LECL TMDL Task Force
Canyon Lake Alum Update

Presentation to LECL TMDL Task Force

May 19, 2025

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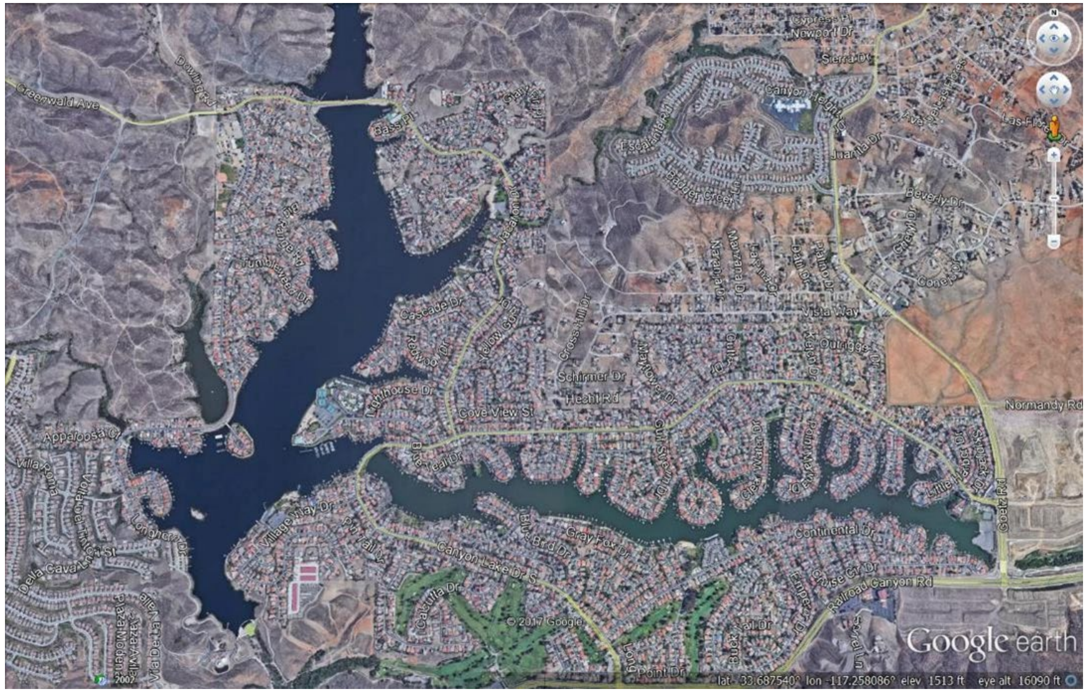
Agenda

- Alum Addition Program Overview
- Recent Implementation Challenges
- Canyon Lake In-Lake Treatment Analysis

Alum Addition Program



Selection of Alum Addition for Canyon Lake

- Benefits of alum addition in simulated with DYRESM-CAEDYM
- Routine program of relatively low dose alum additions
- Slurry emitted to water surface forms a floc that binds phosphate as it settles to the lake bottom
- Continues to sequester phosphorus in lake bottom after settling

Table 2. 10-yr average volume-weighted total P and total N concentrations, surface chlorophyll a concentrations, and volume-weighted hypolimnetic DO concentrations.

Scenario	Total P (mg/L)	Total N (mg/L)	Chlorophyll a (µg/L)	DO (mg/L)
Existing	0.364±0.061	1.611±0.078	35.0±2.2	4.49±0.37
BMPs	0.314±0.059	1.501±0.091	31.0±2.3	4.47±0.36
Alum H	0.197±0.059	1.468±0.069	9.6±6.3	4.94±0.50
Alum W	0.250±0.087	1.481±0.075	12.2±6.7	4.88±0.42
Alum H + W	0.200±0.065	1.469±0.062	9.1±5.8	4.97±0.50
Alum H + IL	0.146±0.038	1.465±0.048	5.6±5.8	5.07±0.46
Alum H + W + IL	0.151±0.058	1.454±0.045	5.3±5.3	5.08±0.46
BMP + Alum H	0.191±0.045	1.343±0.080	8.6±6.4	4.96±0.49
BMP + Alum W	0.245±0.078	1.343±0.080	11.6±6.7	4.88±0.44
BMP + Alum H + W	0.190±0.045	1.348±0.083	8.6±6.0	4.96±0.45
BMP + Alum H + IL	0.138±0.036	1.336±0.080	4.9±5.5	5.11±0.47
BMP + Alum H+W+ IL	0.152±0.071	1.336±0.081	4.9±5.4	5.09±0.47

From Anderson, 2012. Predicted Water Quality in Canyon Lake with In-Lake Alum Treatments and Watershed BMPs, Technical Memorandum dated 9/18/2012

NALMS Position

- NALMS Position Statement (https://www.nalms.org/nalms-position-papers/the-use-of-alum-for-lake-management/)
  - Alum is a safe and effective lake management tool.
  - Alum applications should be designed and controlled to avoid concerns with toxicity to aquatic life.
  - Watershed management is an essential element of protecting and managing lakes. In cases where watershed phosphorus reductions are neither adequate nor timely, alum is an appropriate tool to accomplish meaningful water quality objectives.

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The Use of Alum for Lake Management

Aluminum sulfate, called alum, when added to lake water removes phosphates through precipitation, forming a heavier than water particulate known as a floc. This floc then settles to the lake bottom to create a barrier that retards sediment phosphorus release. There are two policy-related issues with the use of alum:

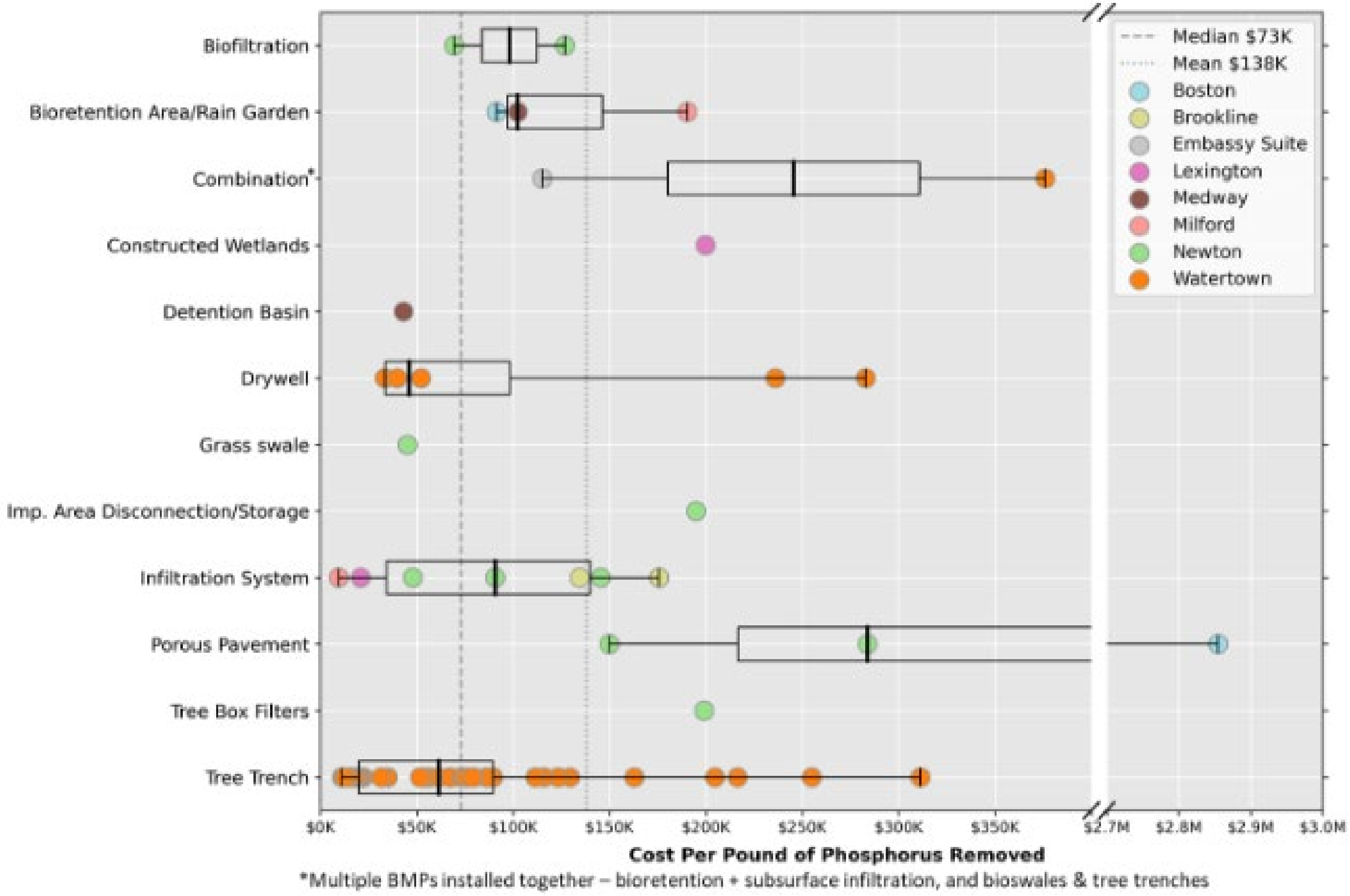
1. Whether alum is safe for humans and aquatic life, and
2. Balancing the use of alum as it is used to mitigate eutrophication symptoms versus the more tedious, but more direct approach of mitigating the causes of eutrophication.

There has also been recent discussion about whether alum is considered an algaecide in the context of NPDES rules. The concern is, if a product makes a claim that it controls algae, then it is presumed to be an algaecide and therefore can be regulated under NPDES. For purposes here, alum is not considered an algaecide for the simple reason that any algae control effects following an alum application are the result of phosphorus reduction rather than any direct toxic effects on algae control.

Cost

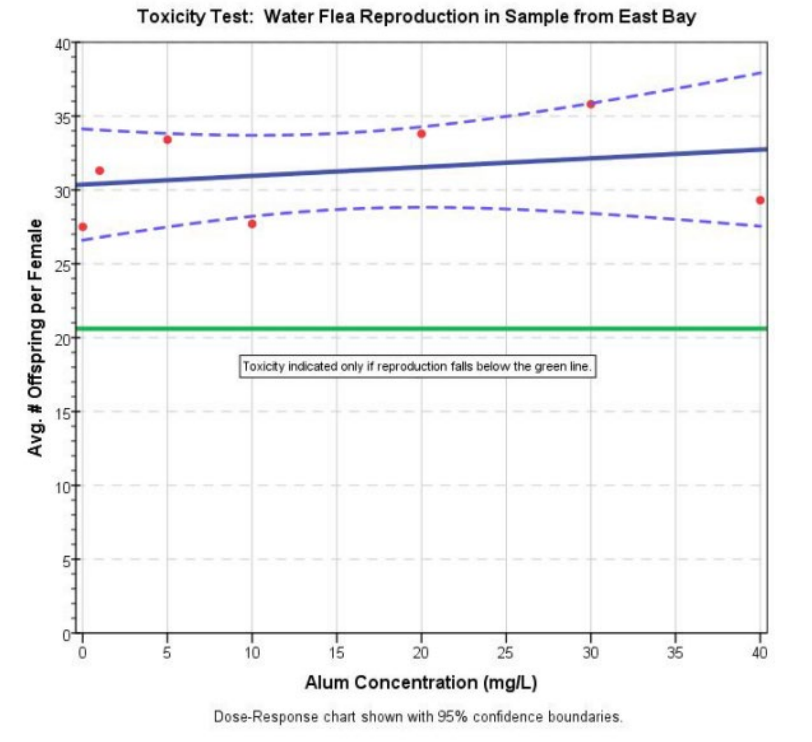
EPA 2022 Cost analysis for TP removal in stormwater BMPs (https://www3.epa.gov/region1/npdes/rda/ar/appendixr-7-cost-benefit-resource-kit-revised-07132022.pdf)

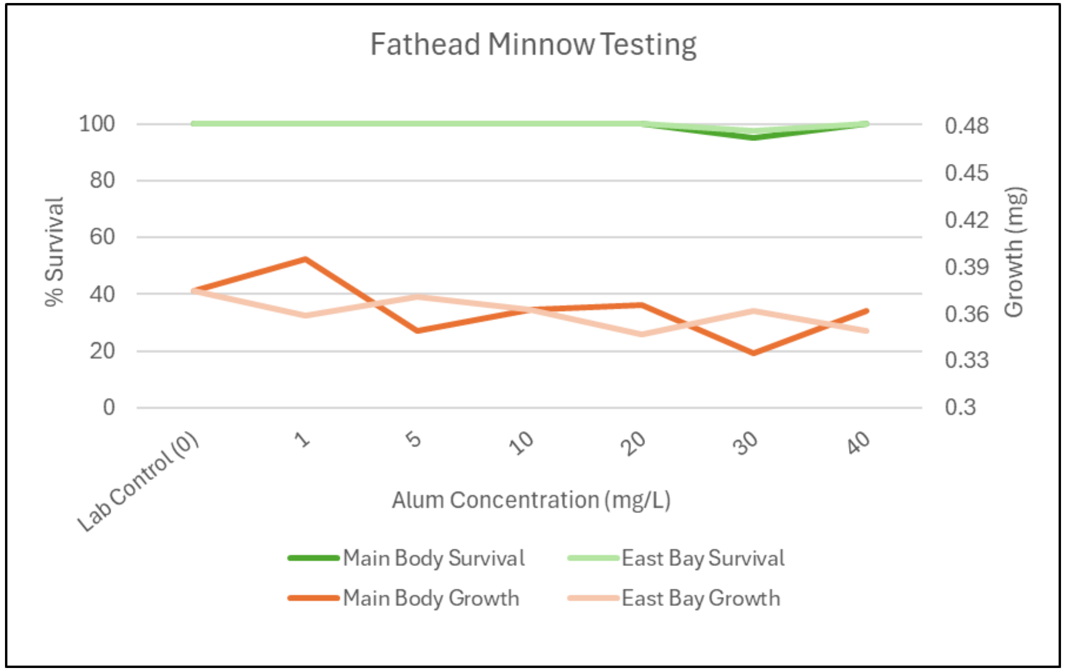
- Budget Cost for FY 2025-2026 of $338,500 with estimated removal of ~2,000 kg/yr
- Alum cost ~ $170/kg TP removed ($77/lb TP),
- Watershed BMPs ~$100,000/lb TP removal (EPA 2022)
- Alum additions are **over 1000 times more cost effective than stormwater controls**

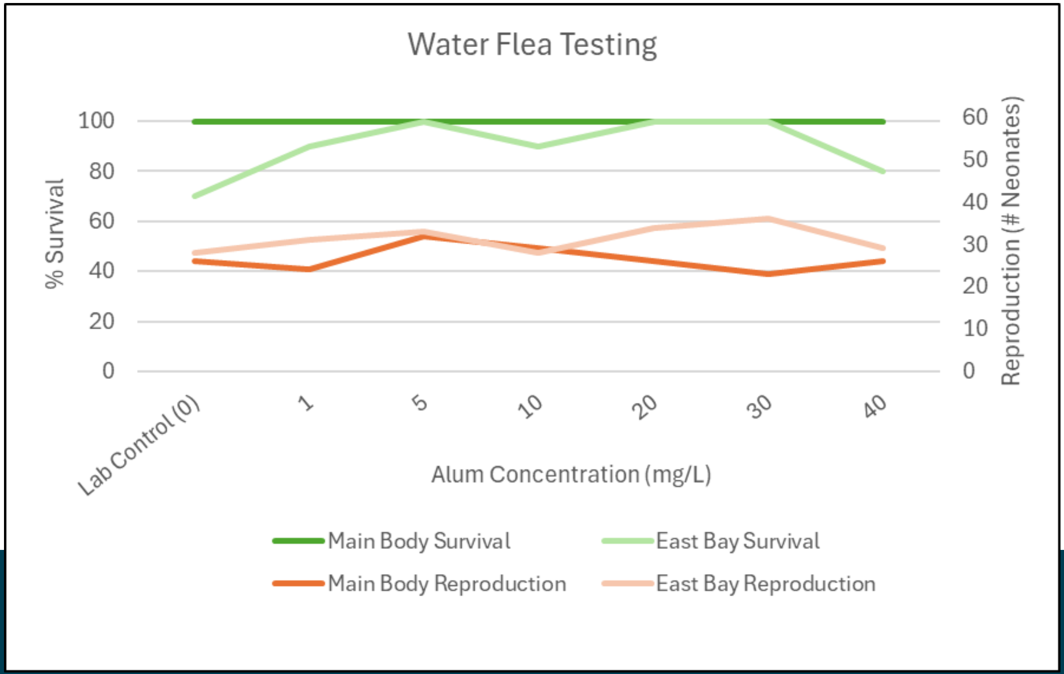


Toxicity Testing (2013)

- Toxicity test results show no effect from alum up to 40 ug/L
- pH range in samples 8.3 - 8.7

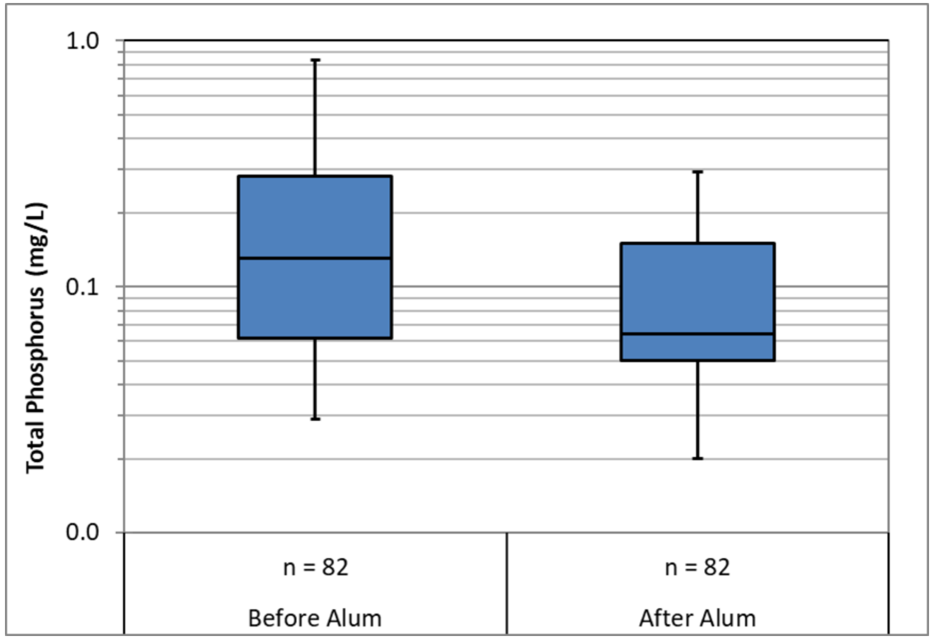


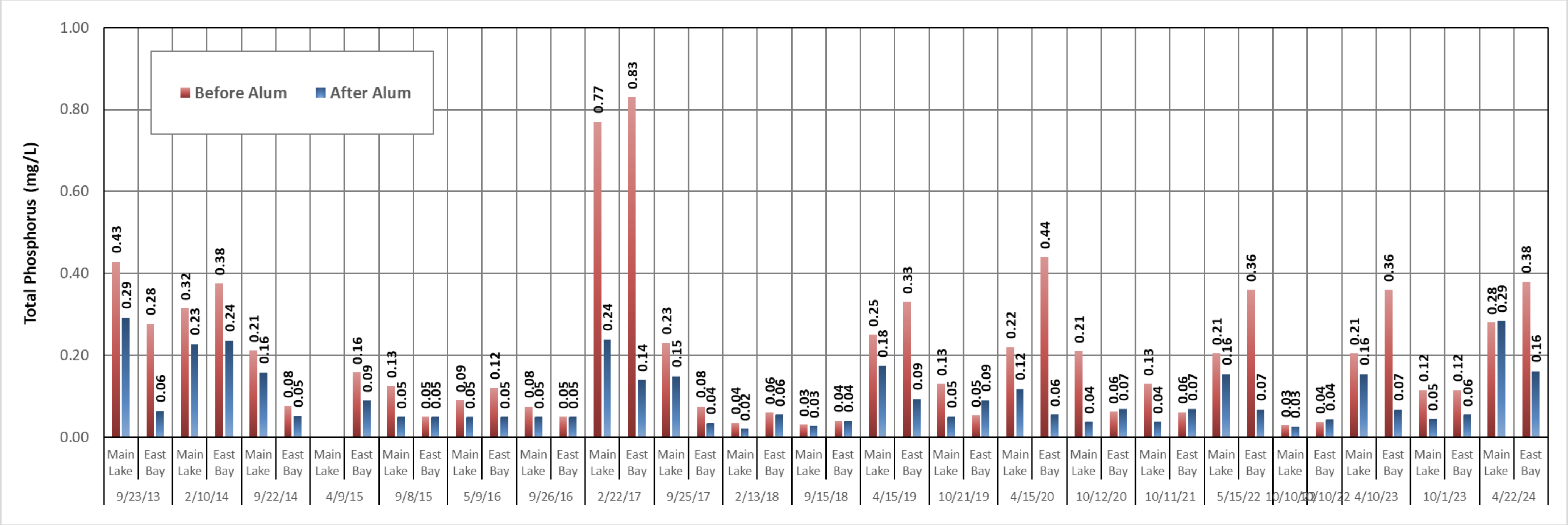




Implementation of Alum Program

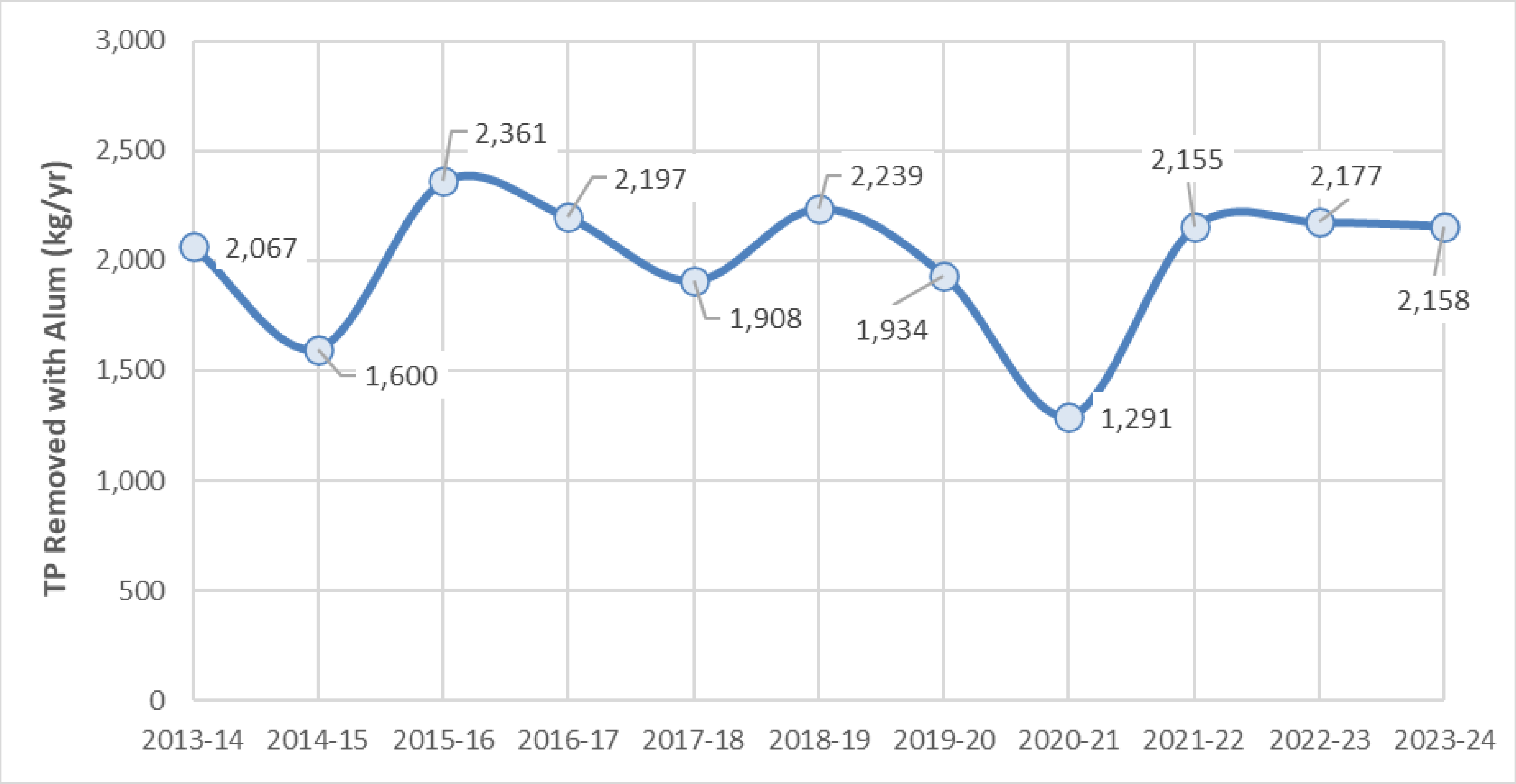
- 24 additions since Sept 2013
- Sampling occurs 1 week prior and 1.5 months after each application





TP Reduction Credits

- Credit estimated using a ratio of alum added to bound phosphorus ratio of 150:1
- Supported by Canyon Lake jar tests as well as ranges reported in literature
- Removal of ~2,000 kg/yr achieved



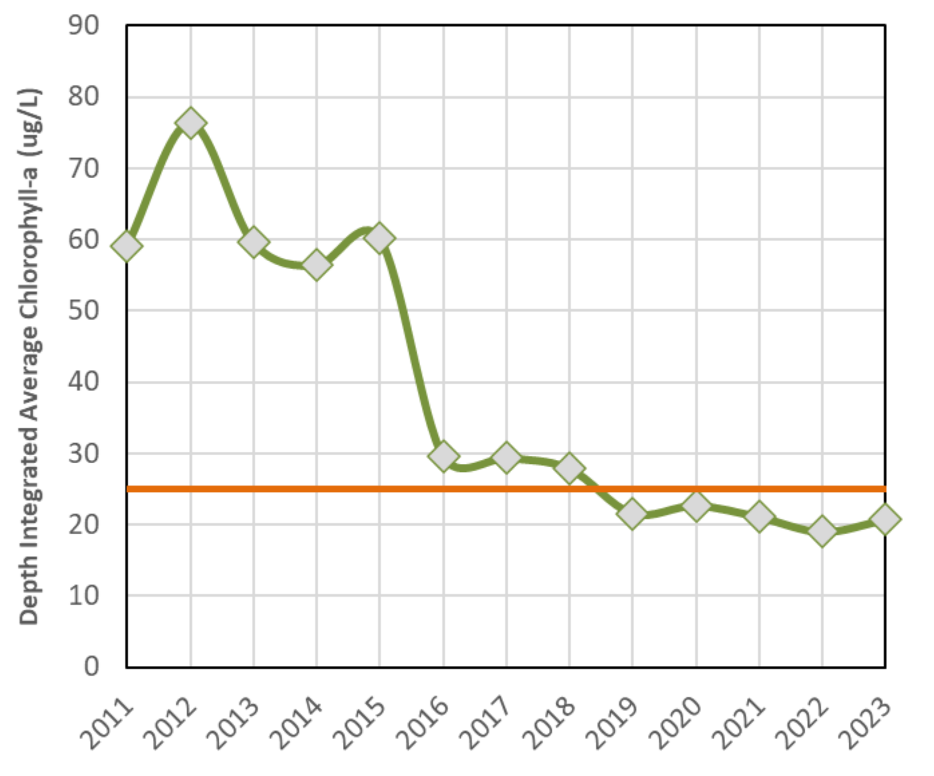
Effectiveness for TP Limitation

- Ratio of Nitrogen to Phosphorus provides an indicator on limitation of algal growth
- Redfield Ratio >7 threshold of N:P puts limitation on algal growth

Canyon Lake Segment	Pre-Alum (before 2013)	Post-Alum (after 2013)
Main Lake	4.6	24.8
East Bay	6.5	24.7

2004 TMDL Compliance Demonstrated

- Numeric target achieved
- Collective WLA/LA achieved with alum addition program



2004 TMDL compliance demonstration

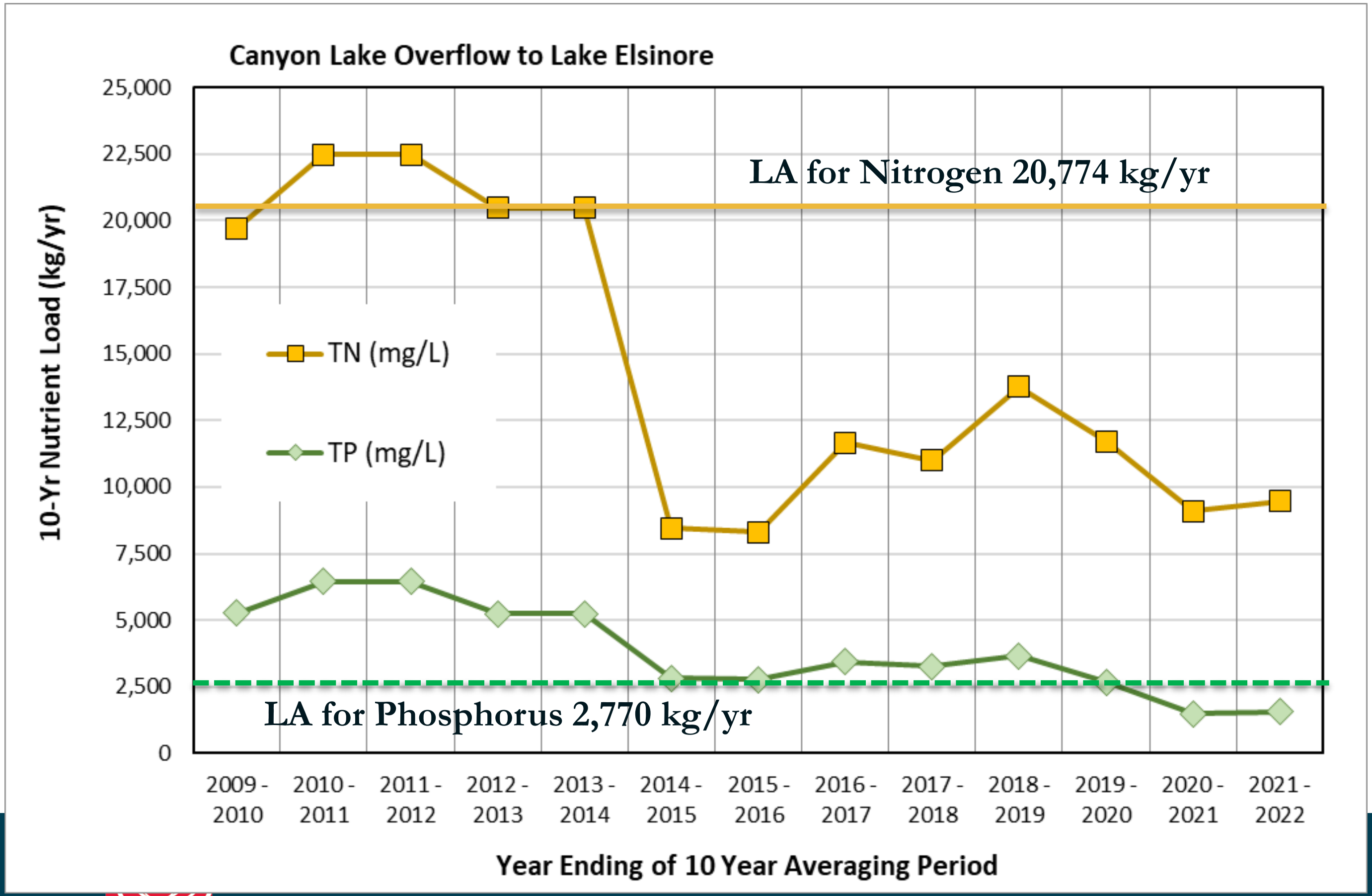
Nutrient	Measured External Load	Internal Load Offset with Alum	Total Net Load	Allocation to Watershed in TMDL[a]	Additional Load Reduction Required[b]
Total Phosphorus	5,871	2,079	3,792	3,845	-53
Total Nitrogen	15,743	0	15,743	22,268	-6,525

[a] TMDL minus allocations for internal sediment and atmospheric deposition
[b] If ≤ zero, compliance with final allocations in TMDL for all watershed sources is effectively demonstrated

Benefit to Lake Elsinore

- 90 percent of drainage area to Lake Elsinore
- Canyon Lake overflow to Elsinore 10-Yr average TP load (2015-24) was 1,956 kg/yr
  - Meets 2004 LA
  - Meets interim milestone in proposed TMDL revision

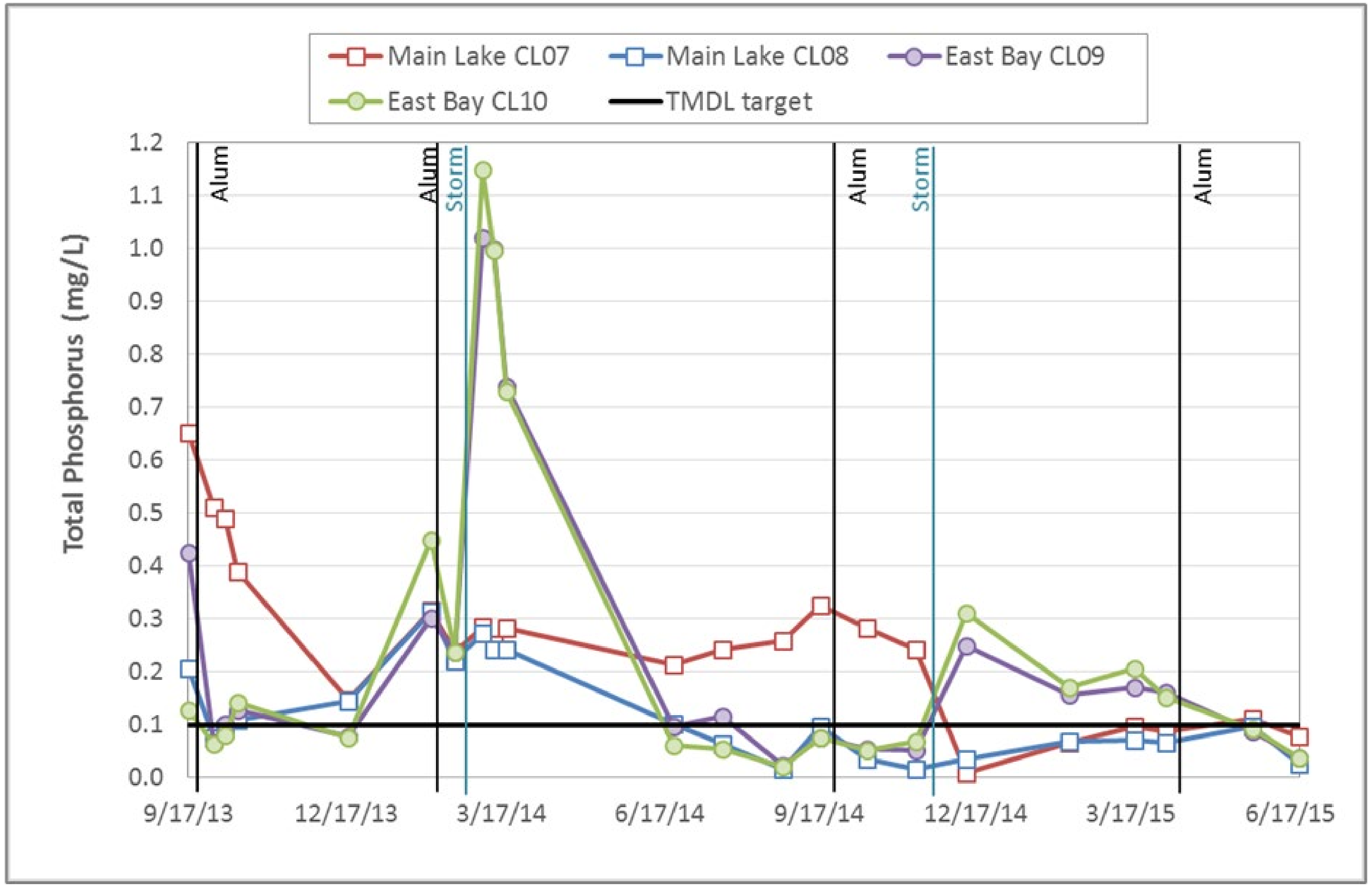
2004 TMDL compliance demonstration



Implementation Challenges

Timing for Spring Application

- Overall strategy for alum application – Spring / Fall
- Seeking a window for application that is after most wet weather events and before algae blooms
- Avoid spring 2014 scenario involving late February alum addition followed by a large March storm



Floating Floc

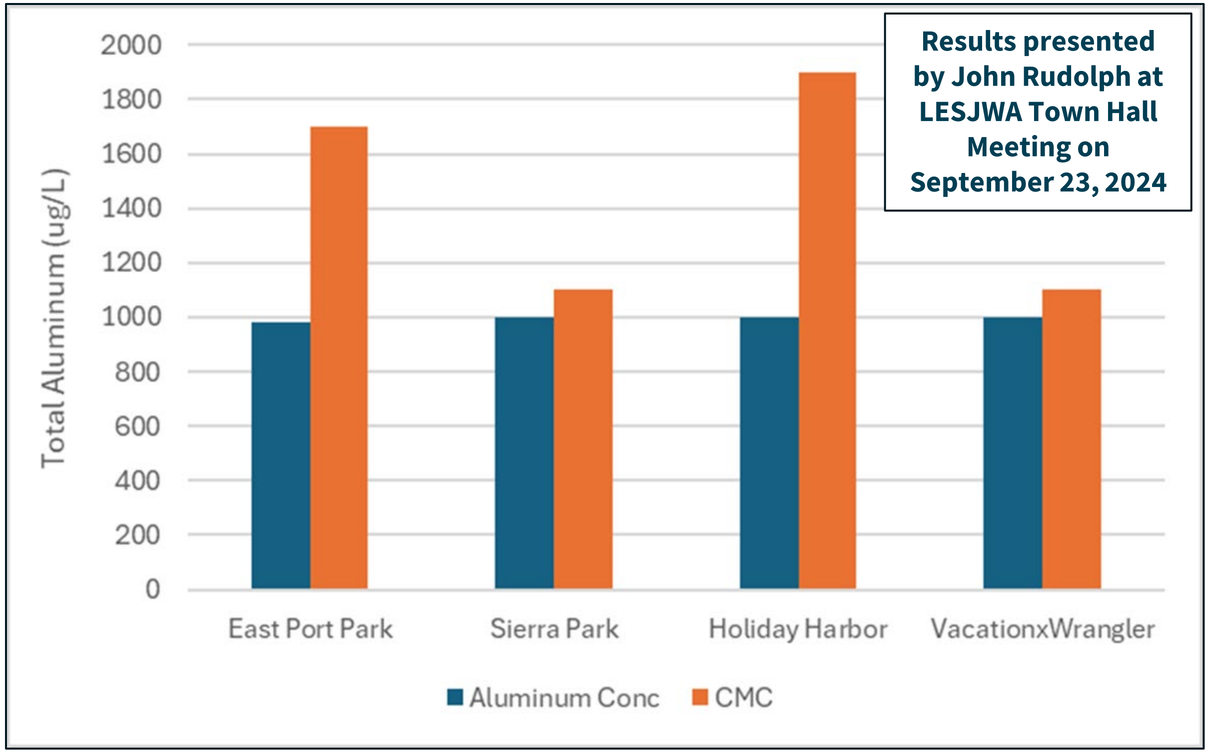
- Spring applications that are too late and occur during active algae blooms
- Concepts for apparent buoyancy of floc
  - Bubbles trapped in floc formation
    - Carbon dioxide bubbles produced via alum hydrolysis reactions in warm, high bicarbonate water
    - Oxygen bubbles produced by algal bloom photosynthesis
  - During algae bloom alum binds with algae or organic matter, the resulting floc can become less dense

Fish Die Offs

- Fish die off observed in April 2024, November 2024, and April 2025
- Timeline between alum application and start of fish die off:
  - April 2024 - Last day of application, exclusively shad
  - November 2024 – 4 weeks, exclusively shad
  - April 2025 – 3 weeks, almost entirely adult bass
- Two most recent die offs were likely not due to alum application
  - November 2024 - short–term low dissolved oxygen from lake destratification
  - April 2025 – Golden algae bloom

Aluminum Toxicity

- April 2024 fish kill occurred during alum application – Shad Only
- Dissolved oxygen was high, Ammonia and Sulfide were low
- High or low pH can lower acute (CMC) and chronic (CCC) total aluminum toxicity criteria
- Total aluminum concentration did not exceed acute criterion, but was close at 2 sites
- Chronic criterion is more conservative (i.e., lower), but don’t expect short-term impacts such as survival



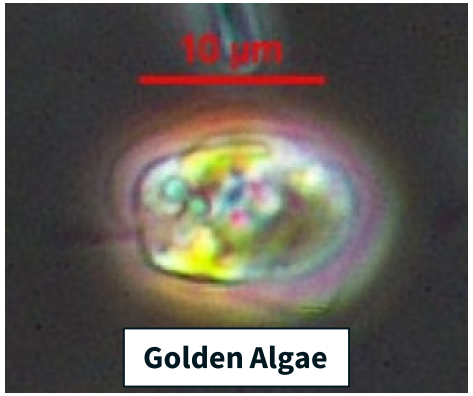
Proposed Alternatives Analysis to Support Phase II Task 4

Create a Historical Synthesis of Alum Additions and Other Issues

- Synthesis of historical applications, offset credits, compliance demonstrations
- Analysis of data collected April 2025 to investigate cause of fish kill
  - Dissolved oxygen[1] – high
  - Ammonia toxicity[1]- below threshold of concern
  - Sulfide toxicity[1] – below threshold of concern
  - Aluminum, Water[1] – below CMC
  - Aluminum, Gill Tissue[2] – results pending
  - Golden algae[2] – present in samples

1 - collected 4/17/25 by WSP two days prior to start of fish kill
2 - collected 4/23/25 by GEI five days after start of fish kill

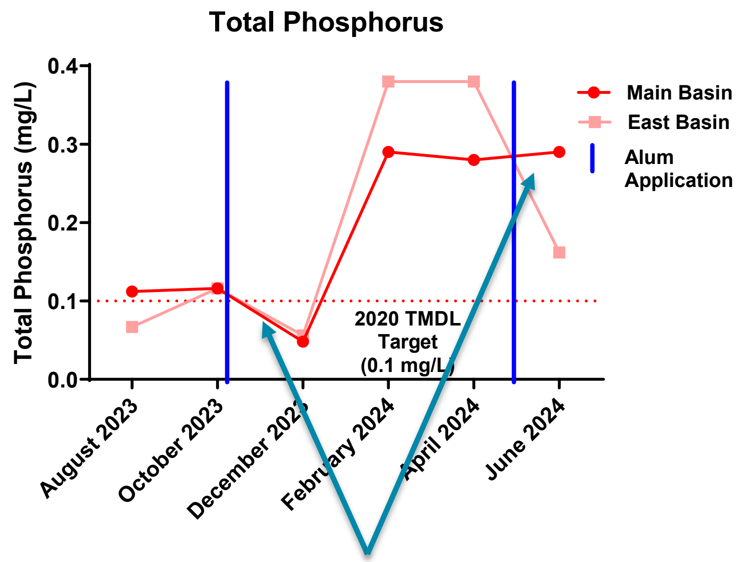
Brown-Orange Water



Golden Algae

Analysis for Future In-Lake Treatment

- Implementation alternatives
  - Delivery method (subsurface emission, drip emitters at lake inflows, or timing applications)
  - Material (heavier doses that will sink faster, use of ballast material, buffered alum, lanthanum for less pH sensitivity and hydrolysis reactions, but 4-5 times more cost in 2025, hybrids)
- Post application effectiveness monitoring
- Operation plan including criteria for actions to manage potential issues
- Re-Evaluate offset crediting basis for future use
- Update toxicity testing over wider pH range
- Supporting information for Task 4 of the Phase II TMDL implementation



Long time to wait for post application samples