypass at Elk Mountain Road near Upper Lake, CA	ACS
Cole Creek at Kelseyville, CA	CCK
Molesworth Creek near Clear Lake, CA	MCH

SPARROW OUTPUT:

Total Phosphorus Yields [kg/km^2/year]

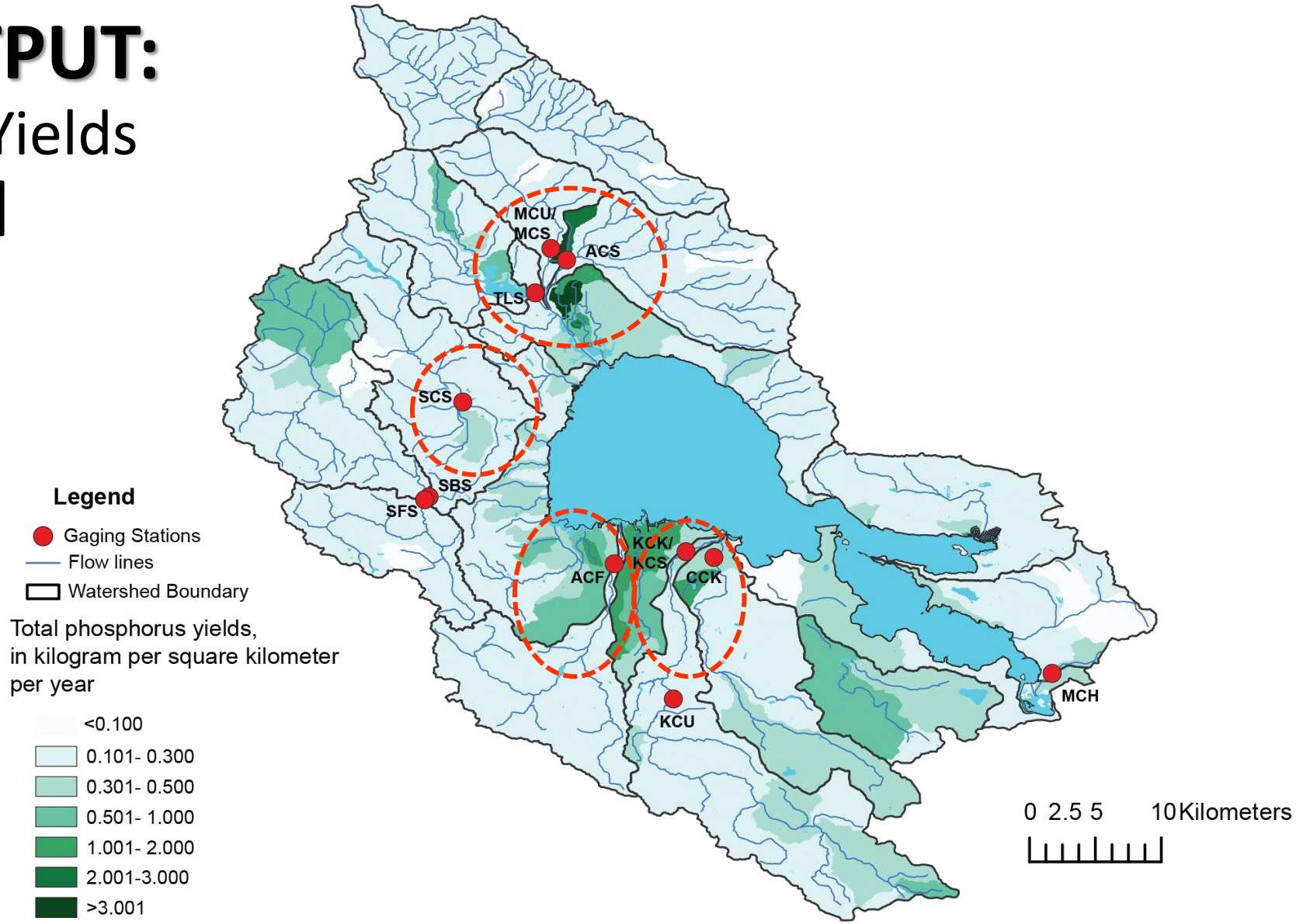
Scotts Creek

Middle/Clover Creeks

Kelsey Creek

Adobe Creek

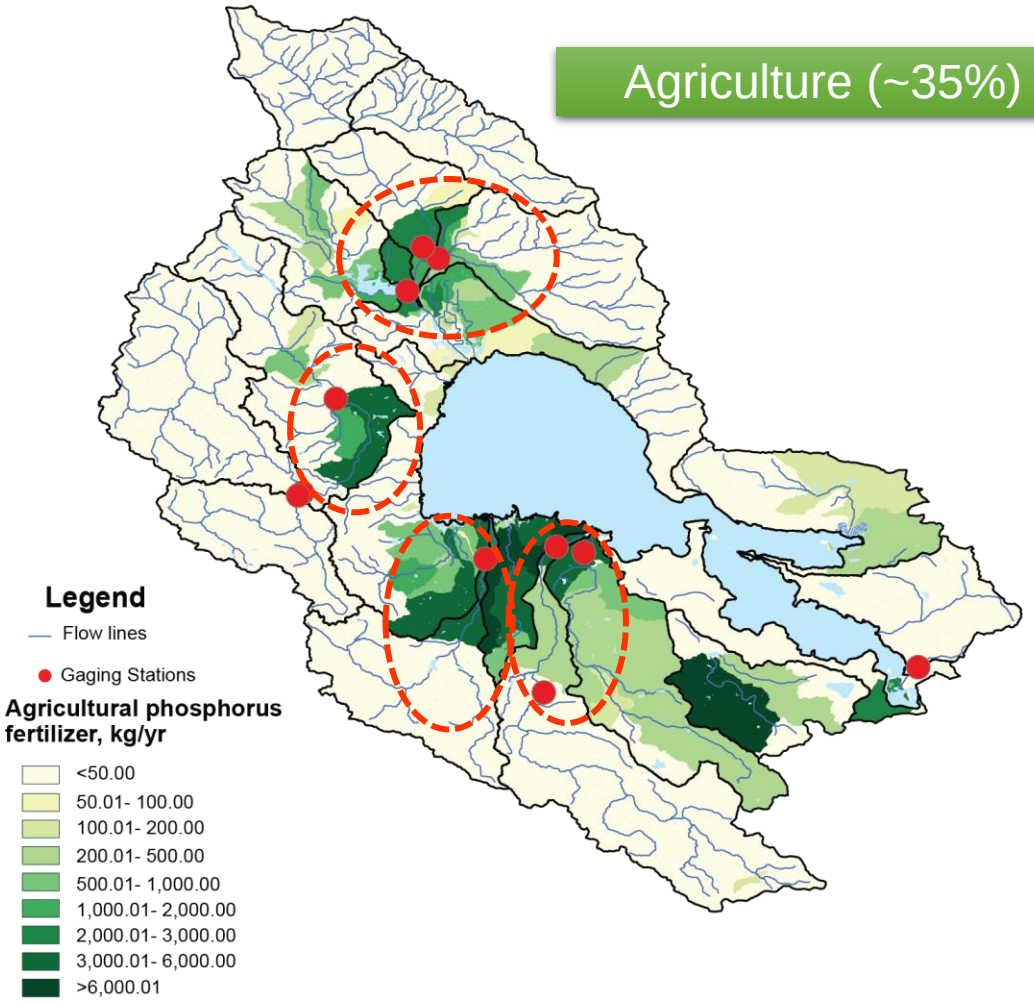
~75% of total TP



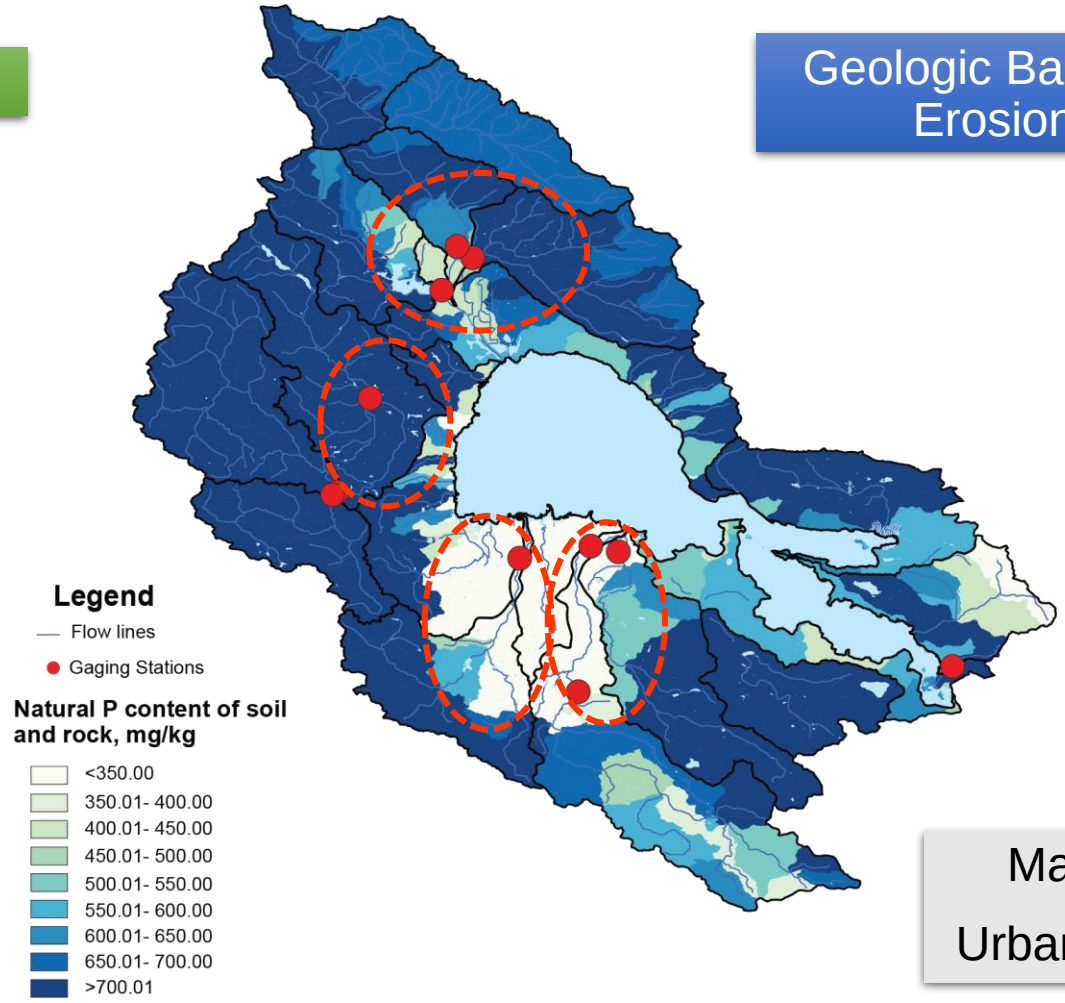
SPARROW OUTPUT:

Total Phosphorus sources

Agriculture (~35%)



Geologic Background and Erosion (~40%)

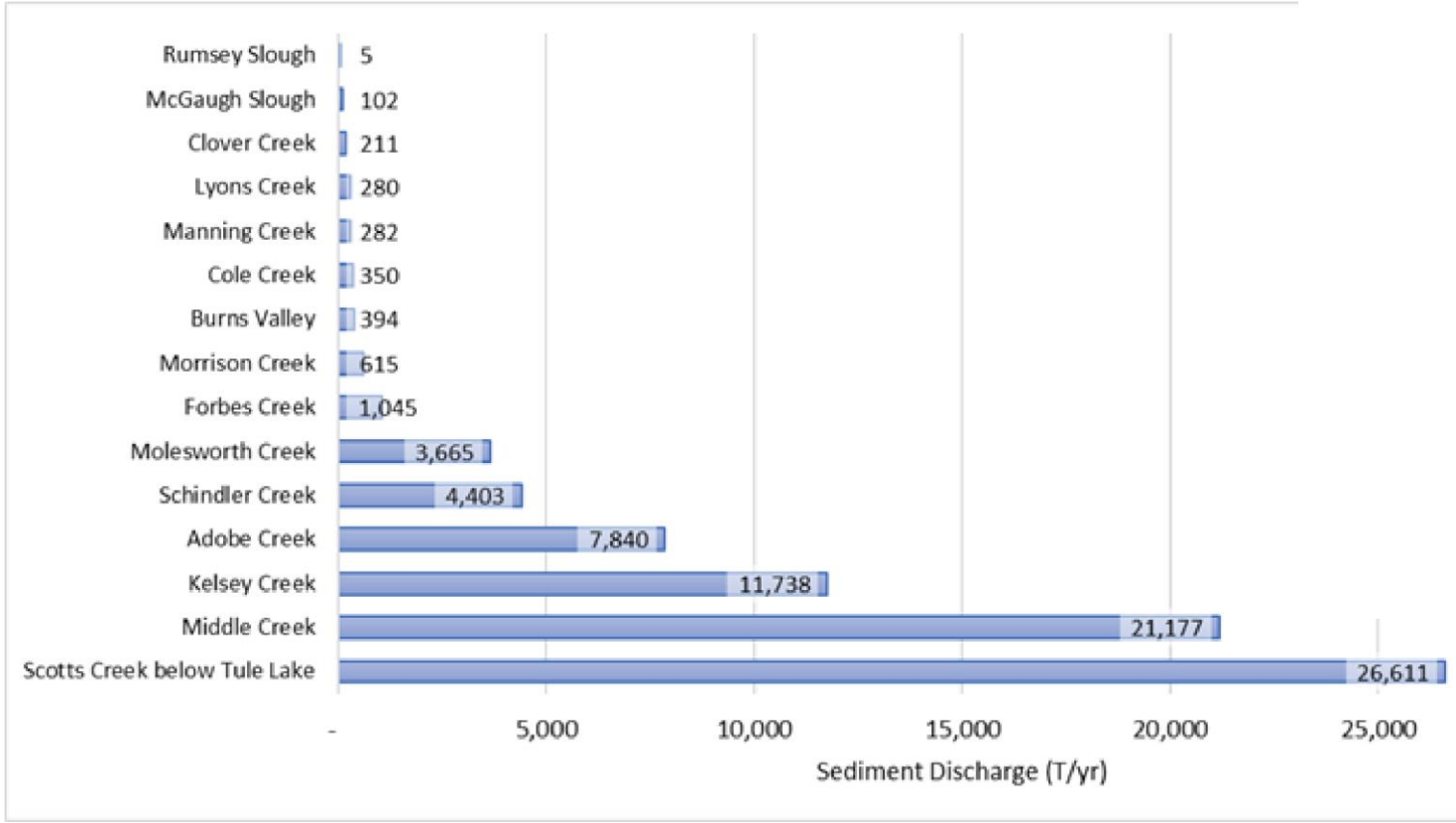


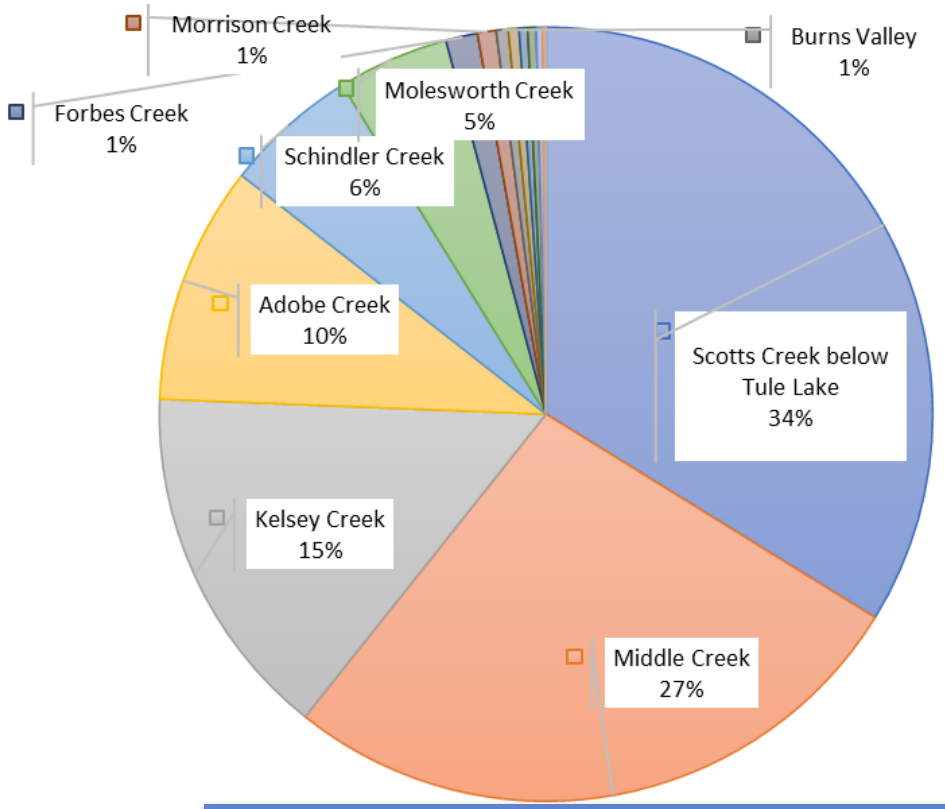
Manure (~15%)

Urban runoff (~10%)

HSPF OUTPUT:

Suspended Sediment Loads





Scotts Creek ~35%
Middle/Clover Creeks ~ 30%
Kelsey and Adobe Creeks ~25%

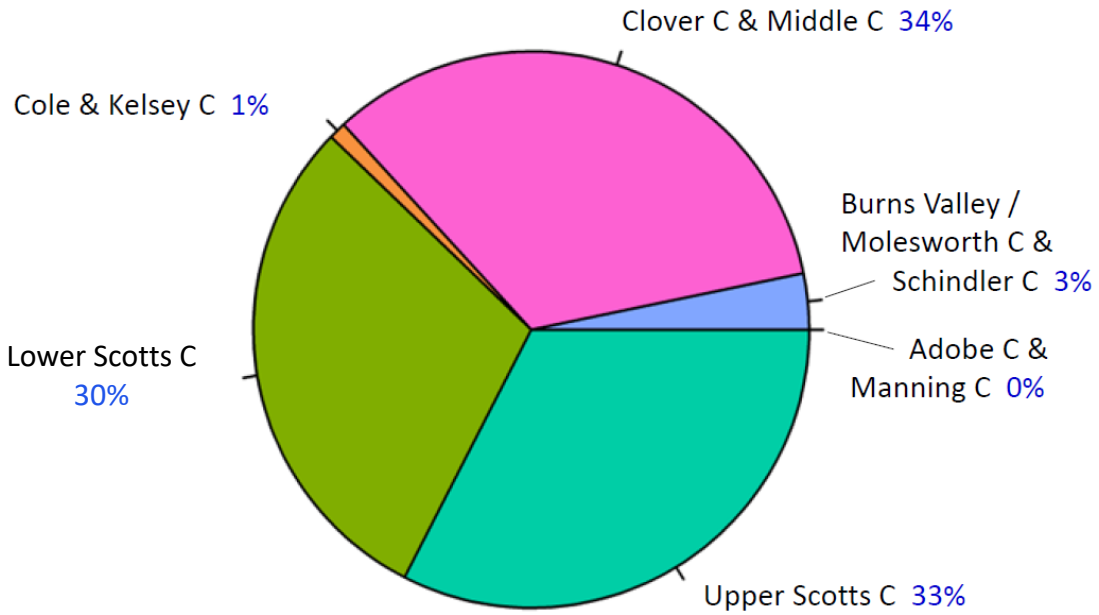
Average water year contribution of sediment discharge to Clear Lake, summarized by major tributary inputs discharge to Clear Lake from 1981-2023

Sediment Fingerprinting :

Results of unmixing calculations – sediment sources

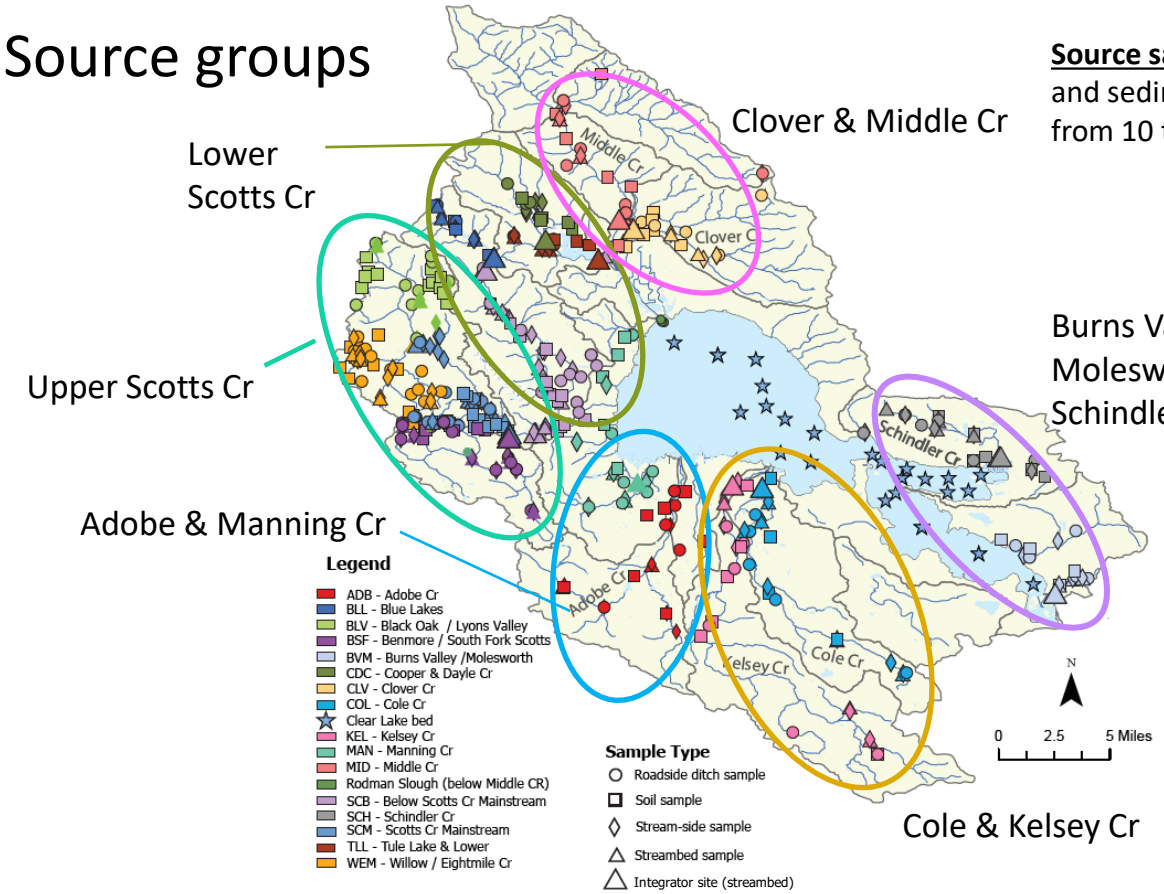
- Upper Scotts Creek
- Lower Scotts Creek
- Middle/Clover Creeks

➡ ~90%



Based on average results for 25 target samples

Source groups



Source samples – 418 soil and sediment samples from 10 tributaries

Target samples – 25 locations in all 3 arms of Clear Lake

Watershed Key Findings

75% Total Phosphorus and Nitrogen loads from 4 major sub-watersheds

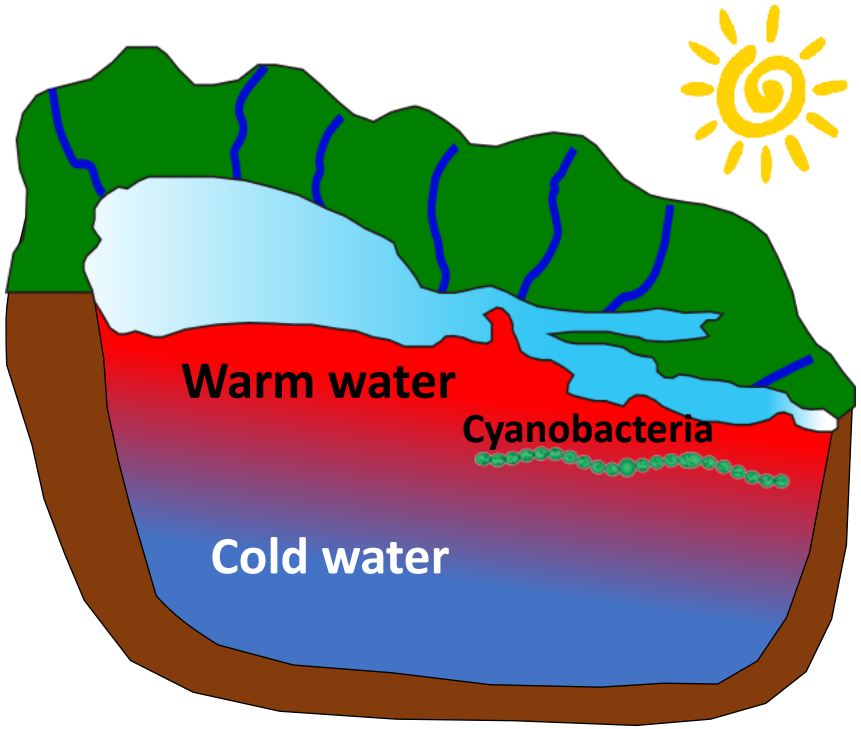
Phosphorus:

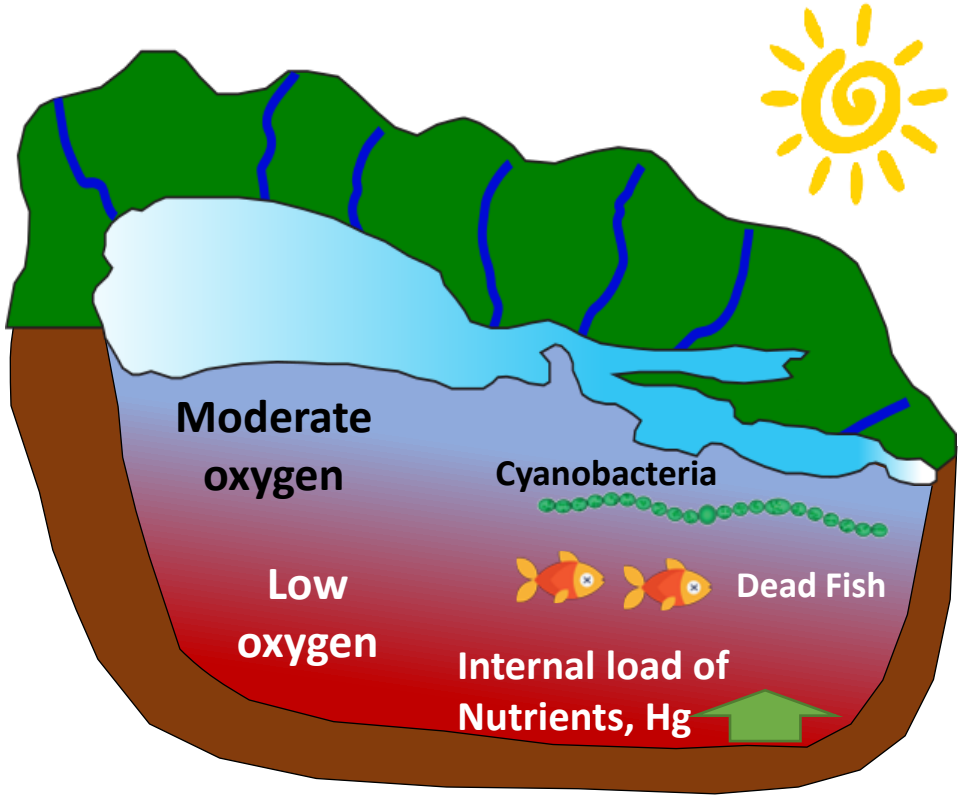
- ~40% **Geologic background and Erosion of stream beds**
- ~35% **Agricultural fertilizer** (*90% of applied phosphorus does not contribute to observed loading in lake)*
- ~25% Manure and urban runoff

Nitrogen: Fertilizer and manure (33%), Atmospheric deposition (29%), and Runoff from grasslands and scrublands (26%)

~90% Stream flow and sediment loads from 4 major sub-watersheds

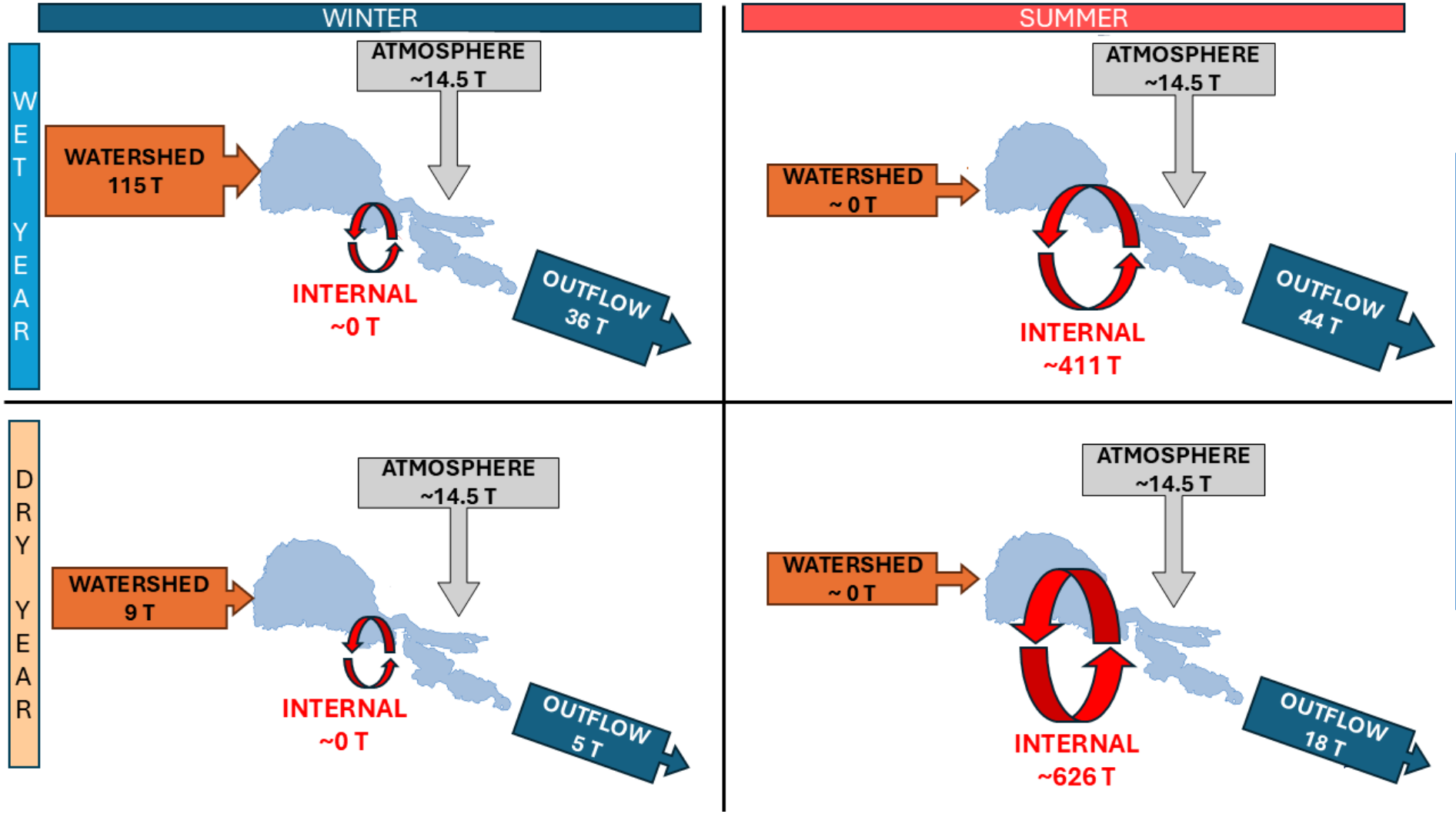
Lake Temperature, Dissolved Oxygen (DO), and Internal Load





Internal P Load (released from the sediments) represents 70-95% of total annual P in the water

Nutrient (P) Dynamics: Short and Long Term



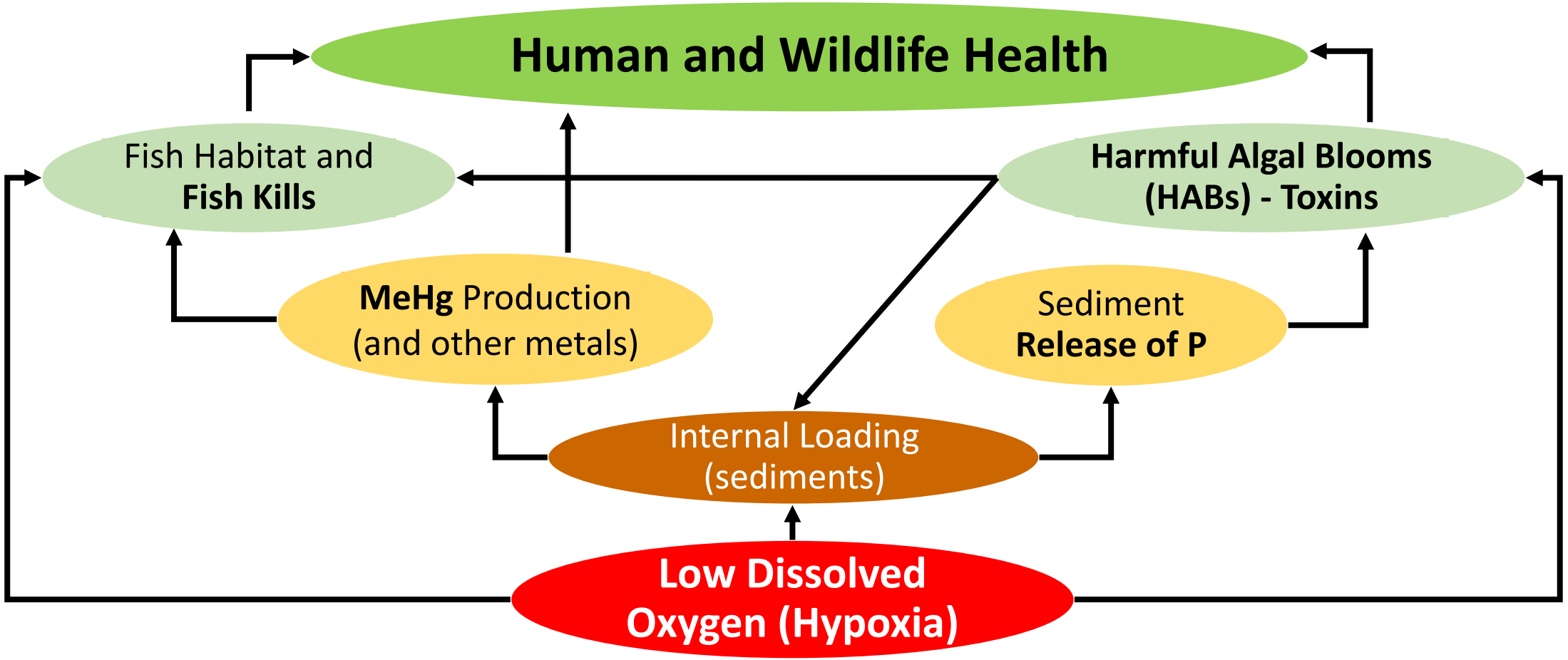
Short term (seasonal)

- Lake has **more P** when **creeks are dry**

Long-term (decadal)

- Lake **accumulates P** because inputs >> outputs
- **More P** in the lake during **dry years**

Causes of Poor Water Quality at Clear Lake



The Power of Predictive Tools

We used in-lake predictive models to evaluate restoration strategies to mitigate HABs **approved** by the Blue Ribbon Committee

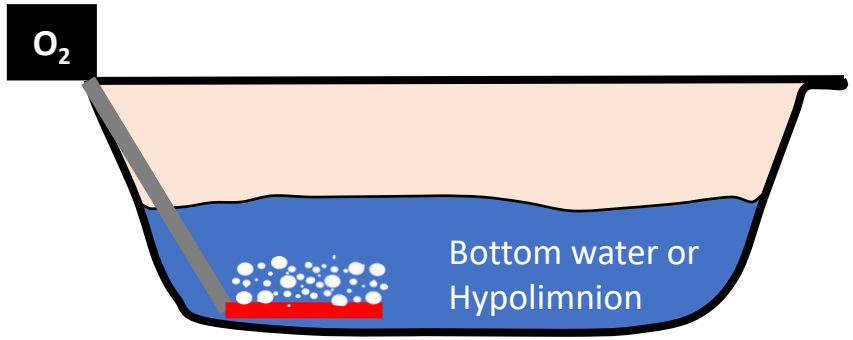
- Sediment P Sequestration
- Ultrasonic Algae Control
- Algae and Nutrient Harvesting
- Hypolimnetic Oxygenation

Clear Lake is **large and very dynamic** (with strong currents, and it mixes frequently)

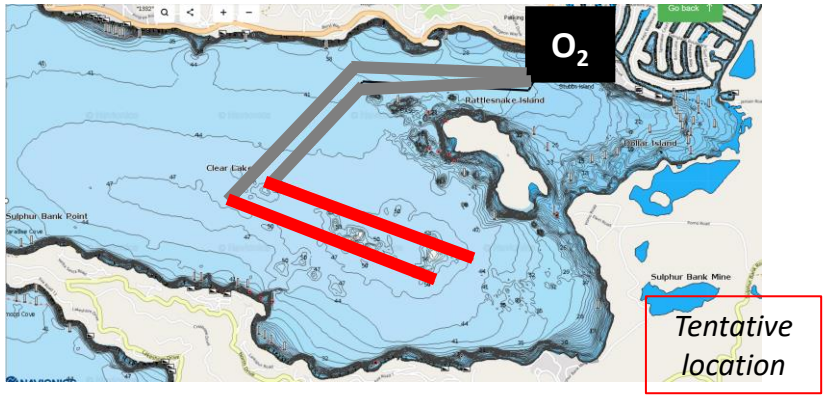
Some restoration projects will only have **localized effect,** and their **efficacy will be compromised** due to Clear Lake's dynamic nature

Hypolimnetic Oxygenation (H.O.)

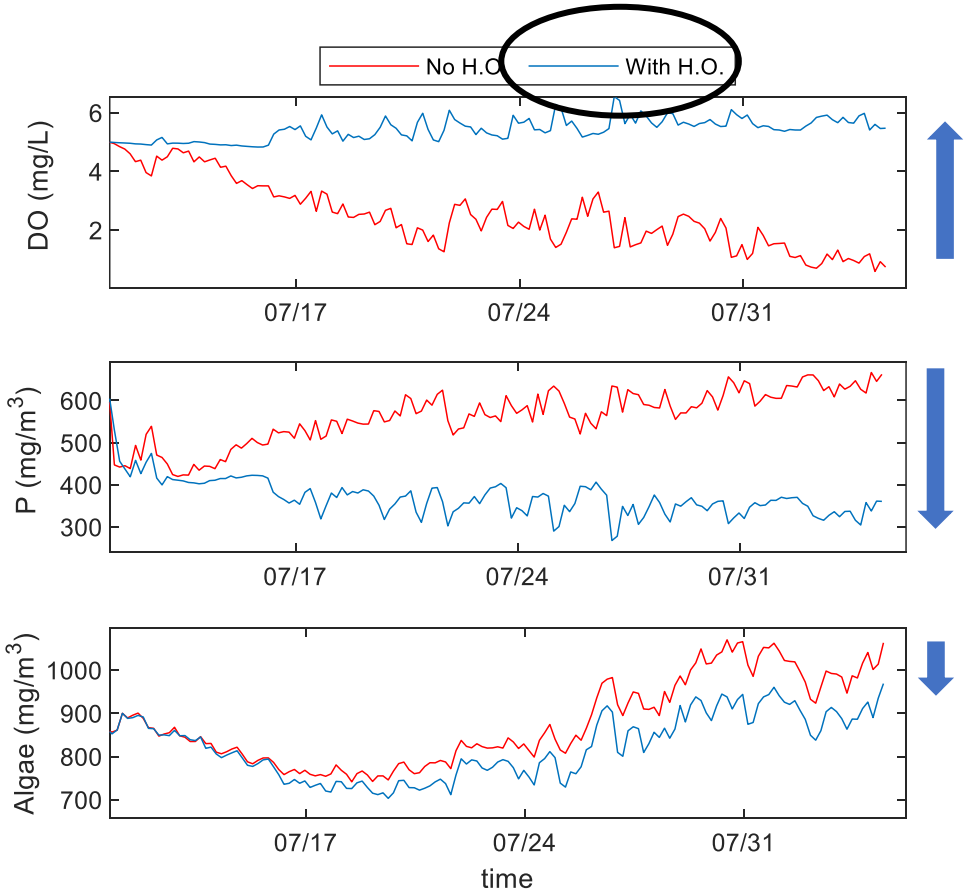
Can treat the **whole lake** and **takes advantage of the dynamic nature** of the lake



Sketch of a Hypolimnetic Oxygenation System



Pilot project in the Oaks Arm partially funded by CNRA

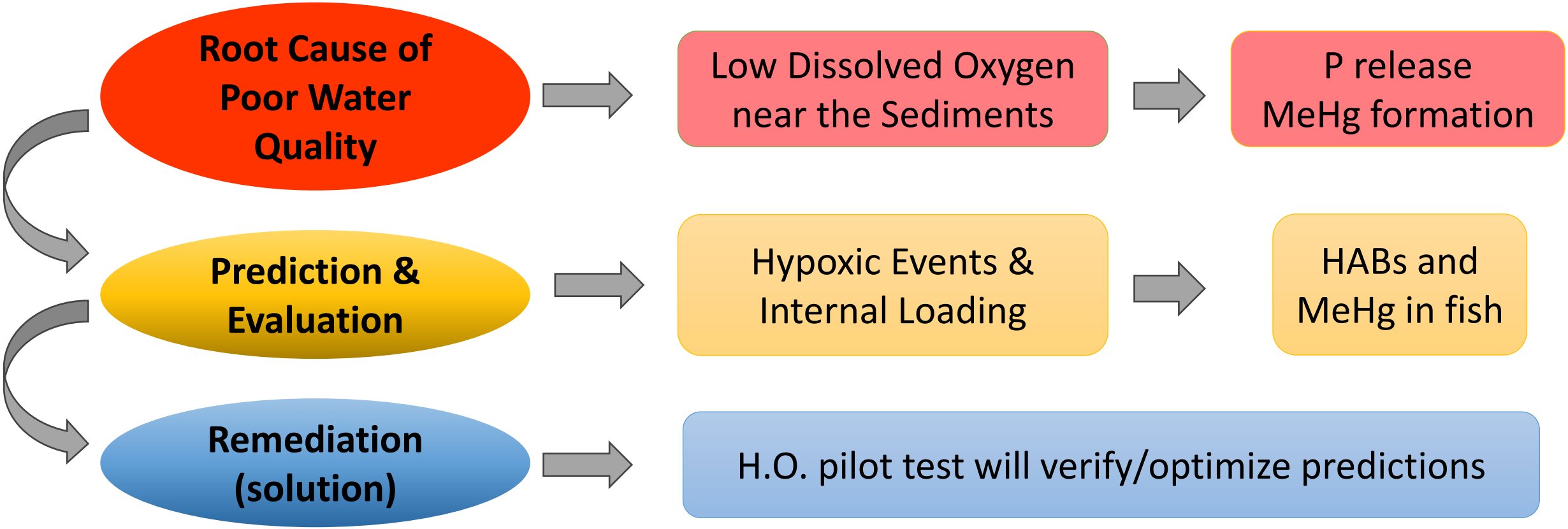


DO > 3.5 mg/L

Phosphorus Concentration reduced by 50%

Algae Concentration reduced by 20%

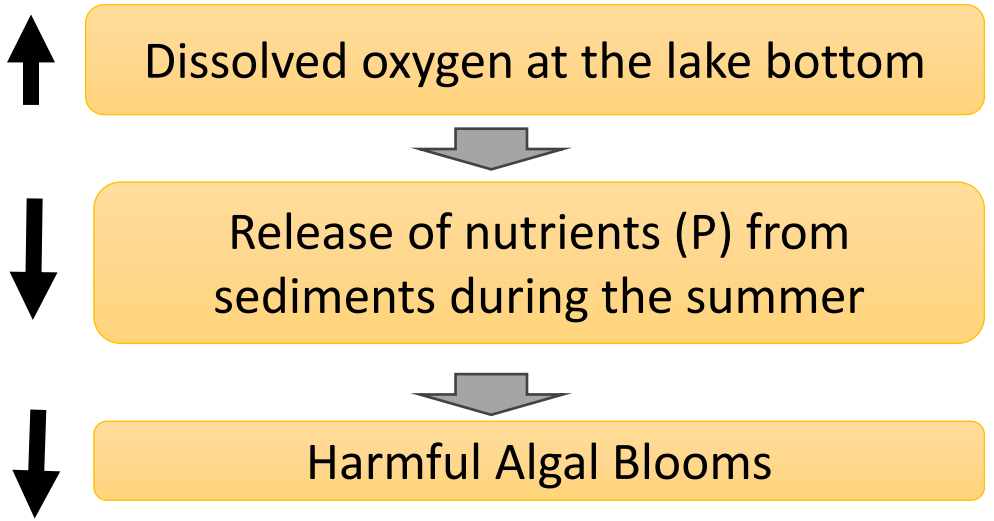
Lake Key Findings



Remediation Goals: Management Implications

Short-term (seasonal): In-lake

Long-term (decadal): Watershed



Reduce nutrient loads from the watershed

Lake accumulates P because inputs >> outputs

In-lake restoration strategies in the short-term (**seasonal scale**) and **watershed restoration** strategies in the long-term (**decadal**)

Recommendations

- Identify high priority areas for **erosion reduction** (Upper Scotts Creek, Lower Middle Creek, and Clover Creek)
- Implement the **Middle Creek Restoration Project**
- Support local **Best Management Practices** in portions of most tributaries
- Understand the relationship between **surface and groundwater** and the effects of climate and pumping on groundwater levels
- Complete the **H.O. pilot project in the Oaks Arm**
- Establish a **sustained, long-term, community-led, science-based monitoring program** with guidance from regional expertise
- Continue using the newly **developed** watershed and in-lake **models**

How can the Models be Applied to Future Projects?

- *Evaluate* success of **erosion reduction**
- *Evaluate* success of the **Middle Creek Restoration** project
- *Optimize* **Hypolimnetic Oxygenation** (H.O.) implementation and operation
- *Evaluate and refine* **future in-lake restoration projects** to mitigate HABs, MeHg
- *Assess* lake response to **new challenges** (climate change and land uses)
- *Update and improve* **predictions** as new monitoring data become available

Summary

- **<u>Sources of Phosphorus from the Watershed (long-term, decadal)</u>**

~40% **Geologic background and Erosion of stream beds**

~35% **Agricultural fertilizer** (*90% of applied phosphorus does not contribute to observed loading in the lake)*

- **<u>Sources of Phosphorus in the Lake (short-term, seasonal)</u>**

Phosphorus **released from the sediments during low oxygen periods** (summer) represents 70-95% of total annual P in the lake water

- Full report available at **clearlakerehabilitation.ucdavis.edu > Publications**

Thank you for letting us be a part of Clear Lake's rehabilitation

https://clearlakerehabilitation.ucdavis.edu/

https://www.lakecountyca.gov/1662/Clear-Lake-Integrated-Science-Symposium-

Pomo of Upper Lake Habematolel

Scotts Valley Band of Pomo Environmental

Elem Indian Colony 1852

Big Valley Rancheria

Robinson Rancheria Pomo Indians California

Koi Nation

Middletown Rancheria of Pomo Indians of California

County of Lake Water Resources

California Natural Resources Agency

U.S. Department of the Interior Bureau of Land Management

California Department of Fish & Wildlife