Lake Lawrence Cyanobacteria Management Plan
Preliminary Findings and Management Options

December 11, 2025

THURSTON COUNTY
WASHINGTON
SINCE 1852

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Agenda

1. Refresher
2. Water and Phosphorus Budgets
3. Management Options
4. Questions and Discussion


What’s the Big Deal?

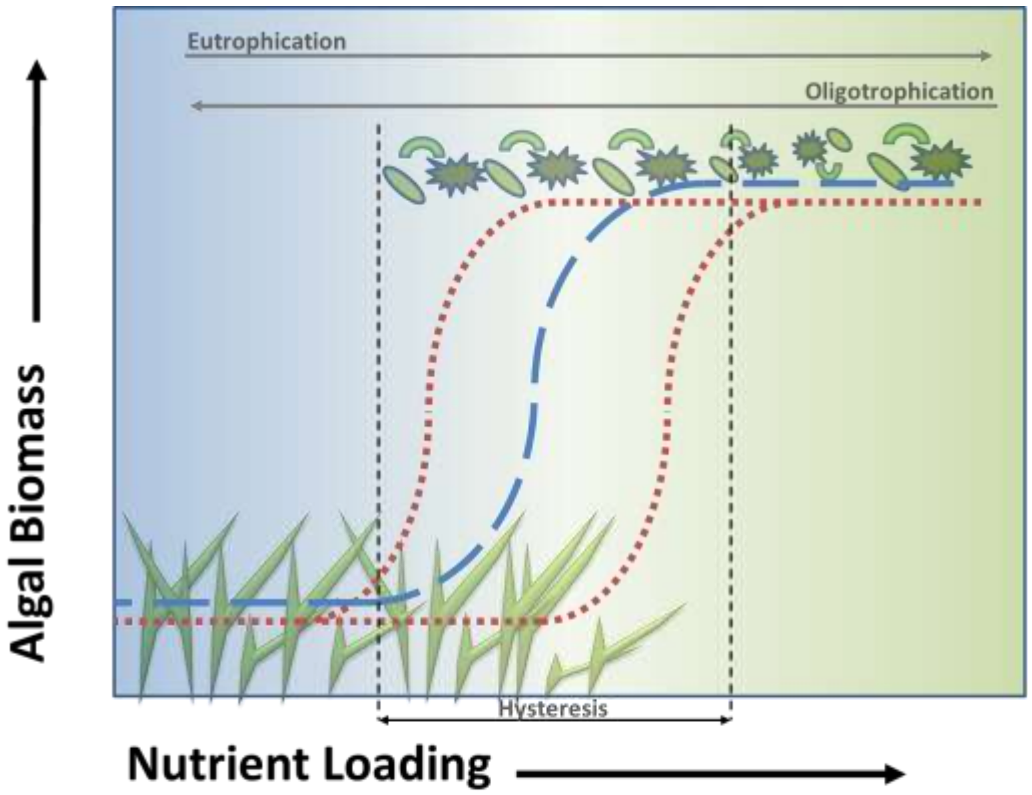
Toxic Algae can cause:

- Skin irritation
- Illness, if consumed
- Reduced recreation
- Smelly odors
- Thick scums
- Reduced water quality
- Poor habitat for wildlife
- Reduced property values
- Reduced tourism

Toxic/Harmful Algae = Cyanobacteria

Lake Eutrophication

- Increasing nutrients in a lake, frequently from land runoff, which increases algae growth and decay
- Natural and cultural nutrient sources



- Moderate amounts support ecological diversity and fish productivity
- Excessive amounts impact ecology and human activities

Lake Trophic State

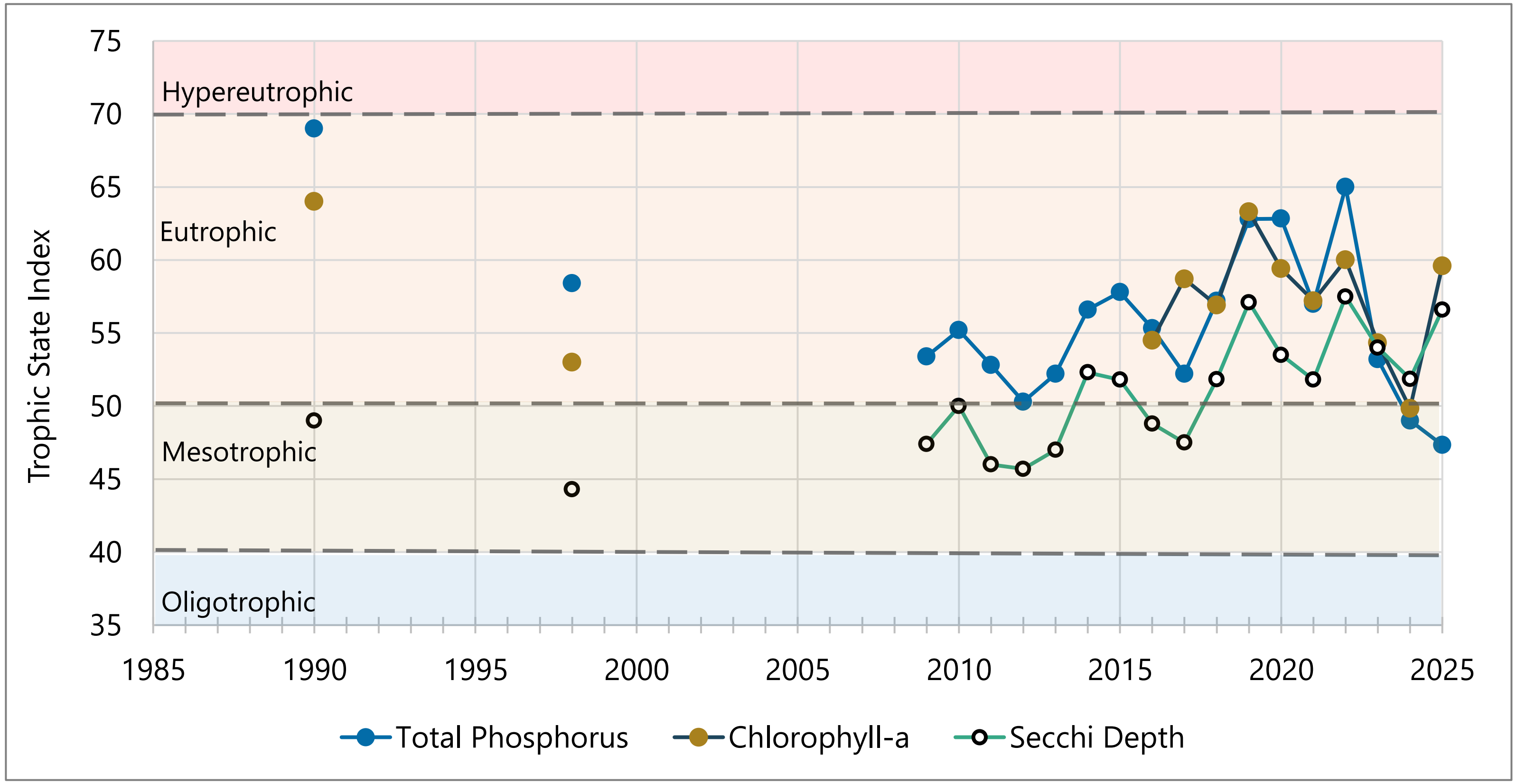
Classes
- Hypereutrophic
- Eutrophic
- Mesotrophic
- Oligotrophic

Indices (Summer Mean)
- Total Phosphorus
- Chlorophyll-a
- Secchi Depth

Lake Lawrence TSI:
- **Eutrophic** (sometime mesotrophic)
- No apparent trend.

Trophic Class	Trophic State Index	Total Phosphorus (µg/L)	Chlorophyll-a (µg/L)	Secchi Depth (meters)
Hypereutrophic	> 70	> 96	> 56	< 0.5
Eutrophic	50 to 60	24 to 48	7.2 to 20.1	1 to 2
Mesotrophic	40 to 50	12 to 24	2.6 to 7.2	2 to 4
Oligotrophic	< 40	< 12	< 2.6	> 4

Big (East) Basin Trophic State Indices



Lake Lawrence
2025 and Contemporary TSI Values

Lake Lawrence Basin	TSI Mean	TSI Phos.	TSI Chl-a	TSI Secchi
Big (East) Basin 2025 (2009-2024 Ave.)	**54.5** (53.8)	**47.3** (55.8)	**59.6** (57.1)	**54.5** (53.8)
West Basin 2025 (2009-2024 Ave.)	**55.4** (56.7)	**56.0** (64.1)	**52.8** (57.8)	**55.4** (56.7)

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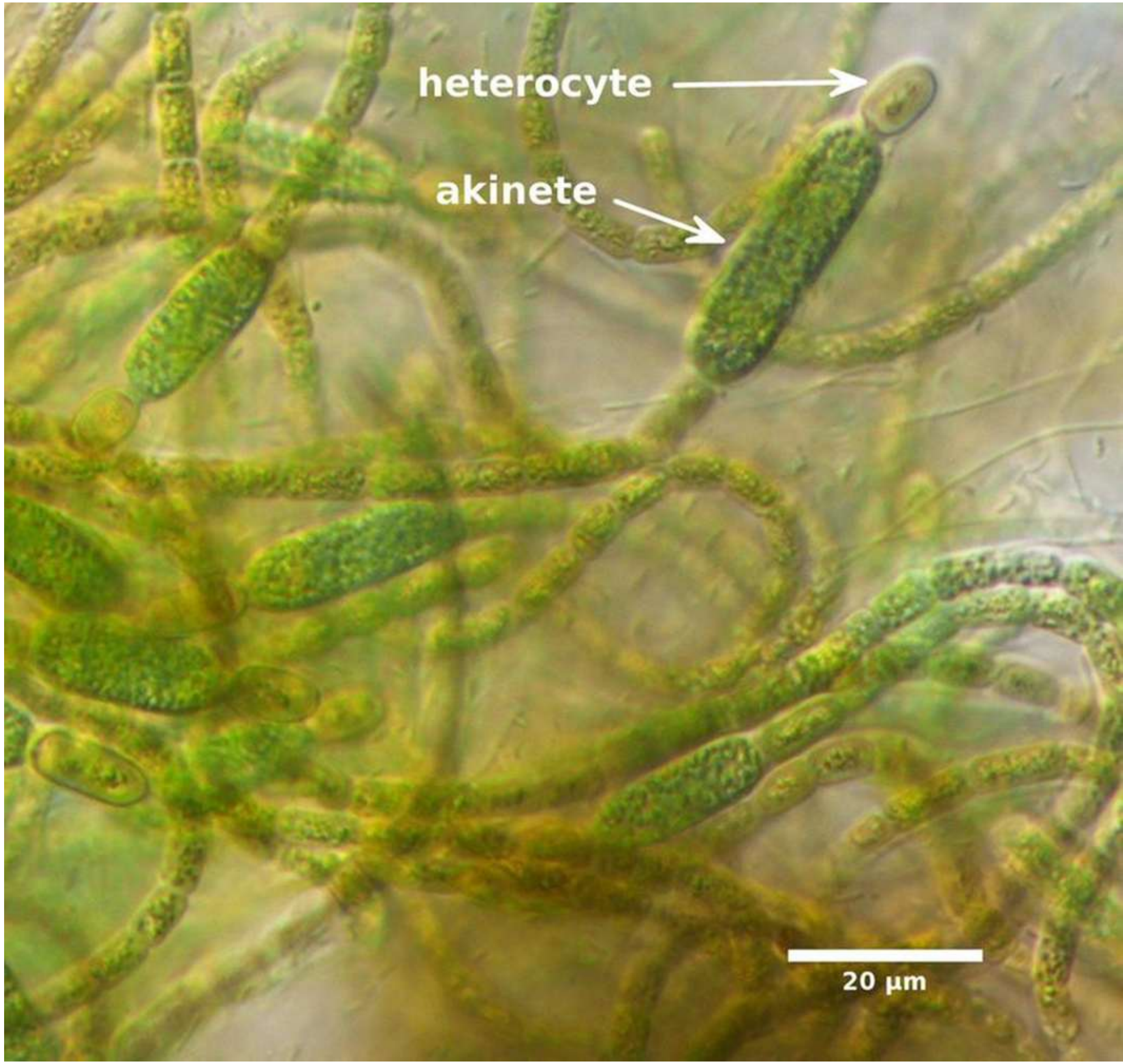
Note: 2025 TP and Chl-a Data only May-June
Others are May to October

Cyanobacteria

- Blue-green Algae – primitive algae group with bacteria structure and photosynthetic pigments
- Competitive advantages:
  - Vertical migration
  - Phosphorus luxury uptake
  - Non-preferred food for grazers
  - Some can fix nitrogen gas
  - Lower energy needs – can grow under lower light conditions



Year	Days with Warning or Danger
2010	59
2011	35
2012	0
2013	16
2014	0
2015	35
2016	0
2017	13
2018	13
2019	19
2020	35
2021	29
2022	19
2023	13
2024	**147** (includes blooms going through Feb 2025)
2025	28

Lake Cyanobacteria Management Plan

Near- and long-term actions to manage water quality in line with identified goals and objectives.

9/22/2023 Sentinel-2

Lake Cyanobacteria Management Plan

The Plan focuses on Surface Water Quality
The Plan does not focus on…

- Fisheries
- Aquatic Plants
- Drinking/Ground Water Quality
- Flooding

We will consider co-benefits/consequences of surface water quality management strategies for those endpoints.

1. Background Information
   - Lake Lawrence and Watershed History
   - Current Management Actions
   - Current Water Quality Conditions
2. LCMP Goals, Objectives, and Success Measures
3. Monitoring Study Findings
4. Water and Phosphorus Load Models
5. Recommended Management Actions and Sequencing (including costs)
6. Adaptive Management Framework
7. Appendices

Project Schedule

Project Step	Action	Period
Lake and Watershed Monitoring	*Published Monitoring Plan (QAPP)*	*October 2024*
	***Public Meeting 1**: Project Overview and Plan*	*July 2024*
	Lake and Watershed Monitoring	*Oct 2024 to Oct 2025*
	***LMDSC/TC Meeting**: Monitoring Update*	*May 2025*
Lake Cyanobacteria Management Plan	**LMDSC/TC Meeting:** P Budget Results, Potential Management Actions	Today!
	Pre-Draft Plan for County & LMDSC review	March 2026
	Public Meeting: Present Draft Plan	April 2026
	Draft Plan for Ecology & Public review	April 2026
	Final Meeting: Present Final Plan	June 2026
	Deliver Final Plan	June 2026

Project Goals and Objectives

Project Goal

Develop a comprehensive, science-based plan to guide public and private investment for the benefit of human recreation and environmental health in Lake Lawrence.

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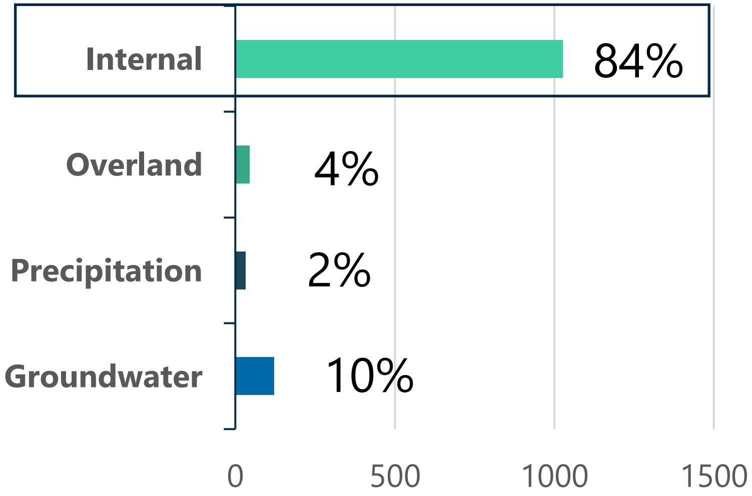
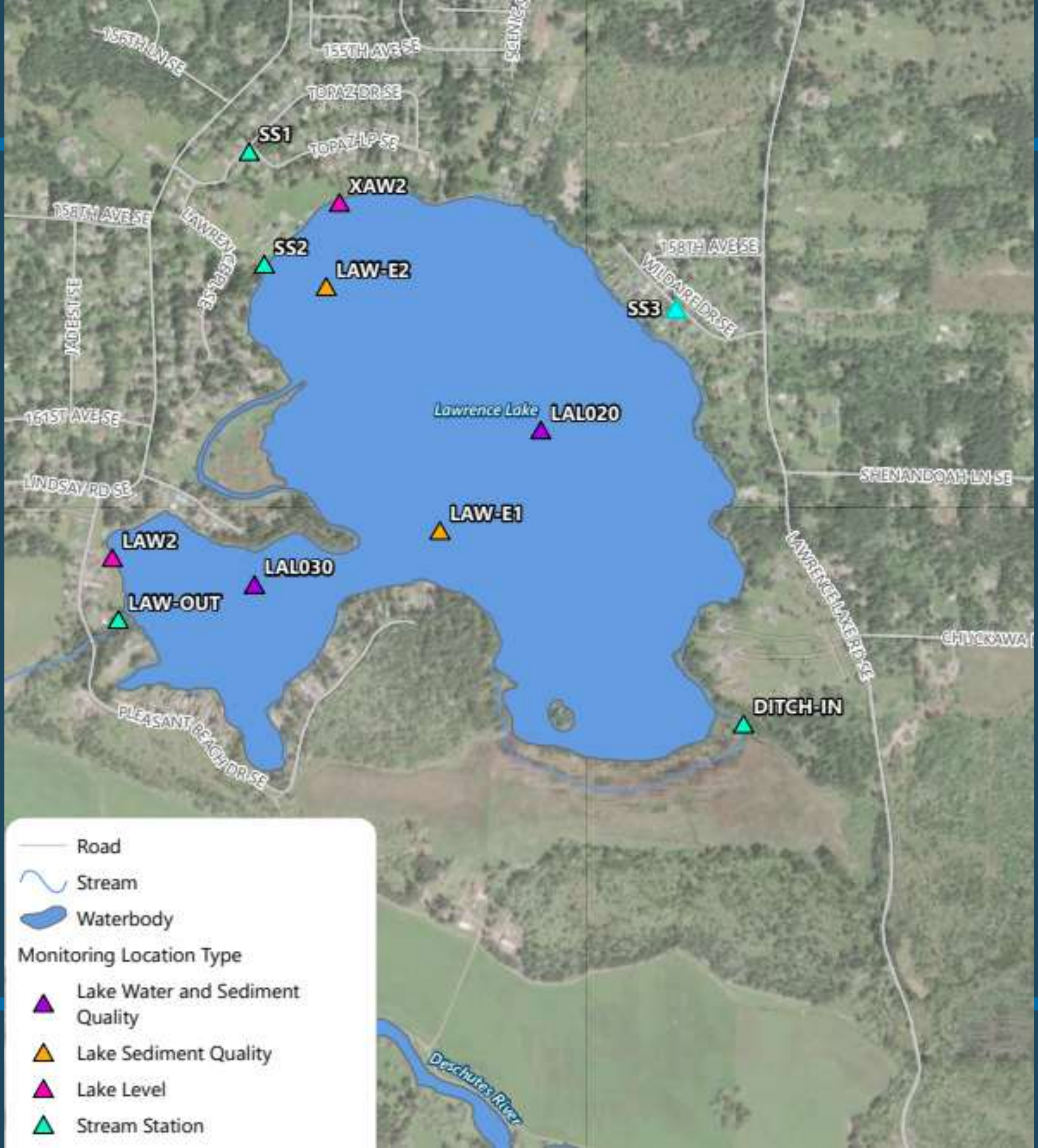
Water Quality Monitoring Goals

1. ***What are the current water quality conditions and plankton dynamics in Lake Lawrence?***

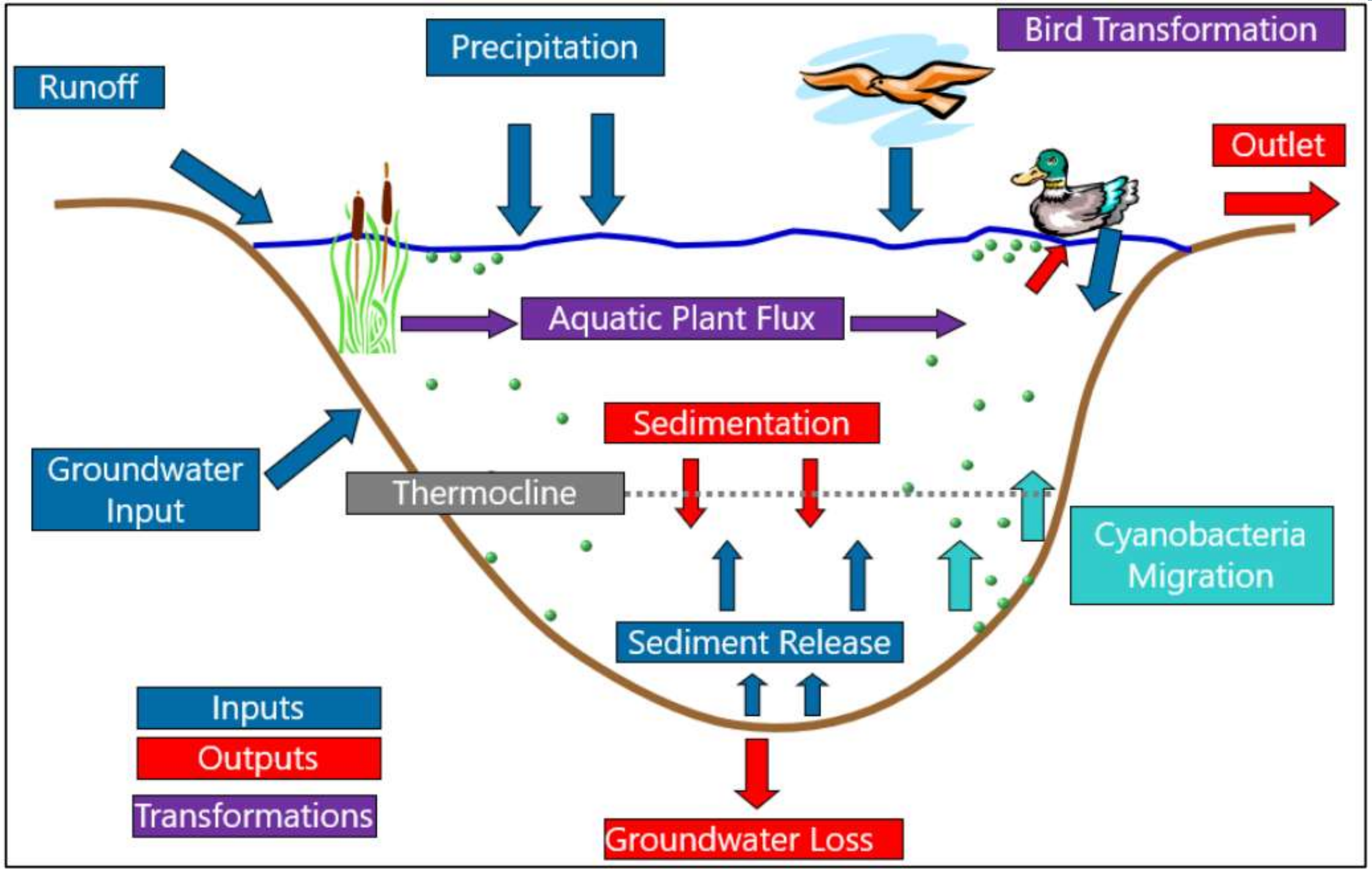


2. ***Have the water and phosphorus budgets changed since 1990? (particularly sediment release)***



SS1
XAW2
SS2
LAW-E2
SS3
Lawrence Lake
LAL020
LAW-E1
LAW2
LAL030
LAW-OUT
DITCH-IN
Deschutes River
Road
Stream
Waterbody
Monitoring Location Type
Lake Water and Sediment Quality
Lake Sediment Quality
Lake Level
Stream Station

Lake Water and Phosphorus Budgets



Water and Phosphorus Budget Elements

Budget Element	Water Budget	Phosphorus Budget
Change in Storage – Gains/Losses within Lake Lawrence	X	X
Direct Precipitation – What falls onto the lake surface	X	X
Evaporation – Evaporation from the lake surface.	X	
Surface Runoff – Wash off into the lake during storms	X	X
Lake Outflow – What leaves through the surface lake outlet	X	X
Groundwater – Subsurface flow of infiltrated water	X	X
Internal Loading – Phosphorus sources within the lake (sediments, aquatic plants, stocked fish, waterfowl)		X

Water Budget

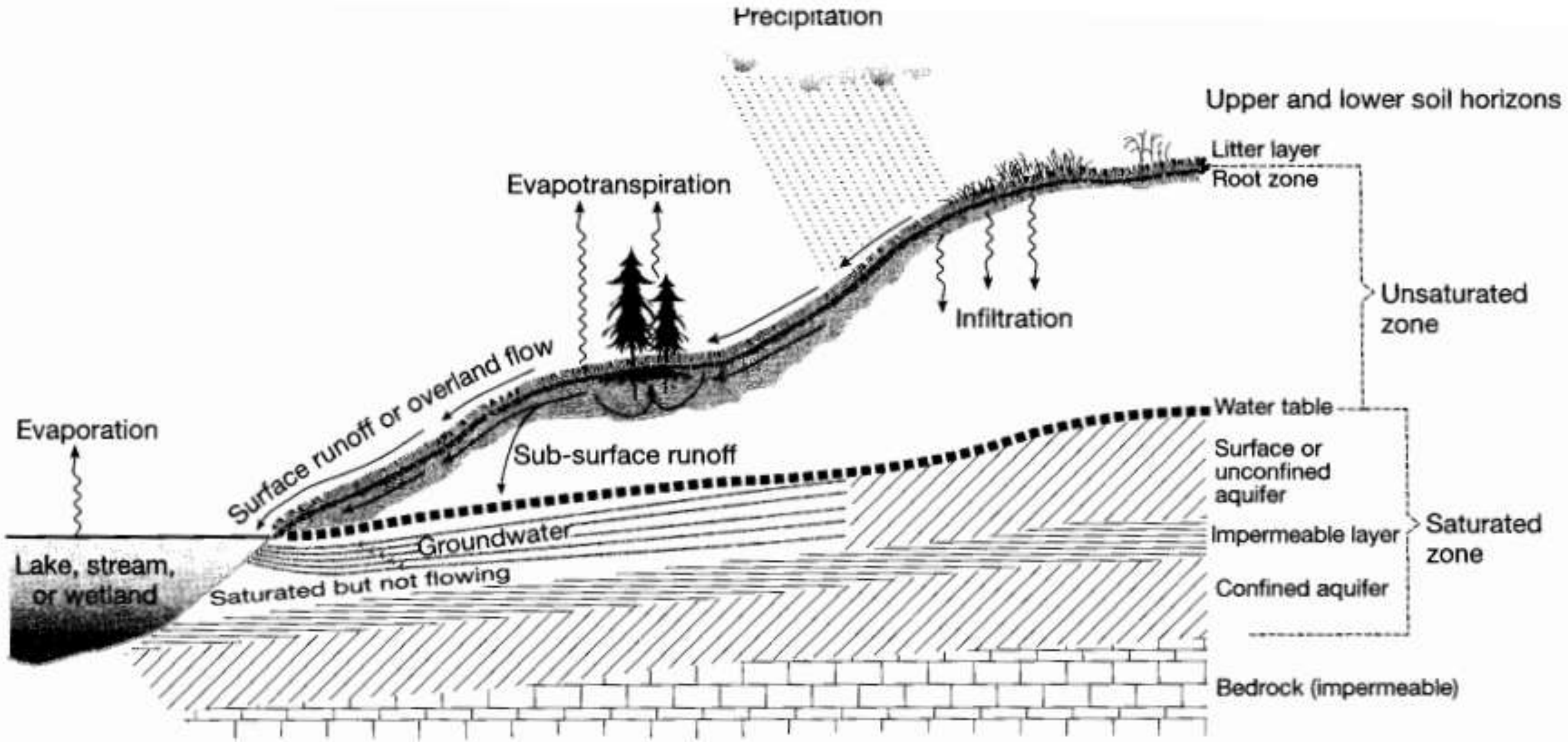
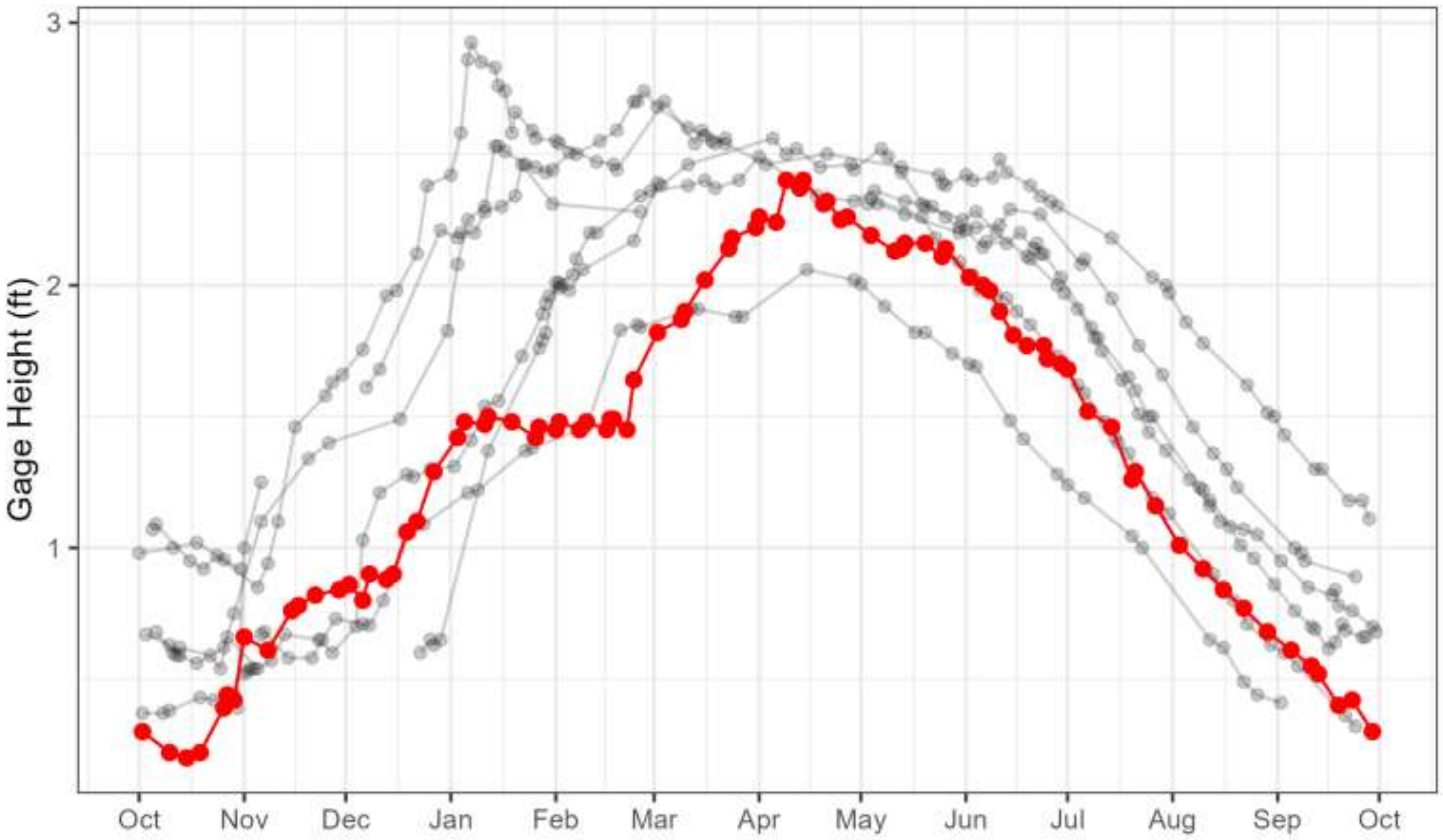
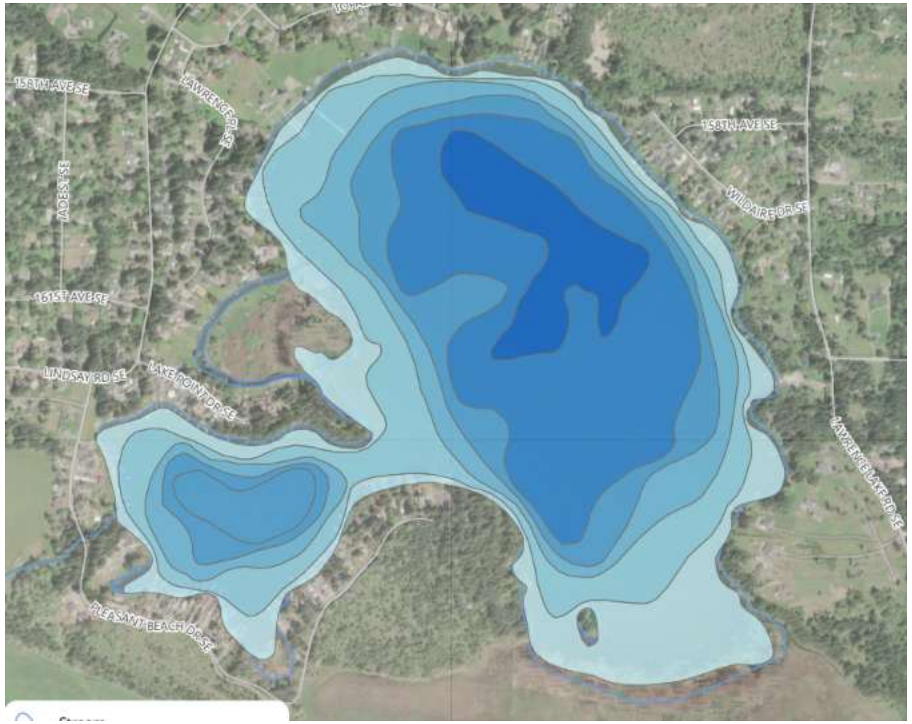


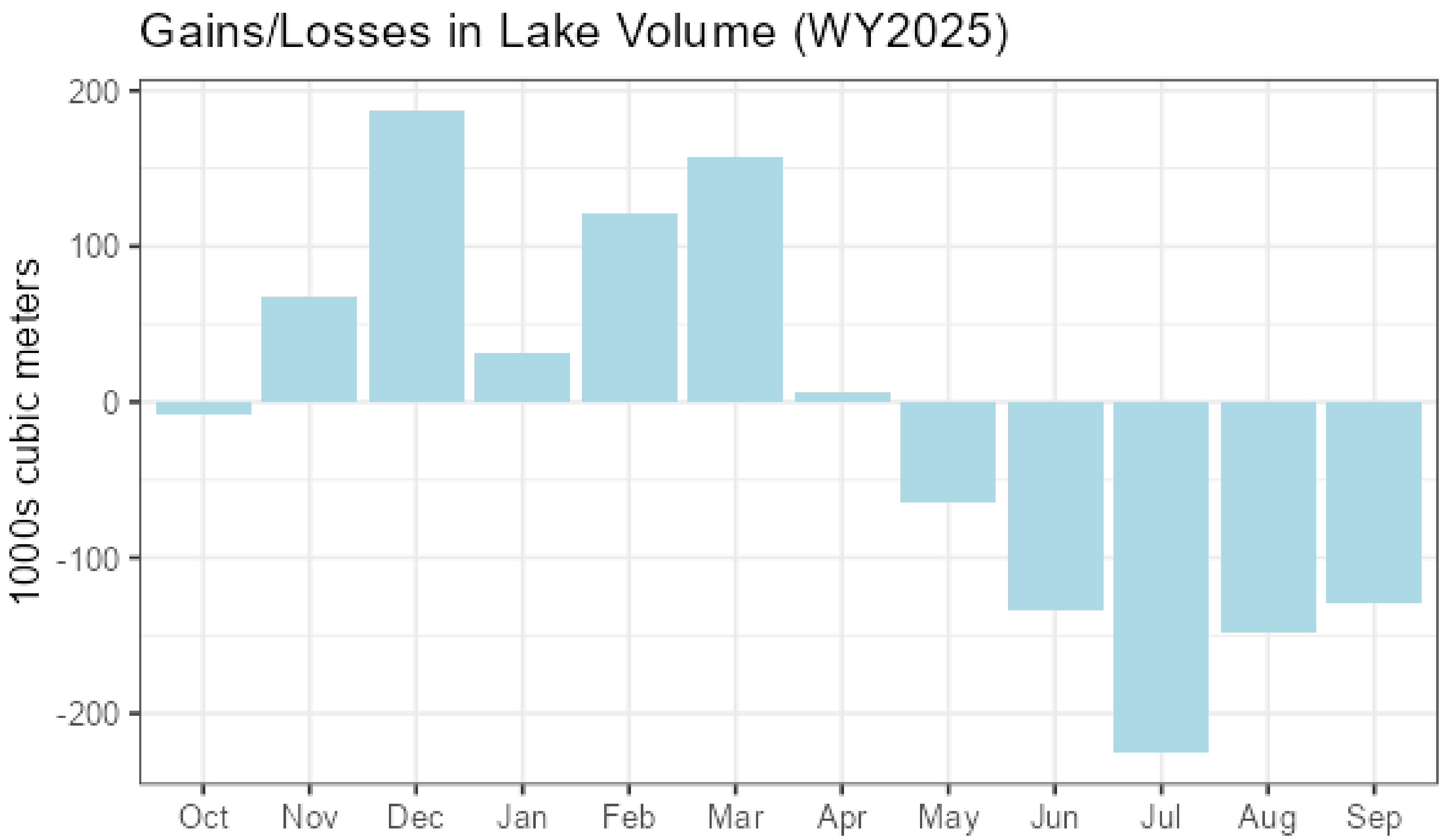
Figure 5–1 Schematic view of water movement in and on catchments, including the flow of groundwater into lakes, streams, or wetlands. Agriculture and other human activities contribute plant nutrients, organic matter, pesticides and other contaminants to runoff and groundwater. *(Greatly modified after Gibbs 1987.)*

Change in Lake Storage
Calculate monthly changes in lake volume

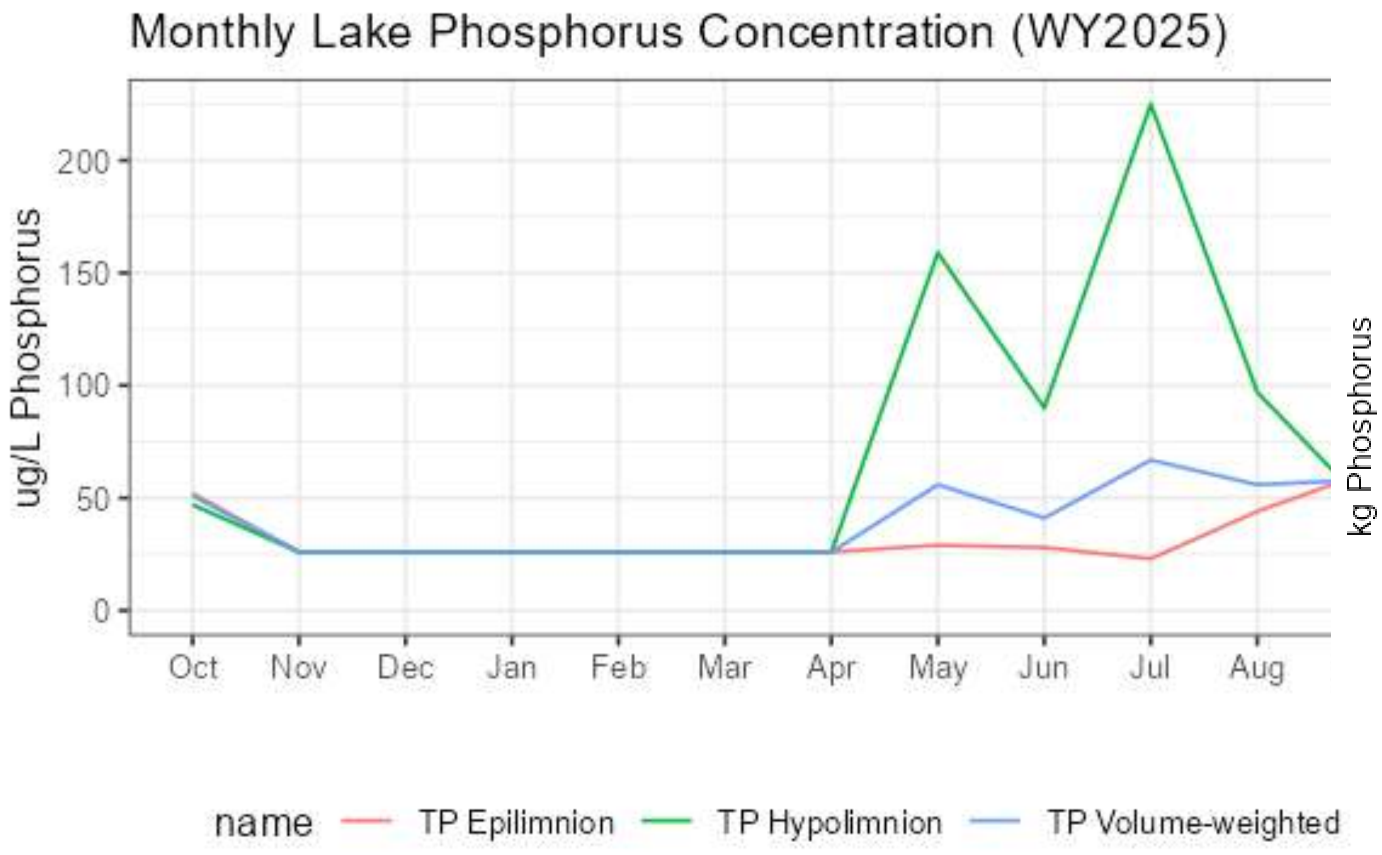


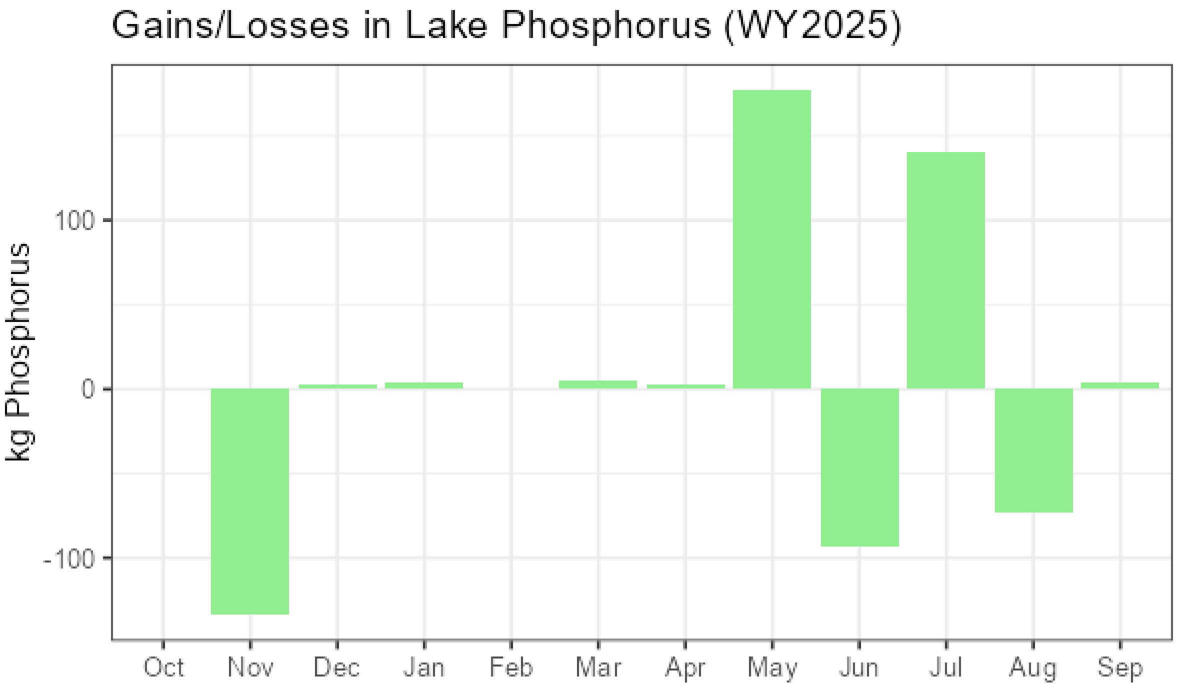


Change in Lake Storage
Calculate monthly changes in lake volume



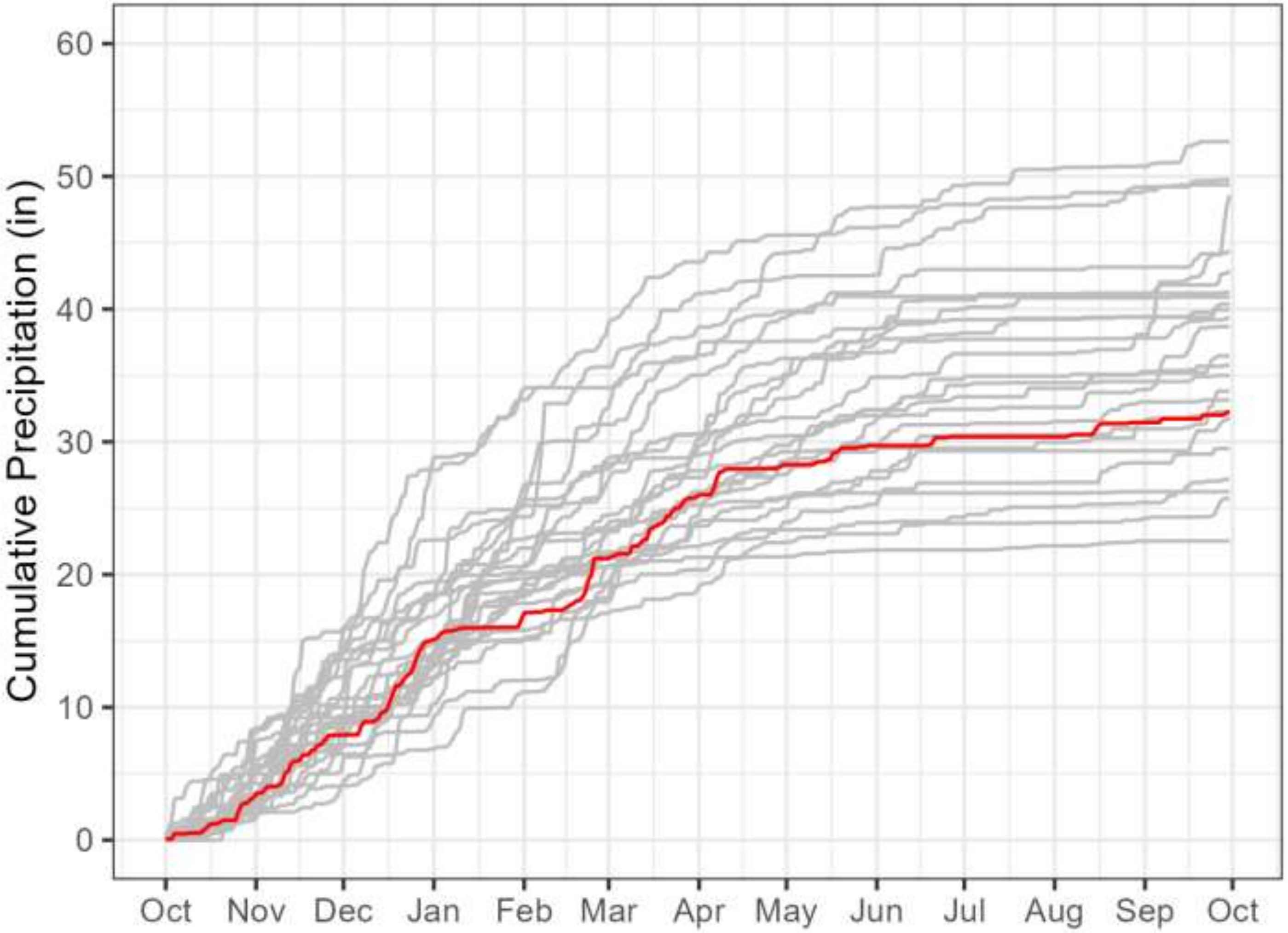
Change in Lake Storage
How much phosphorus is in the lake?

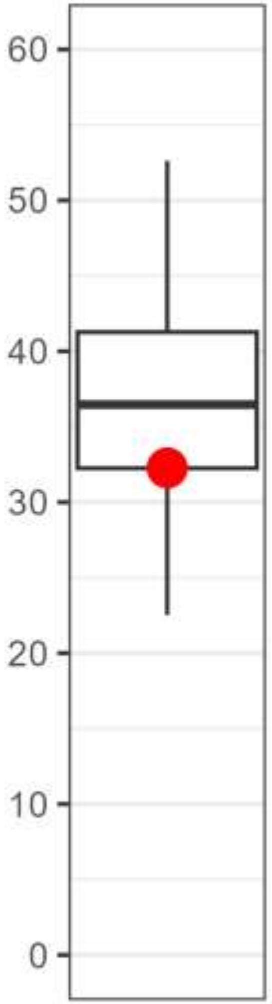




*Assumed while waiting on final results

Precipitation
How much rain is falling on the lake?





Precipitation
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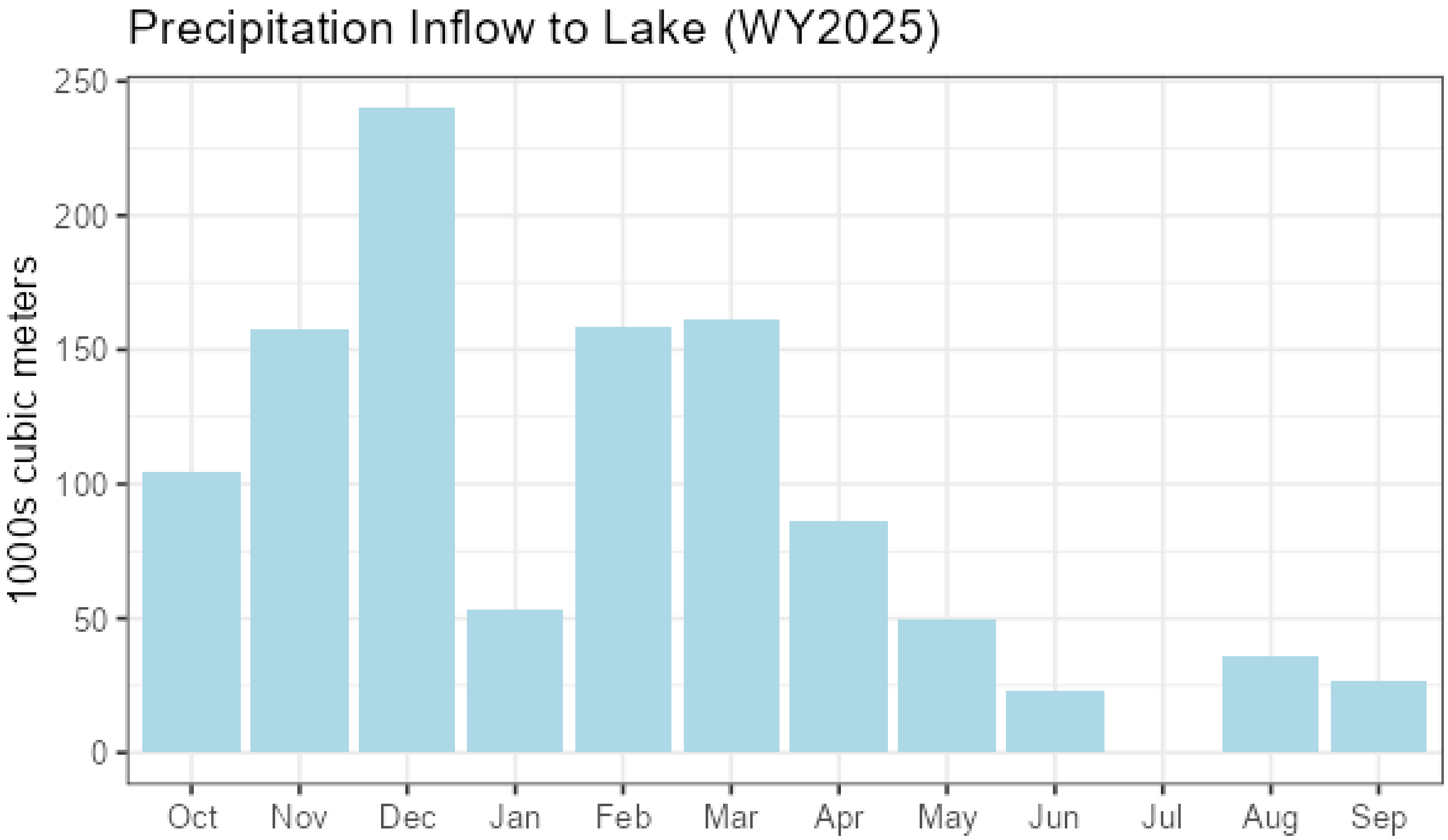
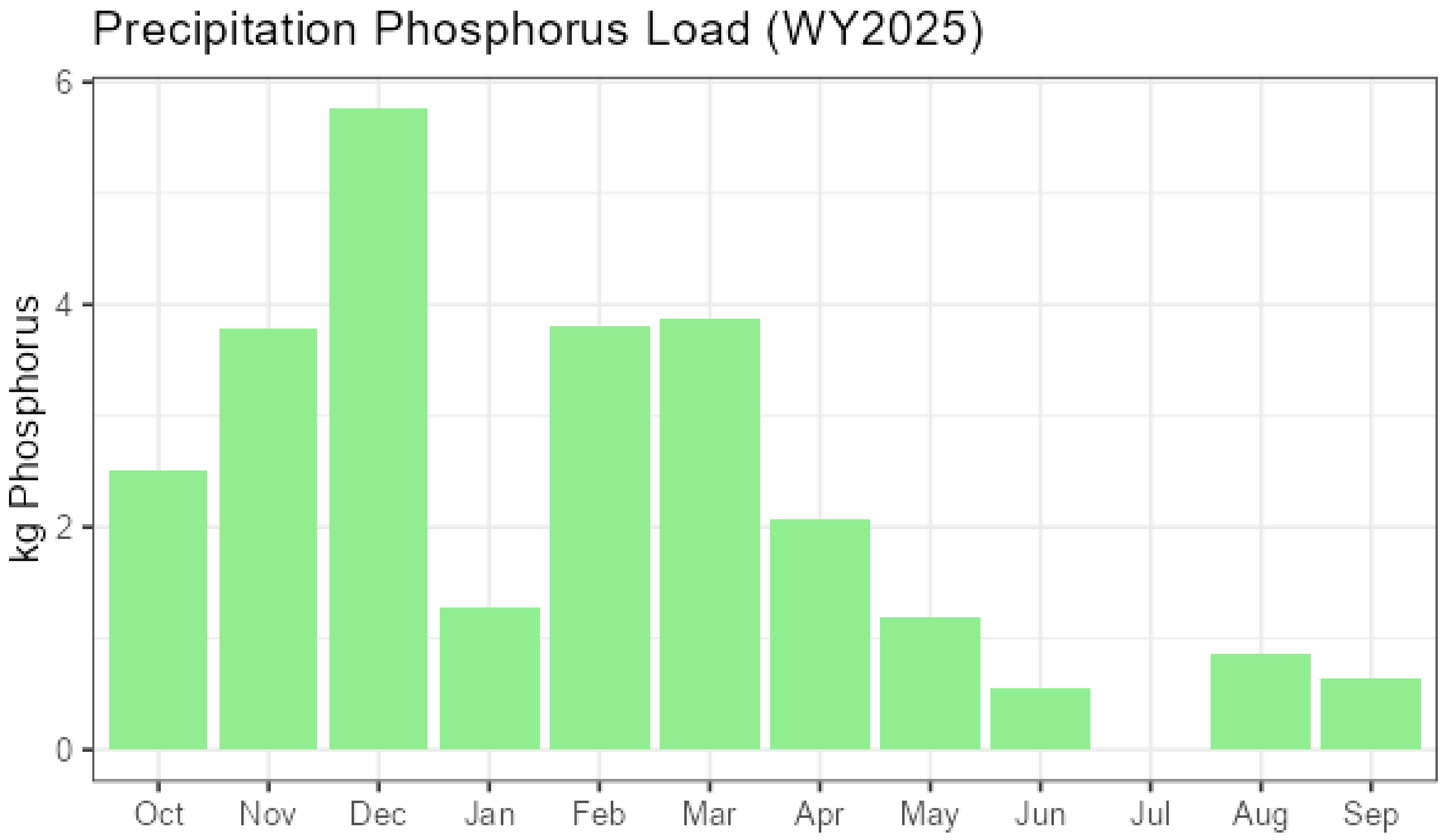
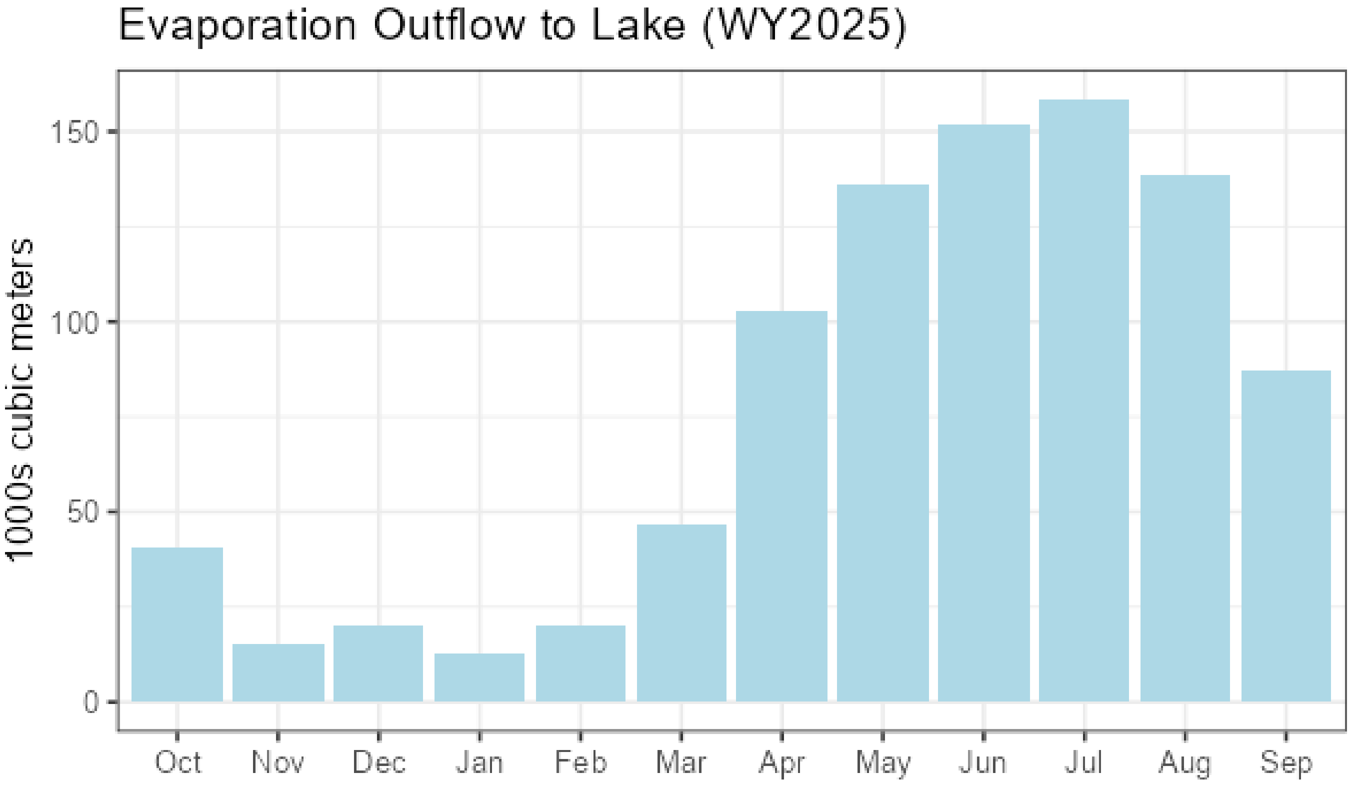


Precipitation - Phosphorus



Assumed concentration of 24 ug/L based on regional studies.

Evaporation



Used Washington State University Agricultural Weather Network estimated evaporation

Surface Runoff

Watershed Monitoring

Collected two storms of four targeted.

Barry has been integral in providing go/no-go information for whether there are sufficient flows

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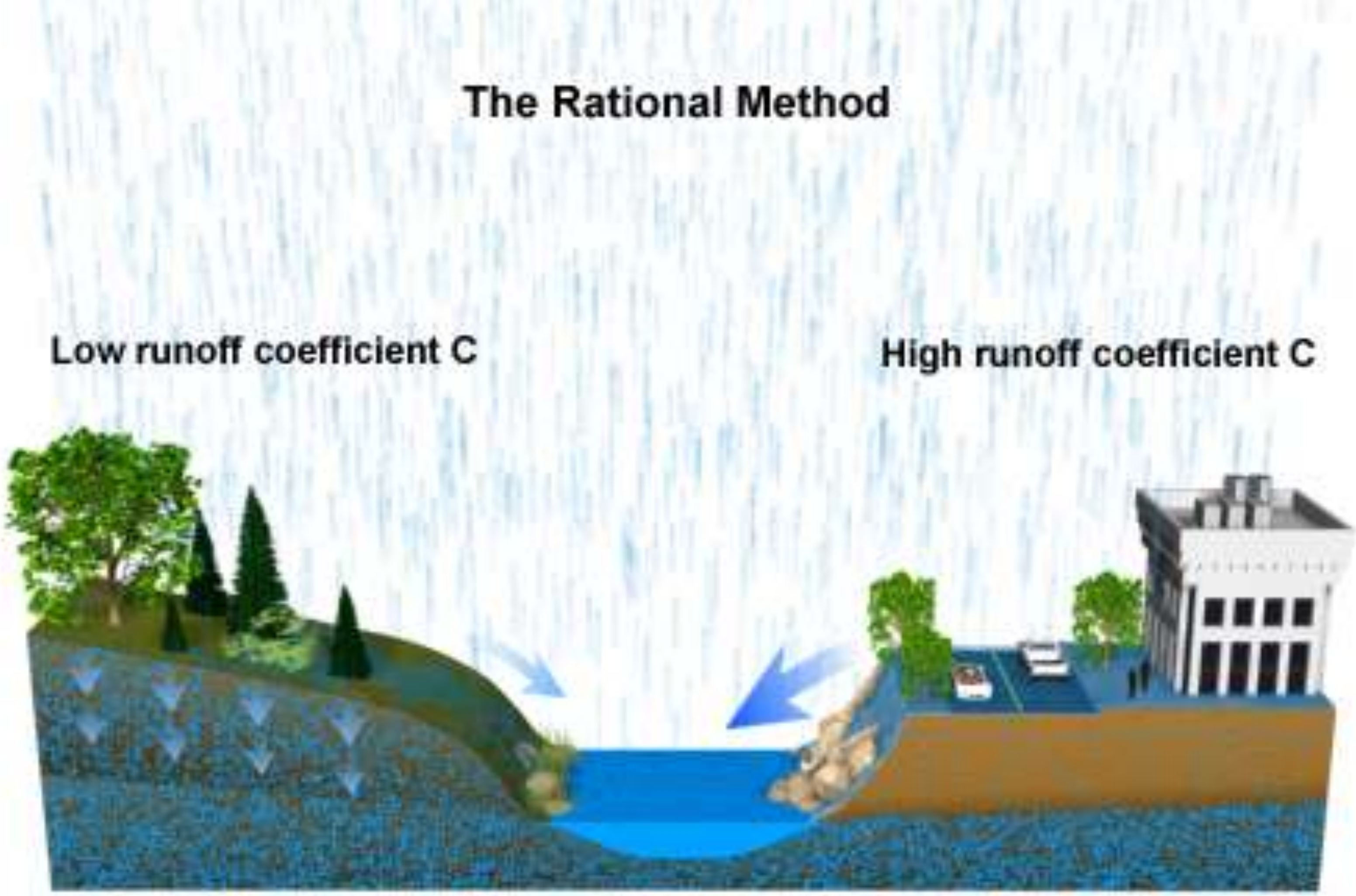
Surface Runoff Phosphorus Results

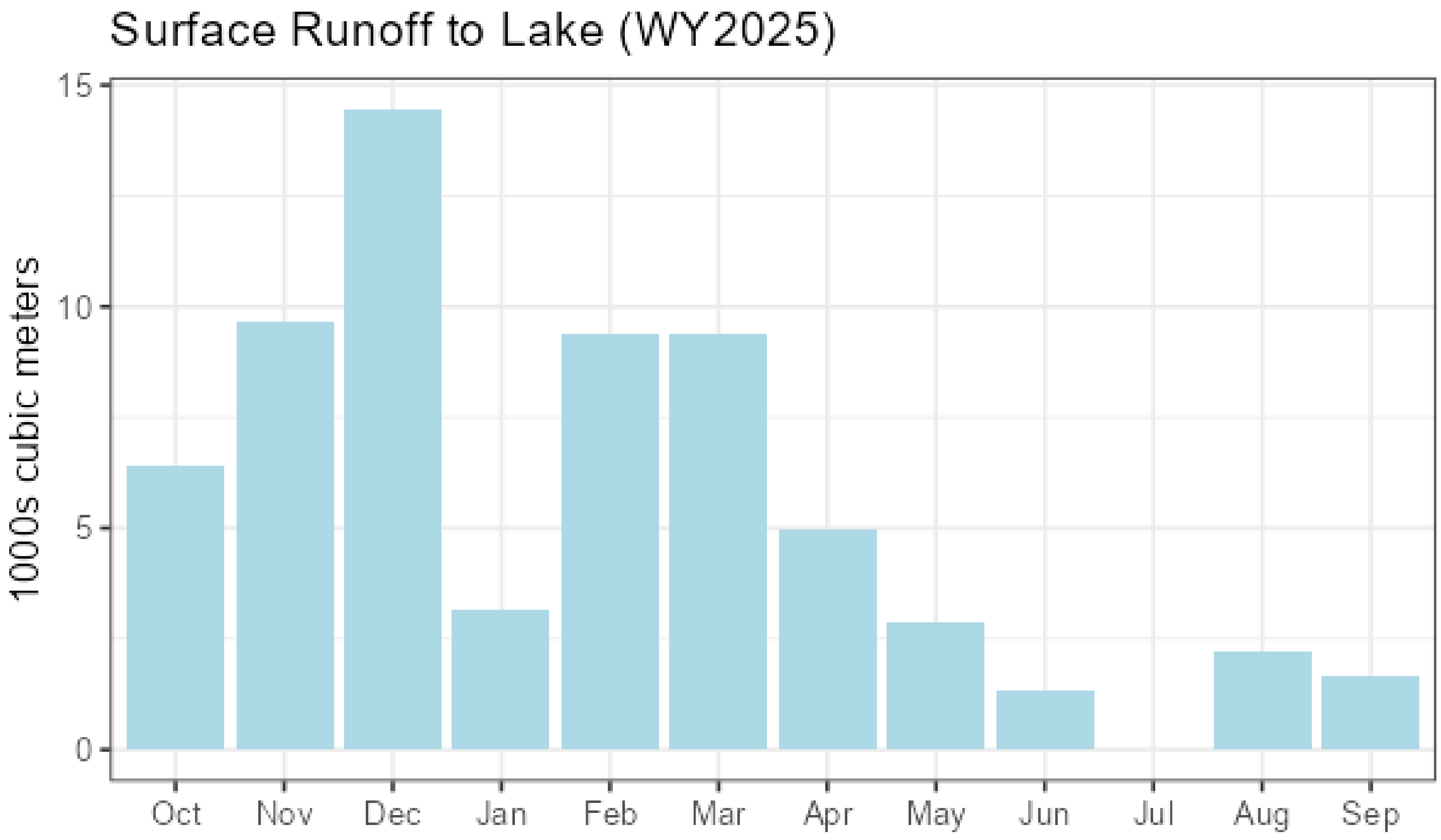
Site	2025-02-25	2025-04-08
SS1	549 ug/L	No flow
SS2	155 ug/L	102 ug/L
SS3	147 ug/L	235 ug/L
DITCH-IN (appears to represent lake)	19 ug/L	44 ug/L
KCM 1991		
Groundwater	63 ug/L	
Overland	Forested: 25 ug/L Residential/Agriculture: 324 ug/L **Volume-weighted: 192 ug/L** (literature values)	

SS3 – 2025-04-08

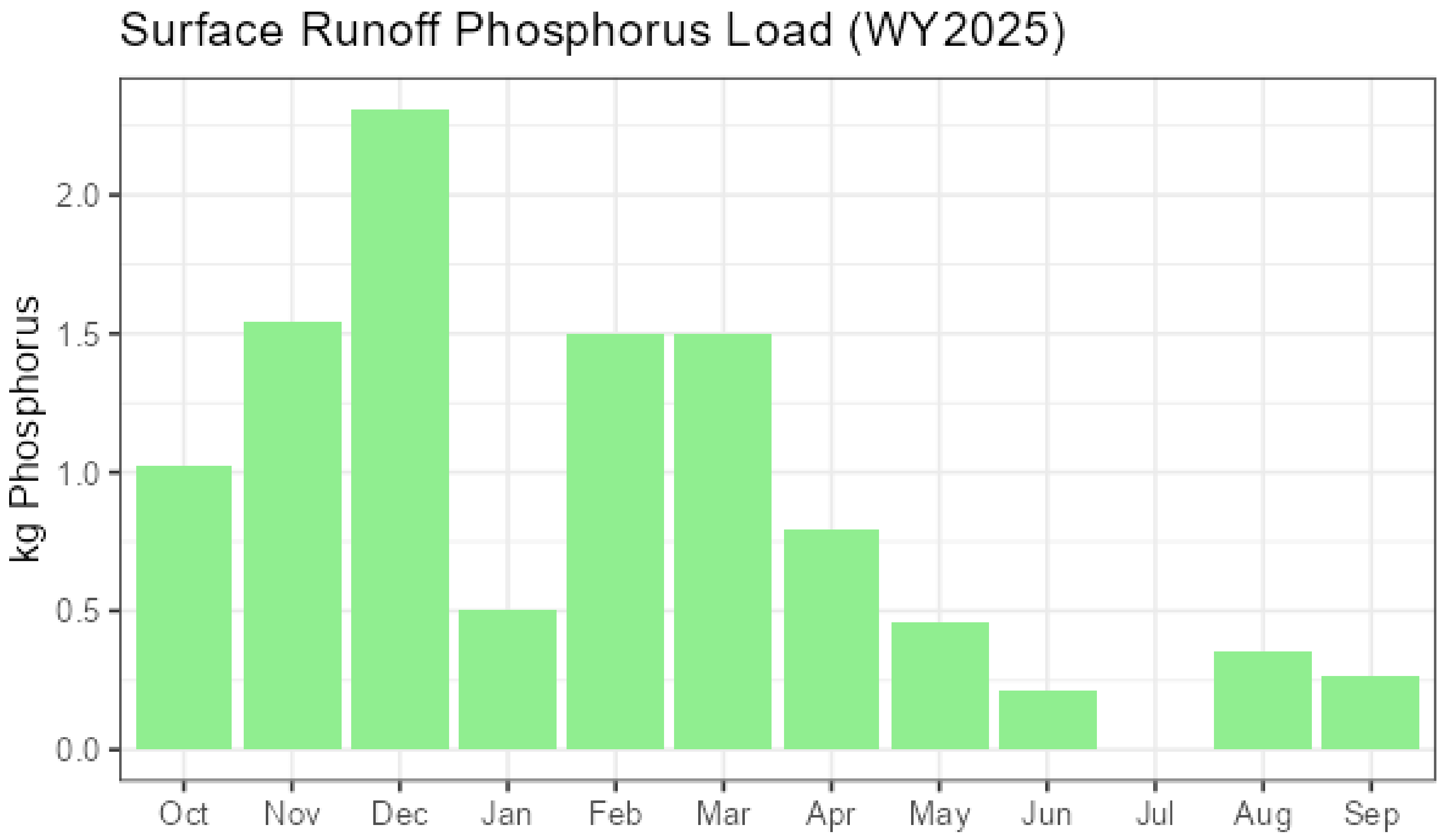
Surface Runoff – Estimating Flows



Surface Runoff – Estimating Flows



Surface Runoff – Estimating Flows



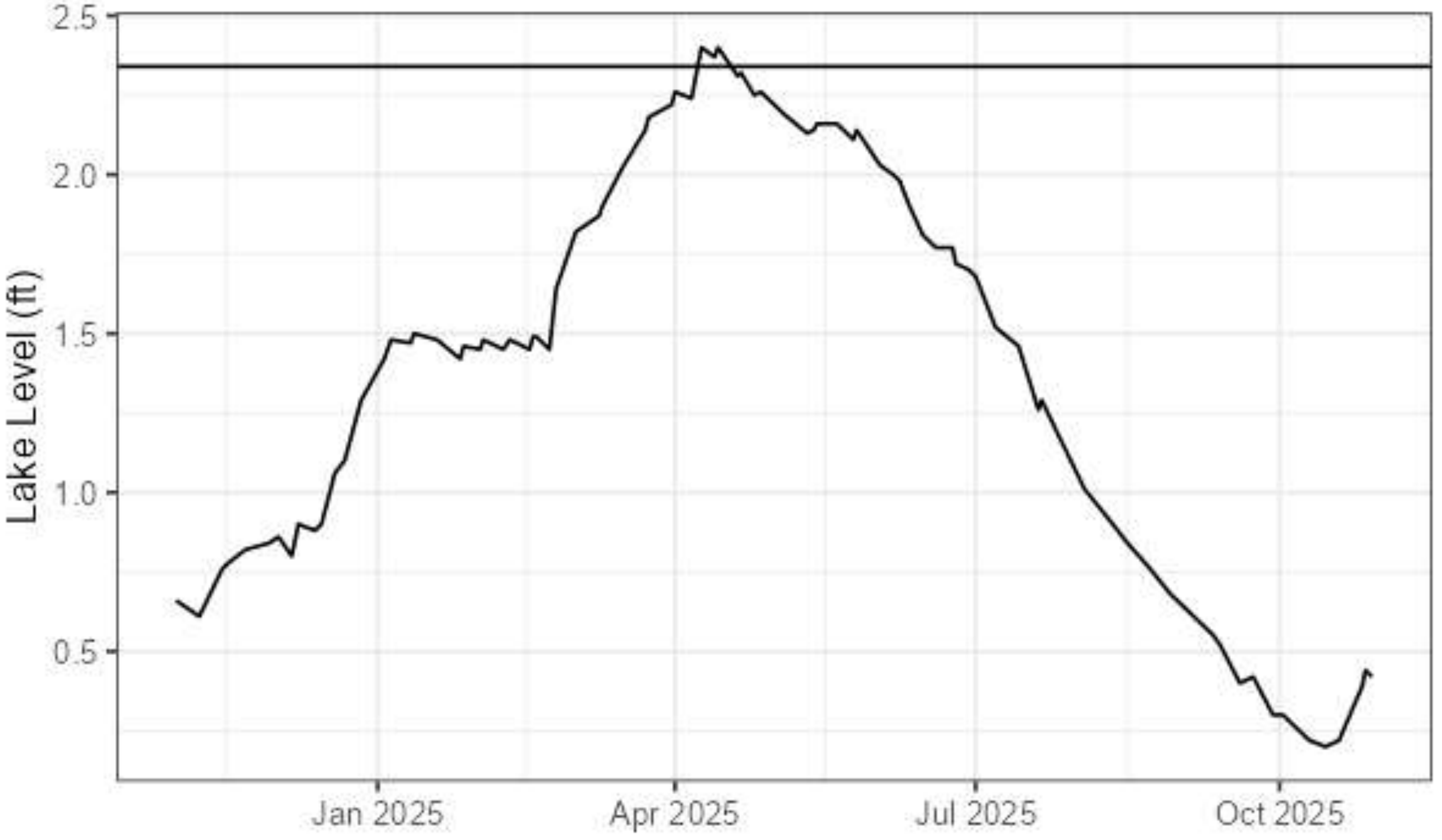
P Loading:
Multiply by average runoff concentration of 160 ug/L

Lake Outflow

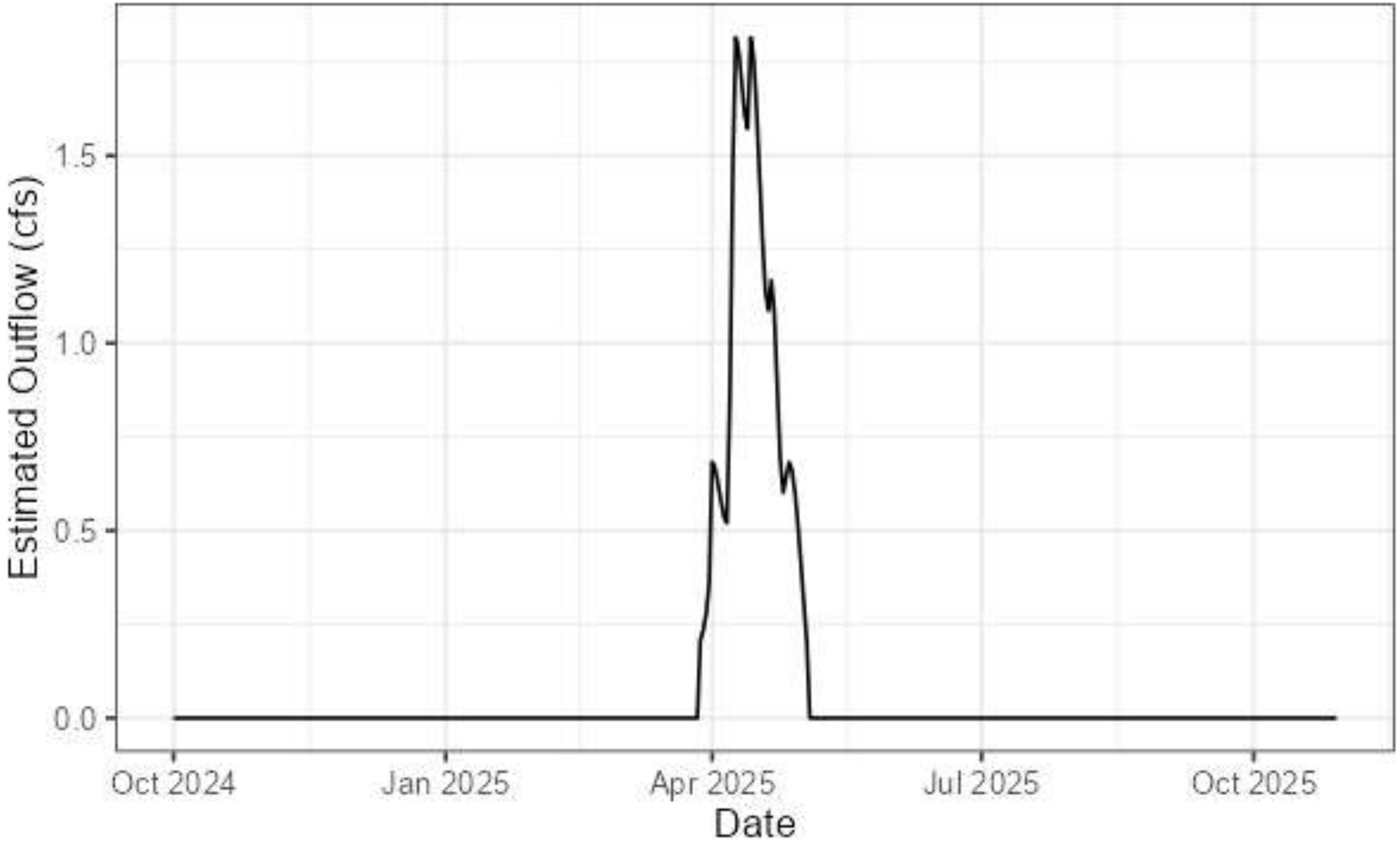
February 25, 2025 Sampling Event

April 8, 2025 Sampling Event

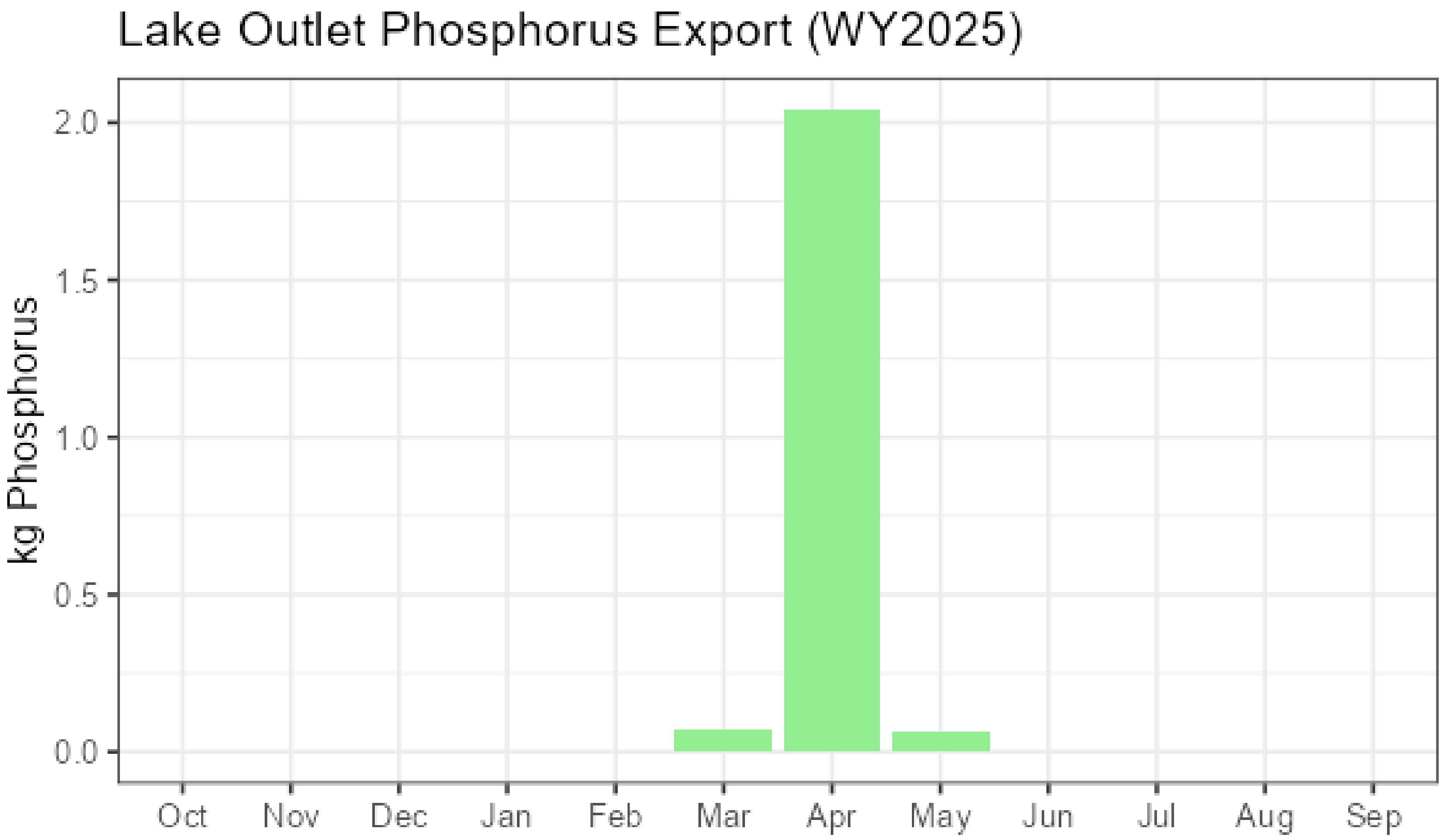
Lake Level was barely above weir in 2025



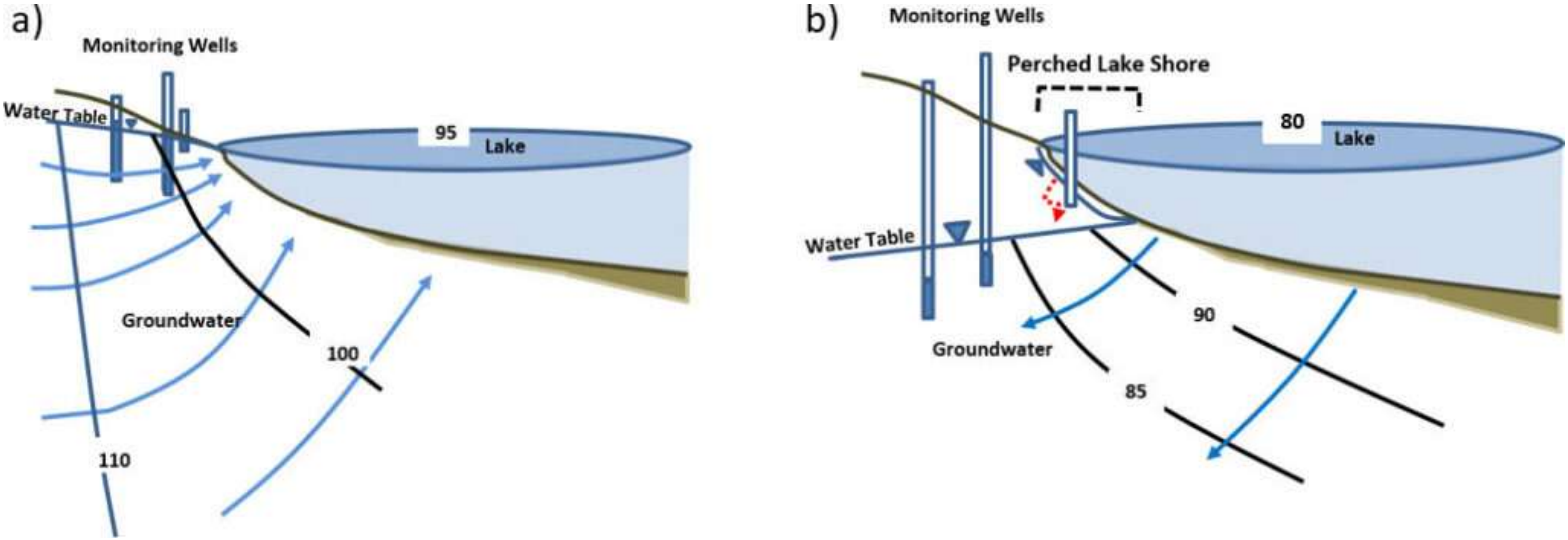
Lake Outflow



Lake Outflow – Phosphorus Export



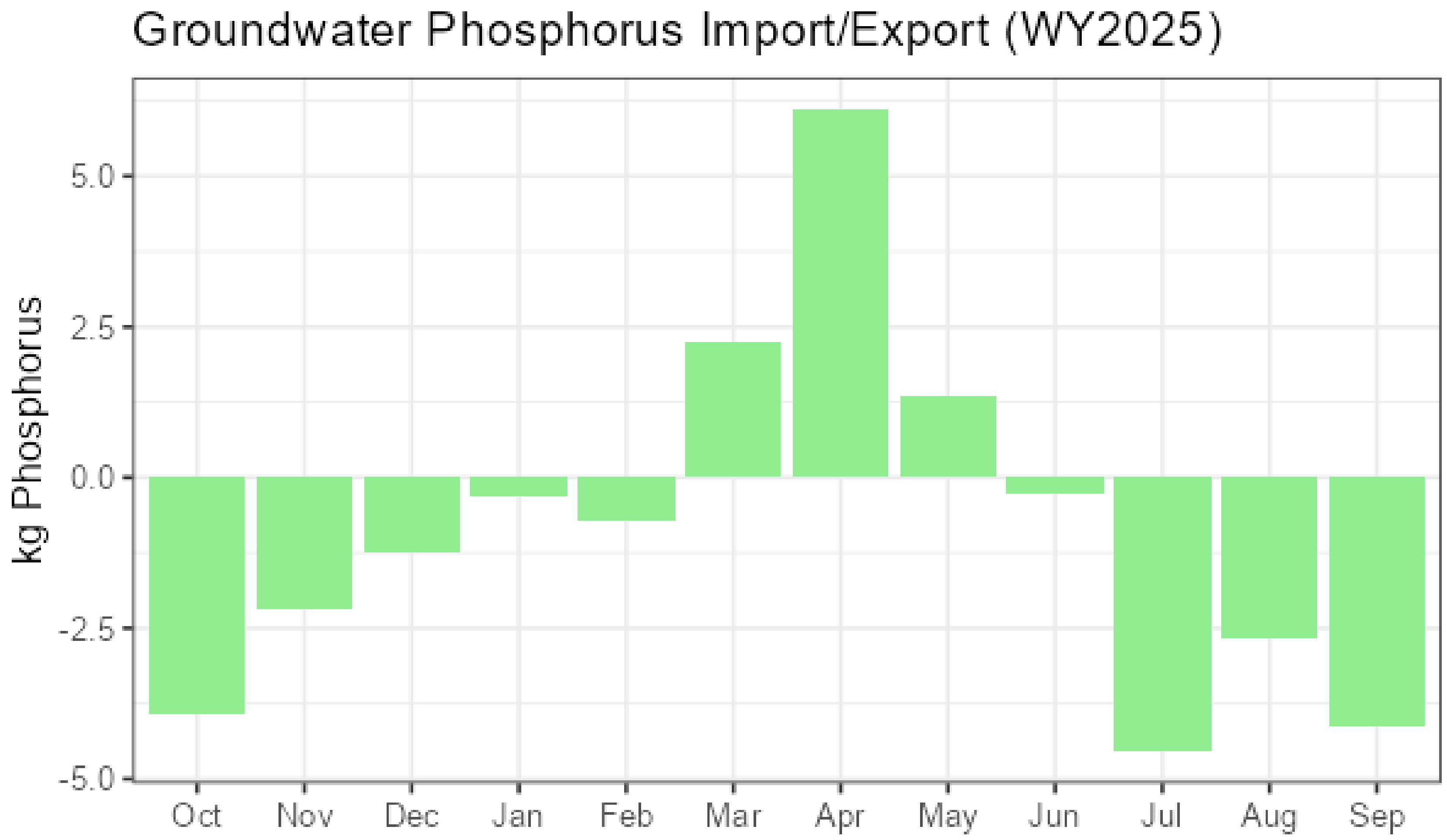
Groundwater / Subsurface



Groundwater / Subsurface (1000s m^3)

Month	Inflows		Outflows		Change in Lake Volume	Residual (Out+ Change - In)
	Precipitation	Surface Runoff	Evaporation	Outflow		
10	104.2	6.4	40.4	0.0	-7.2	**-77.5**
11	158.0	9.6	15.4	0.0	67.7	**-84.6**
12	240.1	14.5	19.9	0.0	187.0	**-47.7**
1	53.3	3.2	12.7	0.0	31.5	**-12.3**
2	158.5	9.4	19.8	0.0	120.9	**-27.1**
3	161.5	9.4	46.5	2.6	157.4	**35.7**
4	86.5	5.0	102.9	78.5	7.0	**96.9**
5	49.8	2.9	135.9	2.3	-64.2	**21.3**
6	23.2	1.4	151.8	0.0	-133.9	**-6.7**
7	0.0	0.0	158.4	0.0	-225.3	**-66.9**
8	36.0	2.2	138.5	0.0	-148.4	**-48.1**
9	26.6	1.6	87.1	0.0	-129.8	**-70.9**

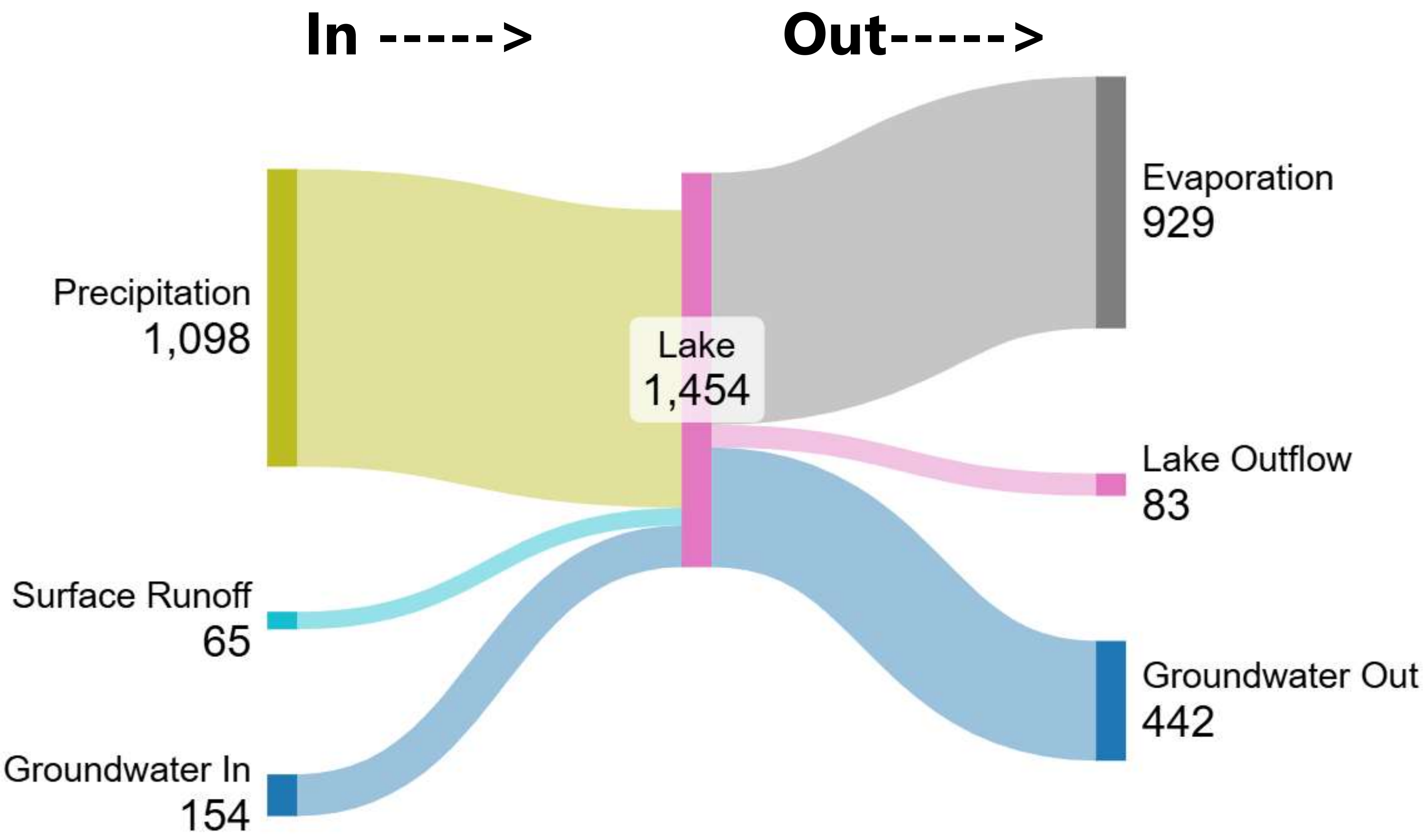
Groundwater Phosphorous



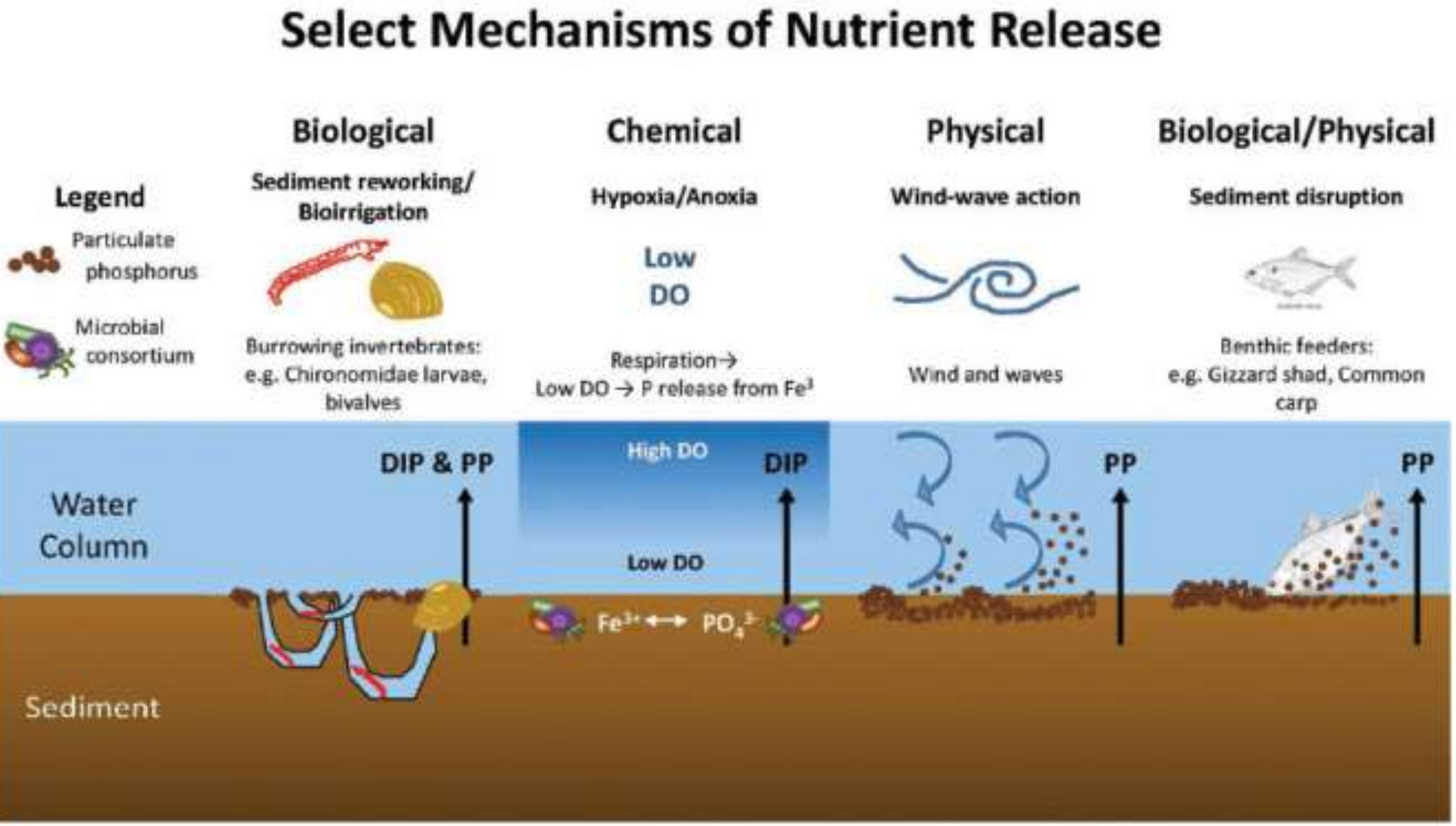
Multiply inflow by literature value of 63 ug/L.

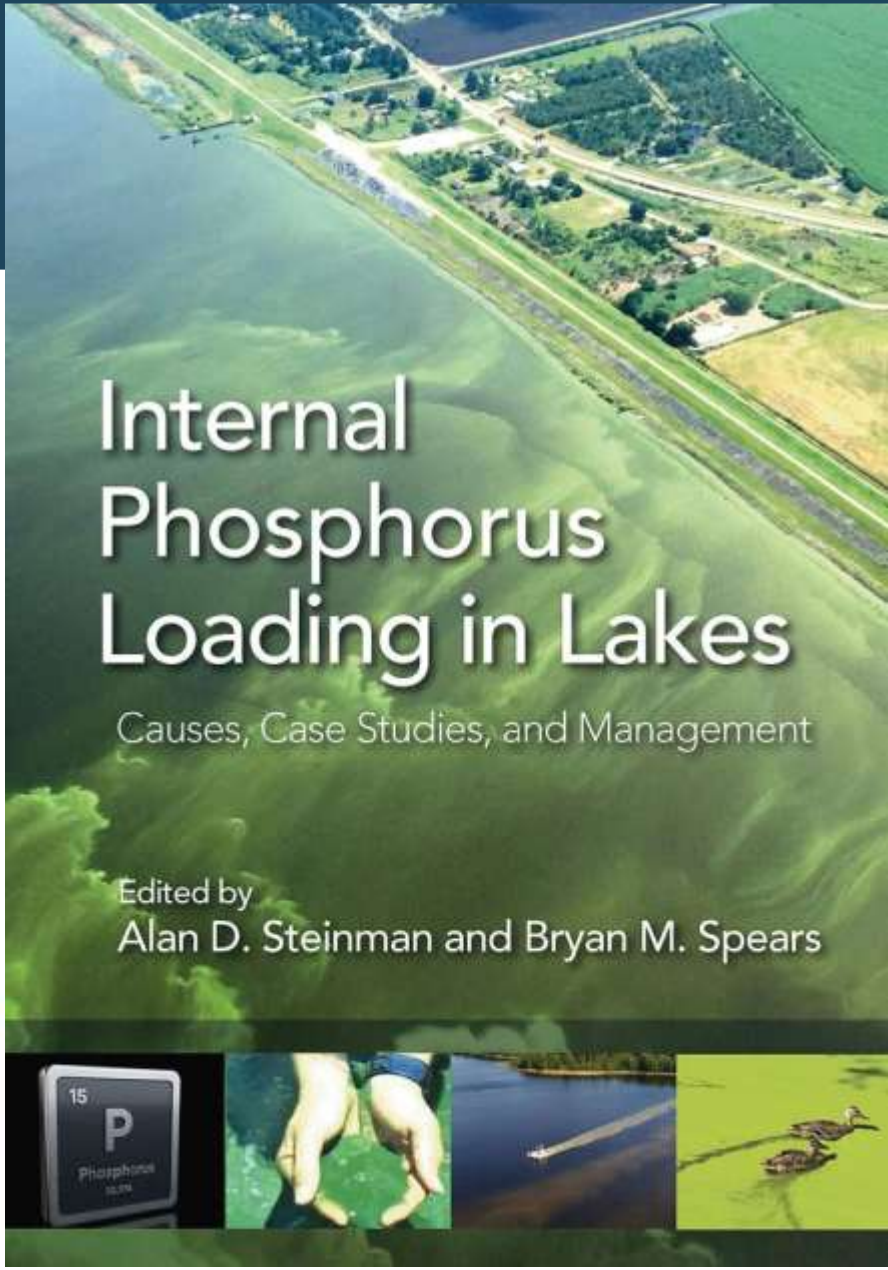
Outflow by lake phosphorus concentration (variable)

Lake Lawrence Water Budget (1000s m^3) (preliminary)



Internal Loading





Sediment Quality

Near surface

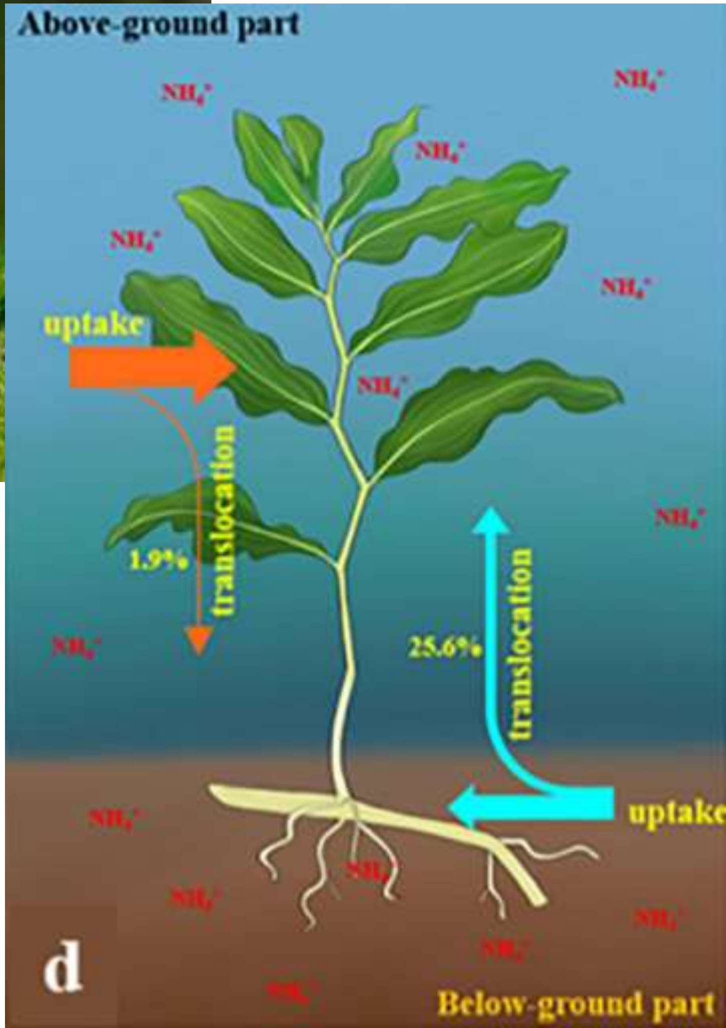
12-16 cm beneath

20-26 cm beneath

Lake Lawrence Sediment Chemistry (9/25/2024): (mg/kg-dw)

Core Sample Site	Depth Interval (cm)	Loosely Bound P	Iron Bound P	Aluminum Bound P	Calcium Bound P	Biogenic P	Organic P	Mobile P	Active P	Total P	% Active P	Total Fe	% Solids	Fe:TP Ratio
Big Basin (Deep)	0-2	<2.00	467.3	344.6	104.[illegible]	29.2	475.8	467.3	496.5	**1,392.7**	36%	14,900	3.5%	10.7
	4-6	<2.00	546.8	383.2	210.7	311.4	773.0	546.8	858.2	**1,913.7**	45%	15,800	4.5%	8.3
	8-10	<2.00	435.5	228.7	106.[illegible]	24.2	394.5	435.5	459.7	**1,165.2**	39%	14,500	5.0%	12.4
	12-16	<2.00	165.2	340.8	88.[illegible]	370.7	729.1	165.2	535.9	**1,323.4**	40%	9,610	5.5%	7.3
	20-26	<2.00	86.3	230.3	78.[illegible]	29.3	173.0	86.3	115.6	**567.6**	20%	10,100	7.6%	17.8
Big Basin (E1)	0-2	<2.00	36.5	322.0	70.4	527.9	973.1	36.5	564.5	**1,402.1**	40%	4,350	3.1%	3.1
	4-6	<2.00	6.3	142.3	60.[illegible]	906.1	1,103.1	6.3	912.5	**1,311.8**	70%	5,810	3.3%	4.4
	8-10	<2.00	35.3	242.9	56.[illegible]	1,031.9	1,217.9	35.3	1,067.2	**1,552.3**	69%	5,570	4.2%	3.6
	12-16	<2.00	39.3	146.6	65.[illegible]	137.8	295.3	39.3	177.1	**546.9**	32%	5,470	4.6%	10.0
	20-26	<2.00	29.9	100.8	62.[illegible]	420.4	569.2	29.9	450.4	**762.2**	59%	5,590	5.5%	7.3
Big Basin (E2)	0-2	<2.00	22.9	66.7	94.[illegible]	92.2	194.6	22.9	115.1	**378.3**	30%	9,910	16.4%	26.2
	4-6	<2.00	37.9	102.8	120.[illegible]	347.8	473.0	37.9	385.7	**733.8**	53%	7,090	10.8%	9.7
	8-10	<2.00	11.3	113.8	111.[illegible]	54.6	193.9	11.3	65.9	**430.2**	15%	8,840	6.8%	20.5
	12-16	<2.00	3.3	61.6	112.[illegible]	137.1	209.8	3.3	140.3	**386.6**	36%	9,230	7.6%	23.9
	20-26	<2.00	3.7	68.3	91.[illegible]	23.9	92.9	3.7	27.5	**256.8**	11%	8,680	12.3%	33.8
West Basin (Deep)	0-2	<2.00	137.1	166.3	56.[illegible]	21.3	316.8	137.1	158.3	**676.4**	23%	17,600	3.5%	26.0
	4-6	<2.00	186.9	210.9	104.[illegible]	11.1	286.9	186.9	198.0	**788.9**	25%	18,600	4.2%	23.6
	8-10	<2.00	78.2	155.9	38.[illegible]	6.9	435.9	78.2	85.0	**708.0**	12%	13,700	5.0%	19.4
	12-16	<2.00	78.4	209.1	79.7	22.1	219.1	78.4	100.5	**586.3**	17%	10,900	5.5%	18.6
	20-26	<2.00	89.4	218.0	72.[illegible]	76.6	234.3	89.4	166.1	**614.0**	27%	8,960	7.5%	14.6

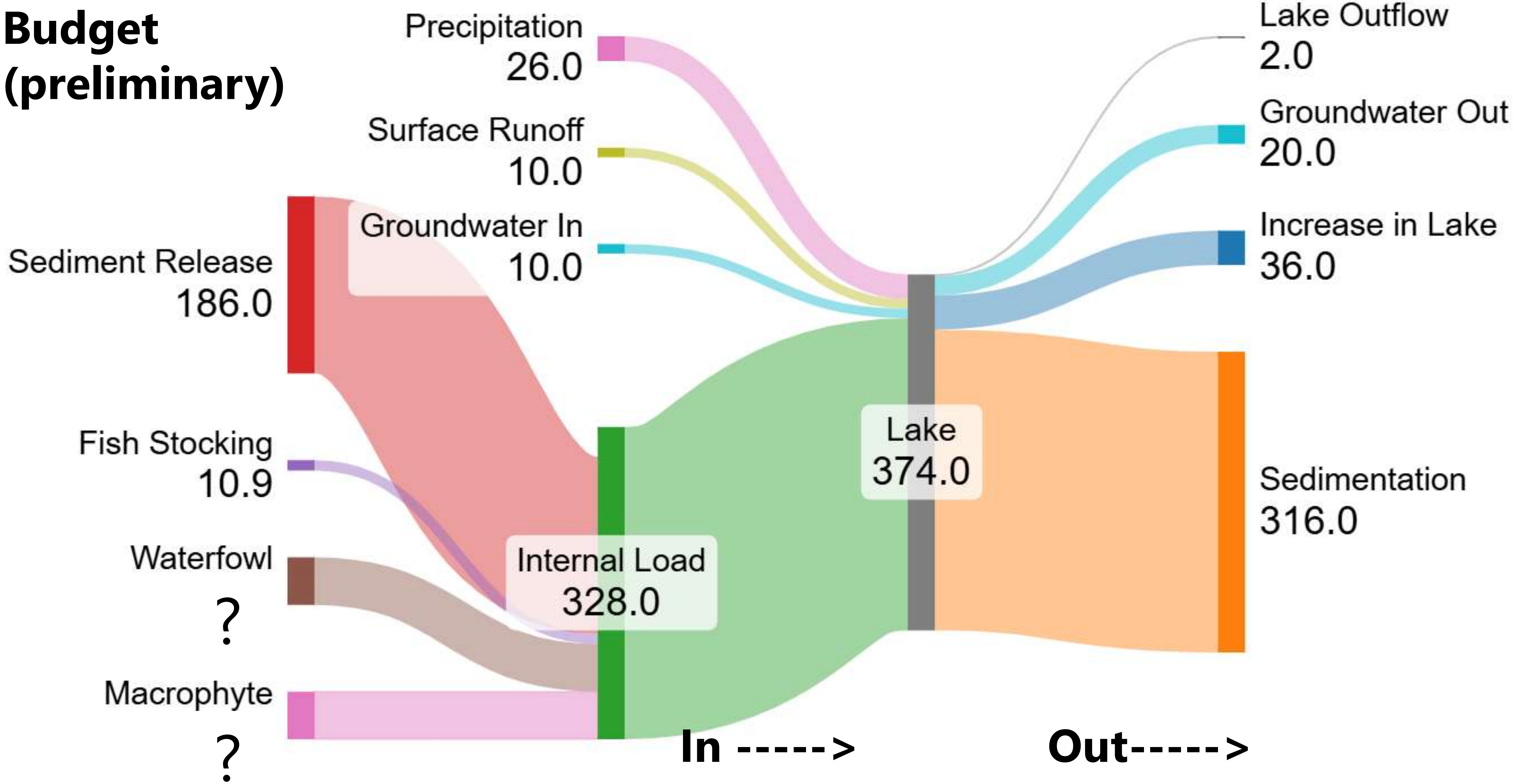
Other Internal P Sources



Internal Loading Estimates

Method	Description	Notes	Internal Load
1. Sediment Release Rates	Calculated based on sediment phosphorus (mobile or total). Not inclusive of other internal sources (waterfowl, stocked trout, macrophyte translocation).	Pilgrim regression (sediment mobile P)	**131 kg**
		Nurnberg regression (sediment total P)	**241 kg**
2. Residual in P Budget	Difference between lake phosphorus import and exports. $P_{internal} = (P_{outlet} + P_{GW-Out}) - (P_{Precip} + P_{surface} + P_{GW-in}) + \Delta P_{Storage}$	Includes other internal sources	**328 kg**
3. Modeled	Using assumed phosphorus settling rates based on lake inflow rate, calculate the unaccounted-for loadings. Nurnberg (1998) methods	Includes other internal sources	**163 kg**

Phosphorus Budget (preliminary)



Annual Water and Phosphorus Budget Summary

October 2024 to September 2025

	Source	Water Budget		Phosphorus Budget	
		Volume (10^3 m^3)	%	Mass (kg)	%
Inflow	Precipitation	1,098	84%	26	7%
	Surface Runoff	65	5%	10	3%
	Groundwater	154	11%	10	3%
	Internal	--	--	**328**	**87%**
Outflow	Evaporation	929	64%	--	--
	Lake Outflow	83	6%	2	<1%
	Groundwater Out	442	30%	20	4%
	Sedimentation	--	--	**316**	**96%**
	Change	-137	-2% of lake	+36	16% of input

3 Minute Break

To control cyanobacteria, we need to control phosphorus

Management Plan Framework

Long-term Management

- Scientifically sound and proven technologies
- Cost-effective over a 20+ year timeline
- Low annual costs and management needs
- Preference for ecologically neutral or beneficial.
- Consider phosphorus source control and management

Near-term Management

- Scientifically sound and proven technologies
- Provide relief from blooms in the next few years
- Cost-effective
- More open to chemical-based methods but with preference to minimize environmental impact

Lake Management Alternatives

In-Lake Controls - Feasible

1. **Hypolimnetic Oxygenation***
2. **Phosphorus Inactivation***
   - **Alum (buffered or unbuffered)**
   - **Lanthanum**
   - Iron, Calcium
3. *Algaecides*
4. *Dredging*

* **Recommended**

In-Lake Controls - Infeasible (high cost and/or low effectiveness/confidence)

1. *Microbes/Enzymes*
2. *Dye*
3. *Barley Straw*
4. *Dilution/Flushing*
5. *Drawdown*
6. *Hypolimnetic Withdrawal*
7. *Nanobubbler*
8. *Ultrasound (LG Sonic)*
9. *Biomanipulation*
10. *Lake Circulation*
    - *Surface or whole*
    - *Aeration*
    - *Solar Bee*

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Hypolimnetic Oxygenation

Oxygen Saturation Technology (OST)

- Ensures that the deepest waters of the lake remain oxygenated throughout the summer.
- Maintains chemical conditions such that phosphorus is immobilized in the lake sediments.
- Will increase binding opportunity for phosphorus introduced from groundwater.
- *Added benefit:* Provides cool habitat for cold-water fish, like trout

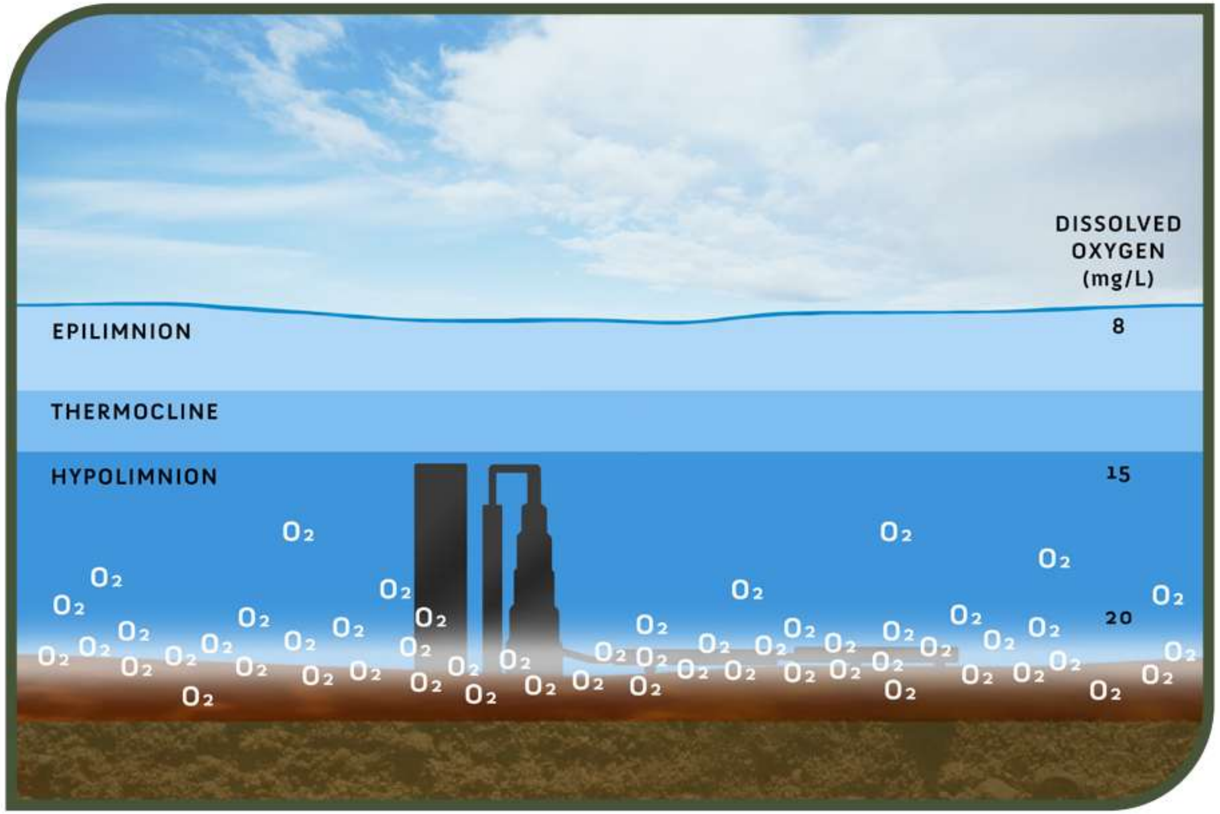


Diagram shows Naturalake OST distributing oxygen rich water throughout the hypolimnetic layer, blanketing and penetrating the sediment.

Recommended Timeline

Design, permitting, and construction will take two to three years. Operational by 2026.

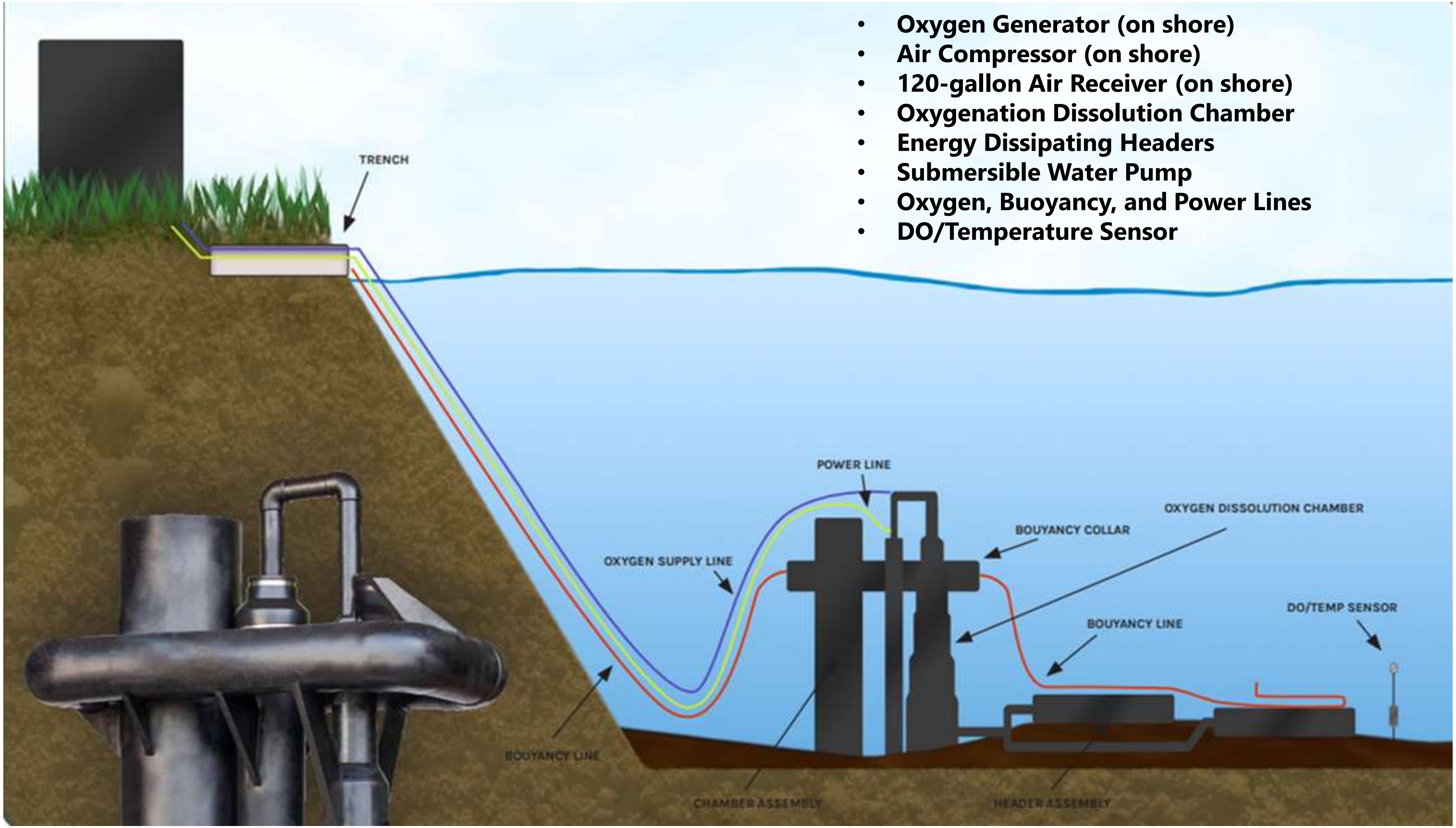
Estimated Cost

\$1.8 million for construction

\$20 thousand in annual operation

OST System Components

- Oxygen Generator (on shore)
- Air Compressor (on shore)
- 120-gallon Air Receiver (on shore)
- Oxygenation Dissolution Chamber
- Energy Dissipating Headers
- Submersible Water Pump
- Oxygen, Buoyancy, and Power Lines
- DO/Temperature Sensor



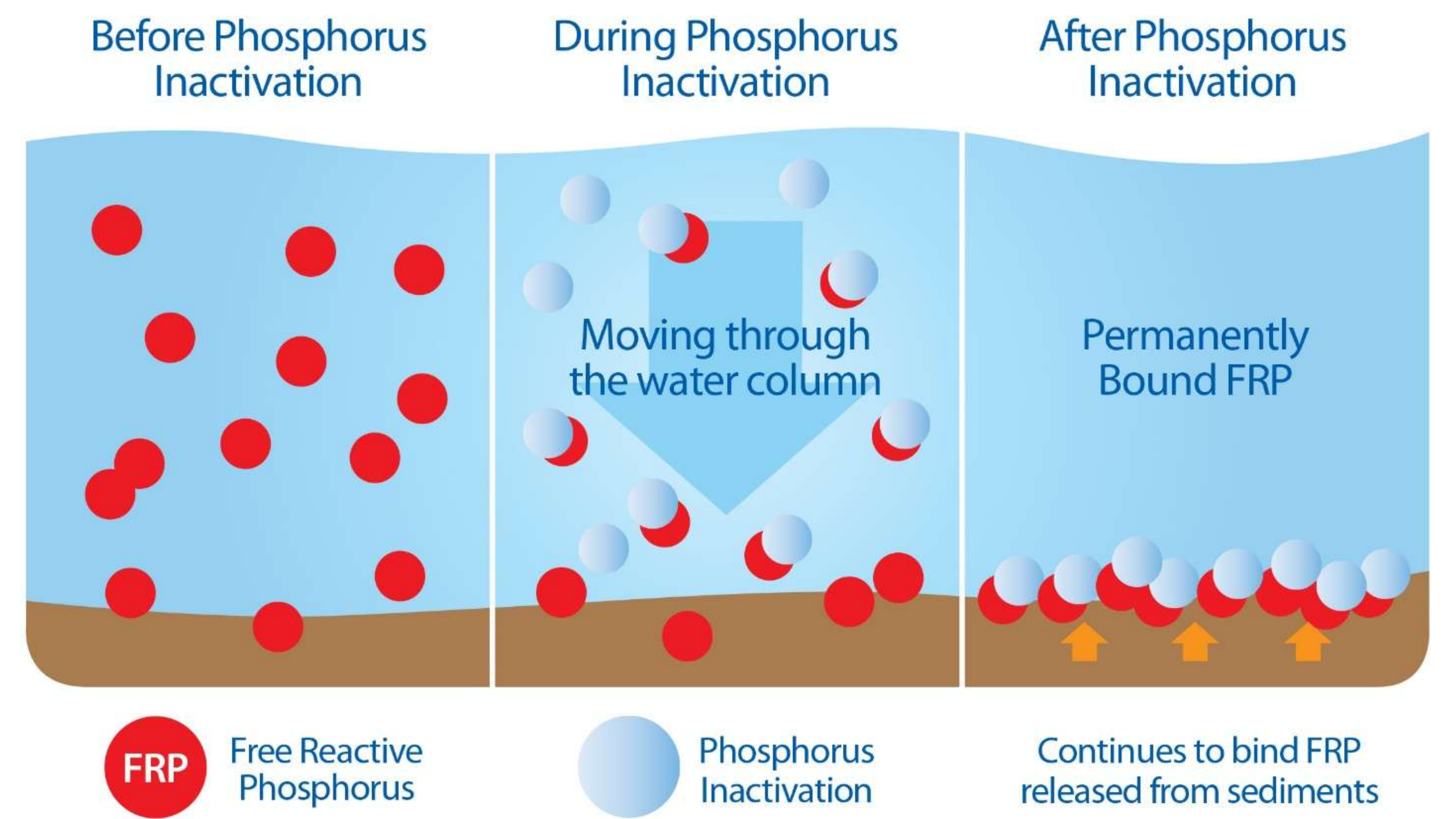
Phosphorus Inactivation of the Lake Sediments

Remove phosphorus available for algae from the water column.

Several chemicals are available

- Alum
- Lanthanum
- Iron
- Calcium
- Additional proprietary blends

Does not improve bottom oxygen or fish habitat



Before Phosphorus Inactivation
During Phosphorus Inactivation
After Phosphorus Inactivation
Moving through the water column
Permanently Bound FRP
FRP
Free Reactive Phosphorus
Phosphorus Inactivation
Continues to bind FRP released from sediments

Phosphorus Inactivation Preliminary Comparison

	Alum	Lanthanum	Iron	Calcium
Commercial Products	Available from general chemical suppliers			
Mode of Inactivation	Forms stable complexes with dissolved phosphorus. Forms floccules that pull particulate phosphorus from the water column. Stable at pH range 5.5 to 9			
Mass Ratio (kg product to kg P)	2 to 20 Al : P			
Lawrence Dose	**6,800 kg Al (unbuffered)** **66,200 kg Al (buffered)**			
Potential Negative Consequences	Possible toxicity with improper application			
Permitting	Approved in Ecology Permit			
Treatment Cost (does not include monitoring +permit**)**	**$90,000 (low dose; unbuffered)** **$1,200,000 (buffered)**			
Longevity	**1 year (unbuffered)** **5 to 10 years (buffered)**			
20 Year Cost Estimate (mid-point longevity; not adjusted; includes $50K for monitoring/treatment)	**$2.8M (unbuffered)** **$3.3M (buffered)**			

Phosphorus Inactivation Preliminary Comparison

	Alum	Lanthanum	Iron	Calcium
Commercial Products	Available from general chemical suppliers	PhosLock EutroSorb G		
Mode of Inactivation	Forms stable complexes with dissolved phosphorus. Forms floccules that pull particulate phosphorus from the water column. Stable at pH range 5.5 to 9	Forms stable complexes with dissolved phosphorus. Does NOT form floccules Stable at pH <9		
Mass Ratio (kg product to kg P)	2 to 20 Al : P	5 La : P		
Lawrence Dose	**6,800 kg Al (unbuffered)** **66,200 kg Al (buffered)**	16,500 kg La (**165,000 kg EutraSorb G**; **331,000 kg Phoslock**)		
Potential Negative Consequences	Possible toxicity with improper application	Possible in-lake or sediment but not expected at planned doses and formulation. (La is applied bound to clay and will bind with P)		
Permitting	Approved in Ecology Permit	Approved in Ecology Permit		
Treatment Cost (does not include monitoring +permit)	**$90,000** **(low dose; unbuffered)** **$1,200,000 (buffered)**	**$1,800,000**		
Longevity	**1 year (unbuffered)** **5 to 10 years (buffered)**	**5 to 10 years**		
20 Year Cost Estimate (mid-point longevity; not adjusted; includes $50K for monitoring/treatment)	**$2.8M (unbuffered)** **$3.3M (buffered)**	**$4.9M**		

Phosphorus Inactivation Preliminary Comparison

	Alum	Lanthanum	Iron	Calcium
Commercial Products	Available from general chemical suppliers	PhosLock EutroSorb G	ZVI Iron Salts	
Mode of Inactivation	Forms stable complexes with dissolved phosphorus. Forms floccules that pull particulate phosphorus from the water column. Stable at pH range 5.5 to 9	Forms stable complexes with dissolved phosphorus. Does NOT form floccules Stable at pH <9	Iron oxyhydroxides provide binding sites for phosphate and other ions. Iron-phosphate bonds may break down in low oxygen conditions.	
Mass Ratio (kg product to kg P)	2 to 20 Al : P	5 La : P	44 Fe : 1	
Lawrence Dose	**6,800 kg Al (unbuffered)** **66,200 kg Al (buffered)**	16,500 kg La (**165,000 kg EutraSorb G**; **331,000 kg Phoslock**)	**149,000 kg**	
Potential Negative Consequences	Possible toxicity with improper application	Possible in-lake or sediment but not expected at planned doses and formulation. (La is applied bound to clay and will bind with P)	Not expected	
Permitting	Approved in Ecology Permit	Approved in Ecology Permit	Approved in Ecology Permit, but not for anoxic areas	
Treatment Cost (does not include monitoring +permit)	**$90,000** **(low dose; unbuffered)** **$1,200,000 (buffered)**	**$1,800,000**	**$270,000**	
Longevity	**1 year (unbuffered)** **5 to 10 years (buffered)**	**5 to 10 years**	**1 to 2 years**	
20 Year Cost Estimate (mid-point longevity; not adjusted; includes $50K for monitoring/treatment)	**$2.8M (unbuffered)** **$3.3M (buffered)**	**$4.9M**	**$4.3M**	

Phosphorus Inactivation Preliminary Comparison

	Alum	Lanthanum	Iron	Calcium
Commercial Products	Available from general chemical suppliers	PhosLock EutroSorb G	ZVI Iron Salts	OASE SeDox
Mode of Inactivation	Forms stable complexes with dissolved phosphorus. Forms floccules that pull particulate phosphorus from the water column. Stable at pH range 5.5 to 9	Forms stable complexes with dissolved phosphorus. Does NOT form floccules Stable at pH <9	Iron oxyhydroxides provide binding sites for phosphate and other ions. Iron-phosphate bonds may break down in low oxygen conditions.	Forms Calcite (CaCO3), stripping P from water column. Precipitates may dissolve in hypolimnion Less effective at pH<9
Mass Ratio (kg product to kg P)	2 to 20 Al : P	5 La : P	44 Fe : 1	50 SedDox : 1
Lawrence Dose	**6,800 kg Al (unbuffered)** **66,200 kg Al (buffered)**	16,500 kg La (**165,000 kg EutraSorb G**; **331,000 kg Phoslock**)	**149,000 kg**	**165,000 kg SedOx**
Potential Negative Consequences	Possible toxicity with improper application	Possible in-lake or sediment but not expected at planned doses and formulation. (La is applied bound to clay and will bind with P)	Not expected	Not expected
Permitting	Approved in Ecology Permit	Approved in Ecology Permit	Approved in Ecology Permit, but not for anoxic areas	Approved in Ecology Permit
Treatment Cost (does not include monitoring +permit)	**$90,000 (low dose; unbuffered)** **$1,200,000 (buffered)**	**$1,800,000**	**$270,000**	**$2,700,000**
Longevity	**1 year (unbuffered)** **5 to 10 years (buffered)**	**5 to 10 years**	**1 to 2 years**	**<3 to 5 years**
20 Year Cost Estimate (mid-point longevity; not adjusted; includes $50K for monitoring/treatment)	**$2.8M (unbuffered)** **$3.3M (buffered)**	**$4.9M**	**$4.3M**	**$13.8M**

Dredging

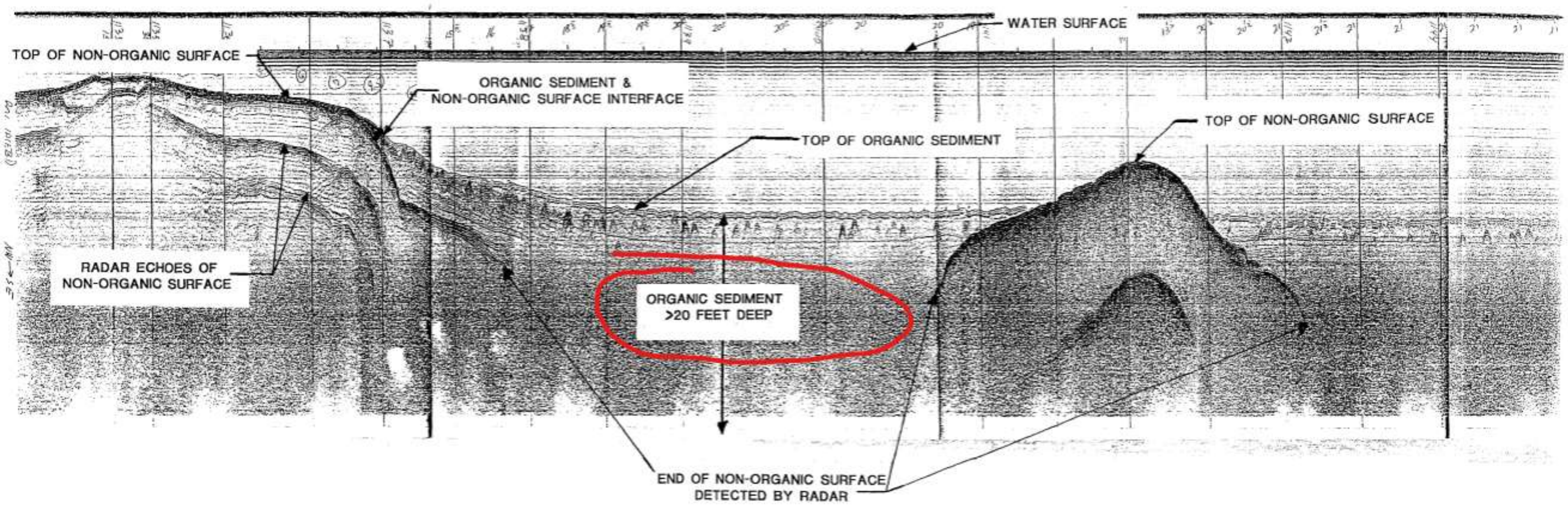
- **Mechanical** - Collect bottom sediment using a boat, crane, and barge.
  - o **Hydraulic** - Underwater cutter and pumps to create slurry, which is piped via floating pipeline.
- Dewater sediments on shoreline.
- Haul away or dispose nearby.
- Estimated 4 to 10 million cubic yards would need to be removed
  - o (enough area to cover 100 acres with 25 to 60 feet of sediment)
- Require extensive permitting
  - USACE 401/404, SEPA, HPA, Shoreline Development, Aquatic Use
- Dredging may take >10 years to complete

Dredging - continued

Dredging Extent	Cubic Yards	Cost if Material Left on Site	Cost if Material Trucked Away
Nearshore – (Would not improve WQ)	120,000	**$7M**	**$9M**
Big Basin – Hypolimnetic Area Only	4,574,000	**$252M**	**$343M**
Whole Lake	10,533,000	**$579M**	**$790M**

- **Permitting**
  Estimated at $200K before work starts

- **Dredging**
  $55 to $75 per yard +
  mobilization/trucking
  (Sea & Shore Construction Inc.)



1995 Nearshore Only Estimate:
$1.85M (1995) = $3.9M
(included haul away)

Algaecides

- Rapid and very effective at removing algae in water column
- Kills both good and bad algae, & fecal bacteria
- Do not reduce nutrients
- Do not provide long-term control, effective for a few hours or days
- Rapidly breaks down into water & oxygen
- May increase nutrients after treatment, for uptake by plants or other algae
- Requires permit

Cost Range

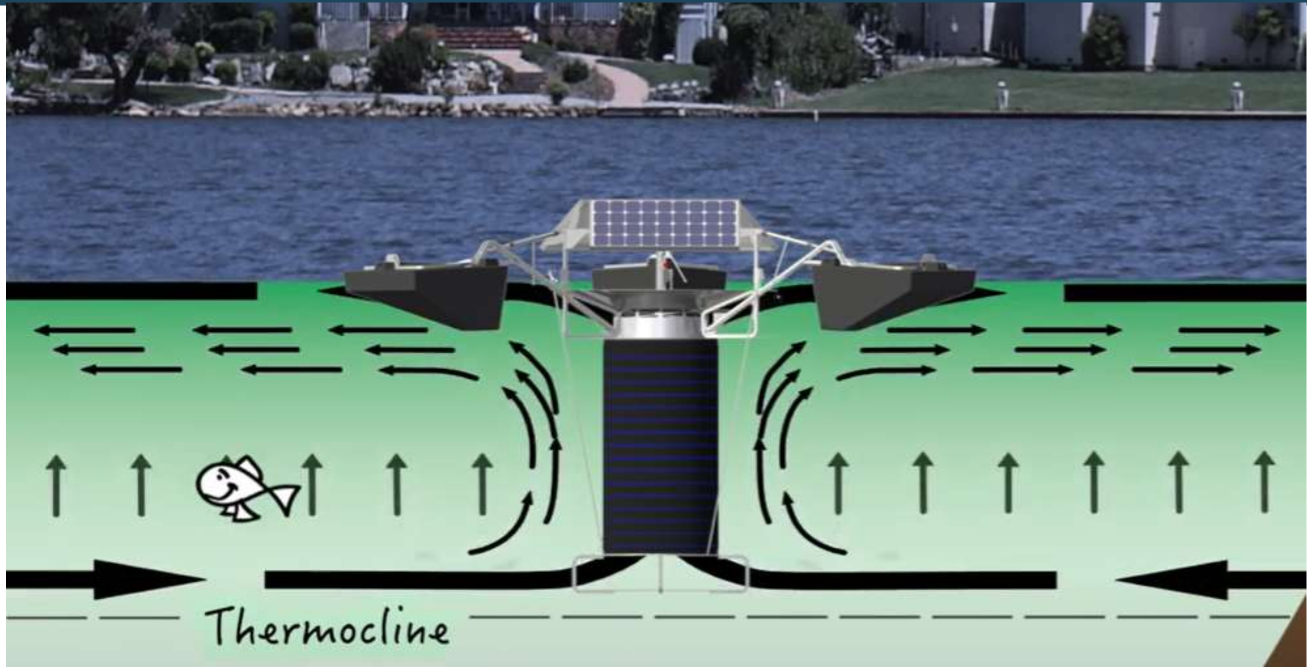
$-$$ thousand every year

sodium carbonate peroxyhydrate

Mixing / Circulation

E.g., SolarBee® lake circulator

- Mix water surface or entire small waterbody
- Mixing decreases the competitive advantage of cyanobacteria
- Does not reduce total algae or eliminate blooms
- Does not pump air, but oxygen is added through turbulence
- Modular, easily scalable, and/or solar-powered options available
- Fewer case studies exist for evaluating the efficacy
- HPA and Shoreline permits may be required



Low confidence in success

Cost Range
$-$$ thousands

Aquatic Plant Harvesting

- Aquatic plants 2–6 feet are cut and collected using a harvester with blades and conveyors.
- No chemicals.
- Plants are moved to shore for disposal or composting.
- This method is short-term, often needing repetition since roots stay intact.
- Conduct in late summer before senescence.
- It is labor-intensive, costly, and challenging in shallow or obstructed waters.
- It can also increase plant fragments drifting to shorelines.

Low-moderate confidence in success

Cost Range

$ thousand(s) per acre

Experimental / Emerging Technologies

- Sonication
- Ozone
- Micro-/ nano-bubbles
- Straw
- Shading (Dyes)

Not well studied, variable results

Option	Detail	Pros	Cons	Cost
Sonication	High frequency ultrasound to prevent algae movement & cause cell damage	Permanent control Non-chemical	Limited radius	$$
Ozone	Damages cyano cells & oxidizes toxins	Algae & toxin control	Structural & safety requirements Rapid decay rates	$$
Micro-/ Nano-bubbles	Small bubbles aerate water to disturb cyanos' buoyancy	Increases O2 transfer Reduce P release Easily scalable	Requires compressed gas supply	$$
Straw (barley or rice)	Decay compounds may inhibit algae growth	Non-chemical Low cost	Not immediate Not well understood May reduce DO	$
Shading Dyes	Reducing light availability	Also controls plant growth	Potential impacts on aquatic life	$-$$

Watershed Management

Controlling Sources of Phosphorus

Watershed Management Strategies

Watershed source is primarily **Groundwater**

1. OSS Inspections, repair, replacement
2. Pollution reduction (e.g., pet waste, fertilizers, waterfowl habitat)
3. Agricultural BMPs

LakeWise ©Snohomish County

HERRERA

Discussion:
Your Thoughts on Lake Management Options

Dredging

Algaecide

Circulation

Sediment Inactivation

Oxygenation

Waterfowl/ Shoreline Management

Aquatic Plant Harvest

Experimental Technologies

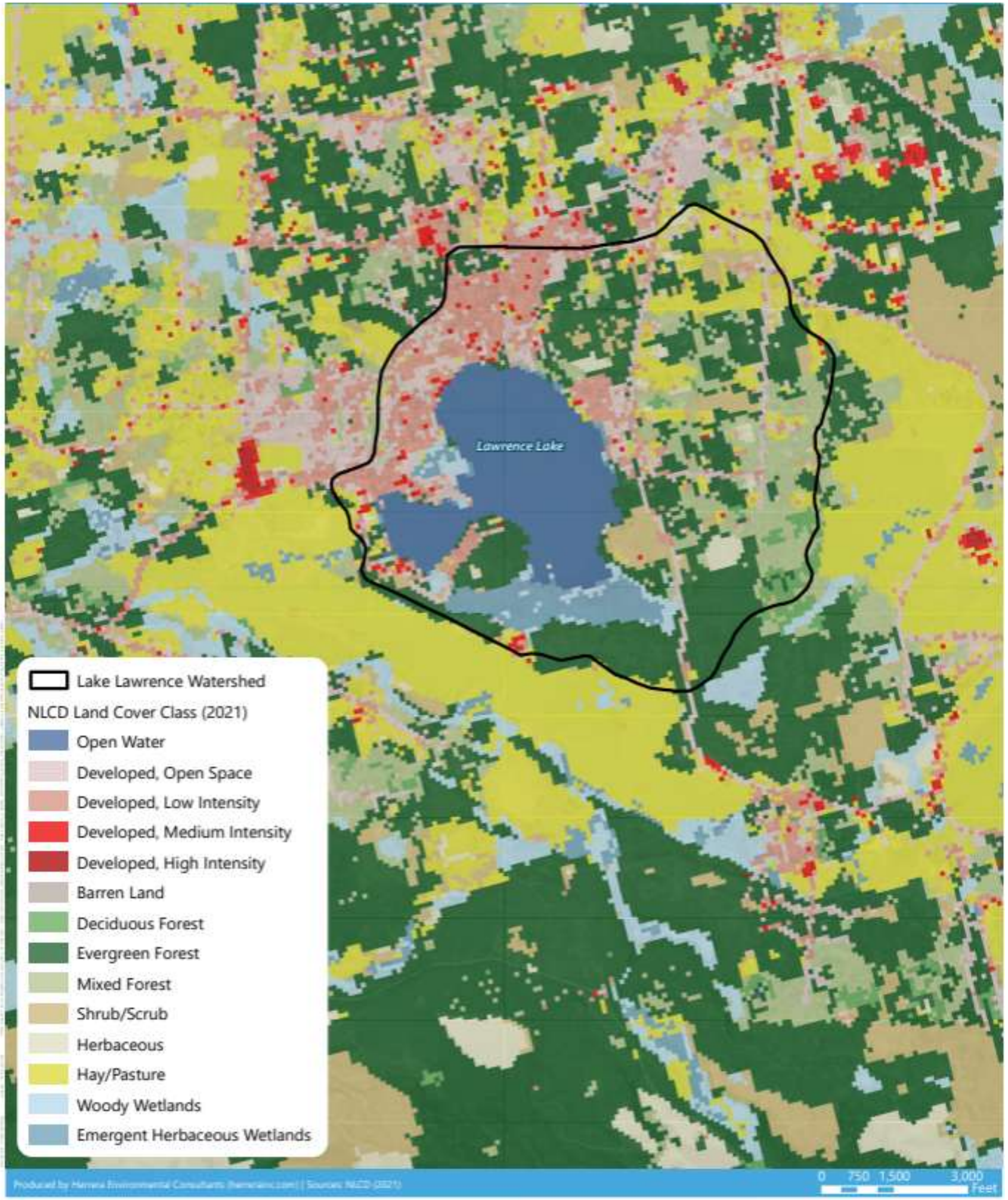
Circulation/ Mixing

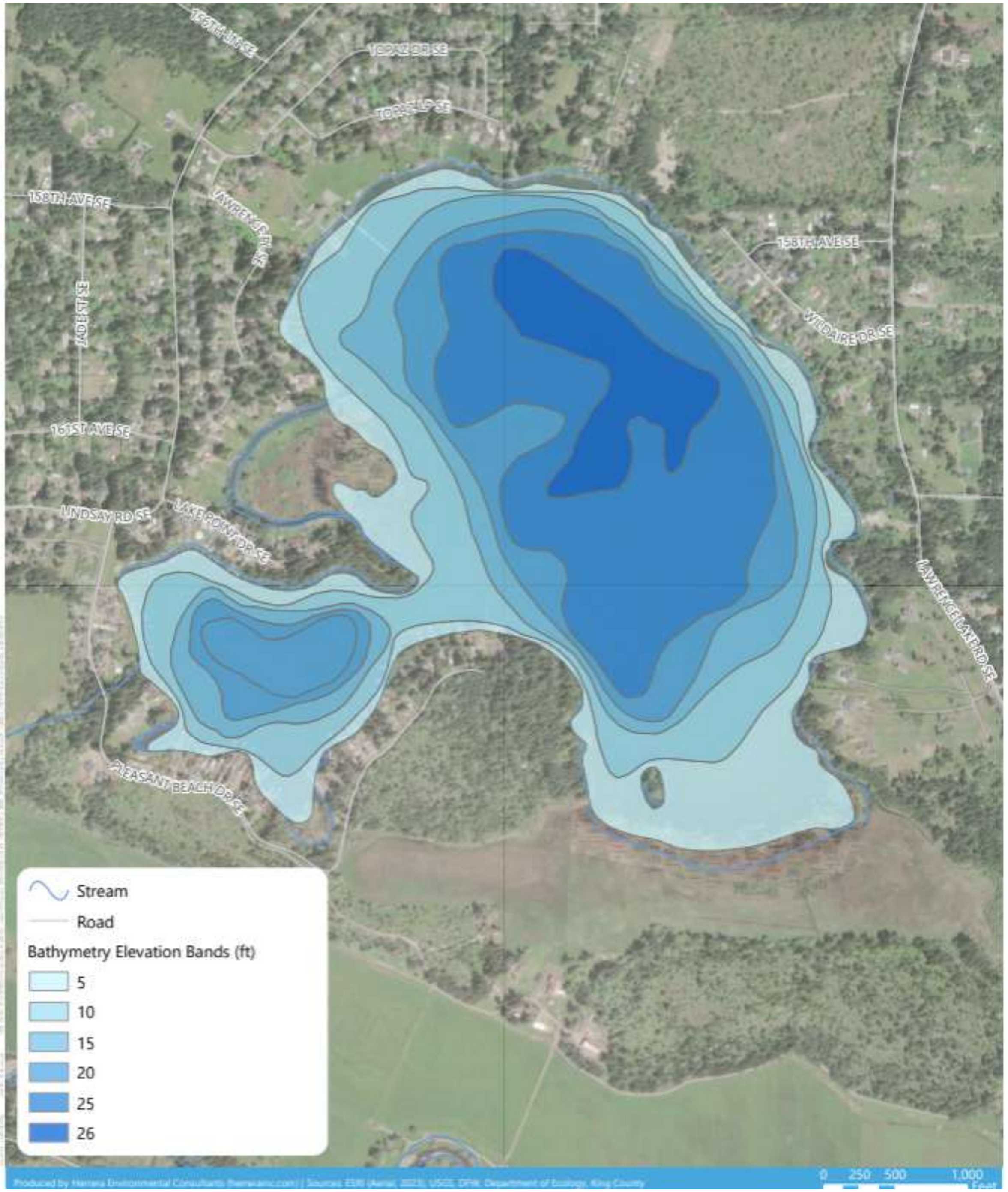
Project Schedule

Project Step	Action	Period
Lake and Watershed Monitoring	*Published Monitoring Plan (QAPP)*	*October 2024*
	***Public Meeting 1**: Project Overview and Plan*	*July 2024*
	Lake and Watershed Monitoring	*Oct 2024 to Oct 2025*
	***LMDSC/TC Meeting**: Monitoring Update*	*May 2025*
Lake Cyanobacteria Management Plan	**LMDSC/TC Meeting:** P Budget Results, Potential Management Actions	Today!
	Pre-Draft Plan for County & LMDSC review	March 2026
	Public Meeting: Present Draft Plan	April 2026
	Draft Plan for Ecology & Public review	April 2026
	Final Meeting: Present Final Plan	June 2026
	Deliver Final Plan	June 2026

Thank you!
Questions?

tclark@herrerainc.com


Lawrence Lake
Lake Lawrence Watershed
NLCD Land Cover Class (2021)
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Herbaceous
Hay/Pasture
Woody Wetlands
Emergent Herbaceous Wetlands
0 750 1,500 3,000
Feet


158TH AVE SE
161ST AVE SE
LINDSAY RD SE
LAKE POINT DR SE
PLEASANT BEACH DR SE
WILDAIRE DR SE
Stream
Road
Bathymetry Elevation Bands (ft)
5
10
15
20
25
26
0 250 500 1,000
Feet

Lake Lawrence – A History

Pre-Colonization

- Inhabited by Cowlitz, Nisqually, and Cayuse, Umatilla, & Walla Walla peoples

1873

- First survey of the lake
- 25-30 settlers
- "Kandel Lake"

1880s-1890s

- Renamed to "Lake Lawrence"
- Two small sawmills along the lakeshore
- Sawdust and wood waste discarded in lake

1908-1928

- Lake used as a reservoir for Tumwater Power Plant
- Deschutes River diverted into lake
- Lake outlet dammed; lake level raised

1920s-1940s

- Edwards Resort popular for recreation
- Lake became fishing destination

1951

- WDFW started rotenone treatments lake to remove bass, perch, etc.
- WDFW started rainbow trout stocking

1960s-1970s

- 1960's- Shoreline and watershed was subdivided and became residential
- Lee Edwards dug canal around 5-acre lot to form "Goat Island"
- Edwards Resort closed in 1973, property divided to private homes and LL Community Club

1980s

- WDFW stopped removing bass
- LMD formed in 1986!

1990s-2000s

- KCM study 1990-1991
- Dredge & design report, 1995
- IAVMP, 2004
- LLCC + WDFW raised rainbows in net pens

THURSTON COUNTY
WASHINGTON
SINCE 1852
Department of Public Works

THIS IS AN EXTRACT OF KEY PORTIONS OF THE PHASE I RESTORATION ANALYSIS THAT IS OVER 400 PAGES AND WE DO NOT HAVE A DIGITAL COPY OF THE REPORT.

Lake Lawrence
Phase I Restoration Analysis
Final Report
December 1991

KCM
Kramer, Chin & Mayo, Inc.
1917 First Avenue, Seattle, WA 98101-1027

in association with
HART CROWSER
HERRERA ENVIRONMENTAL CONSULTANTS
WATER ENVIRONMENTAL SERVICES, INC.
AQUATIC RESEARCH, INC.

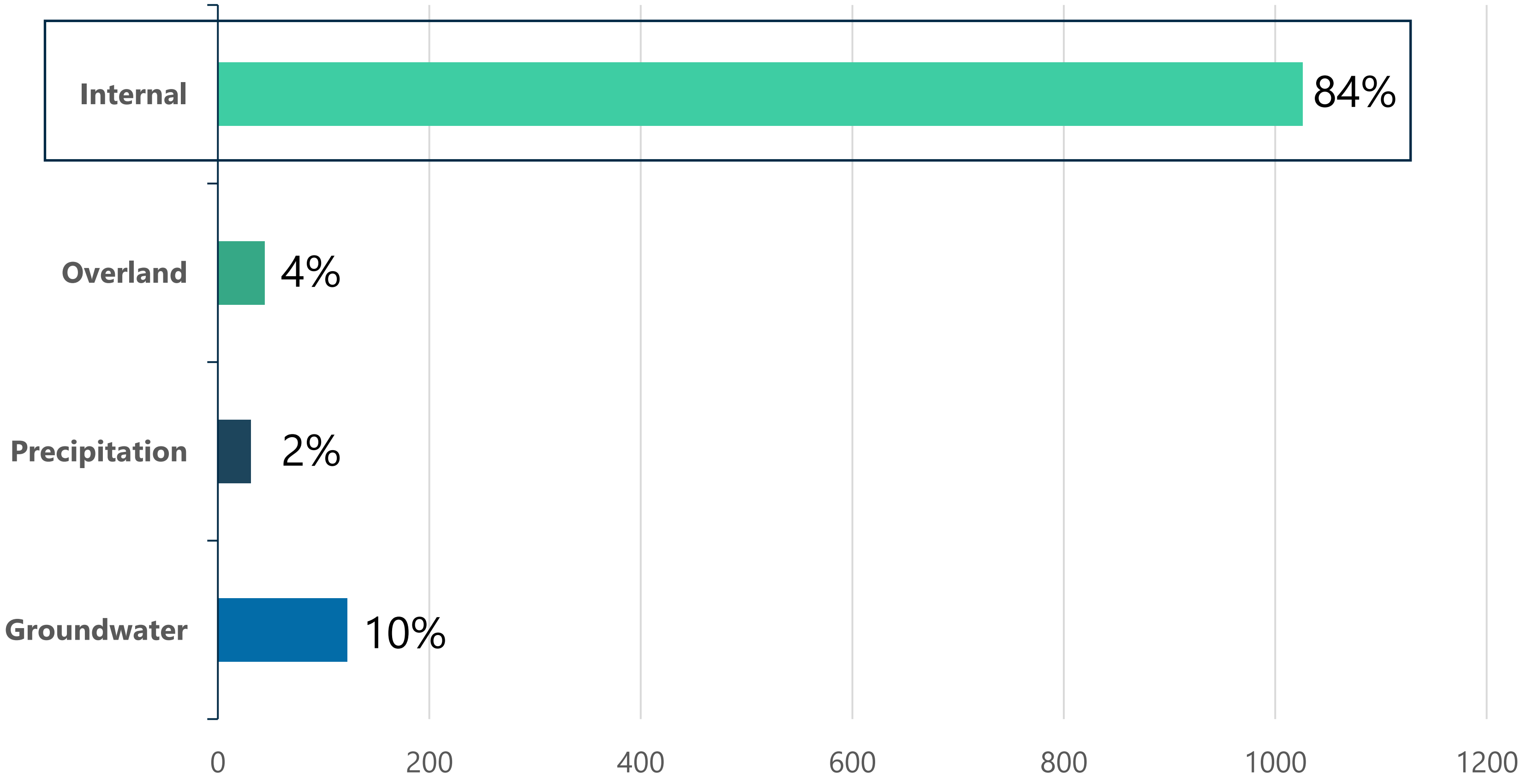
WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Funding assistance provided through the Centennial Clean Water Fund Program (CCWF)

KCM Findings

1. Lake Lawrence is eutrophic, and algae is dominated by cyanobacteria
2. Water enters the lake via groundwater and precipitation. There are no perennial tributaries.
3. Lake Lawrence is stratified from April through October and is hypoxic near the bottom.
4. Phosphorus comes from lake sediment release (84%) and naturally enriched groundwater (10%). Release is more pronounced in the east basin.
5. Algae are limited primarily by phosphorus, especially in the west basin.

Phosphorus Load (kg) (KCM 1991)



Herrera
Science + Planning + Design

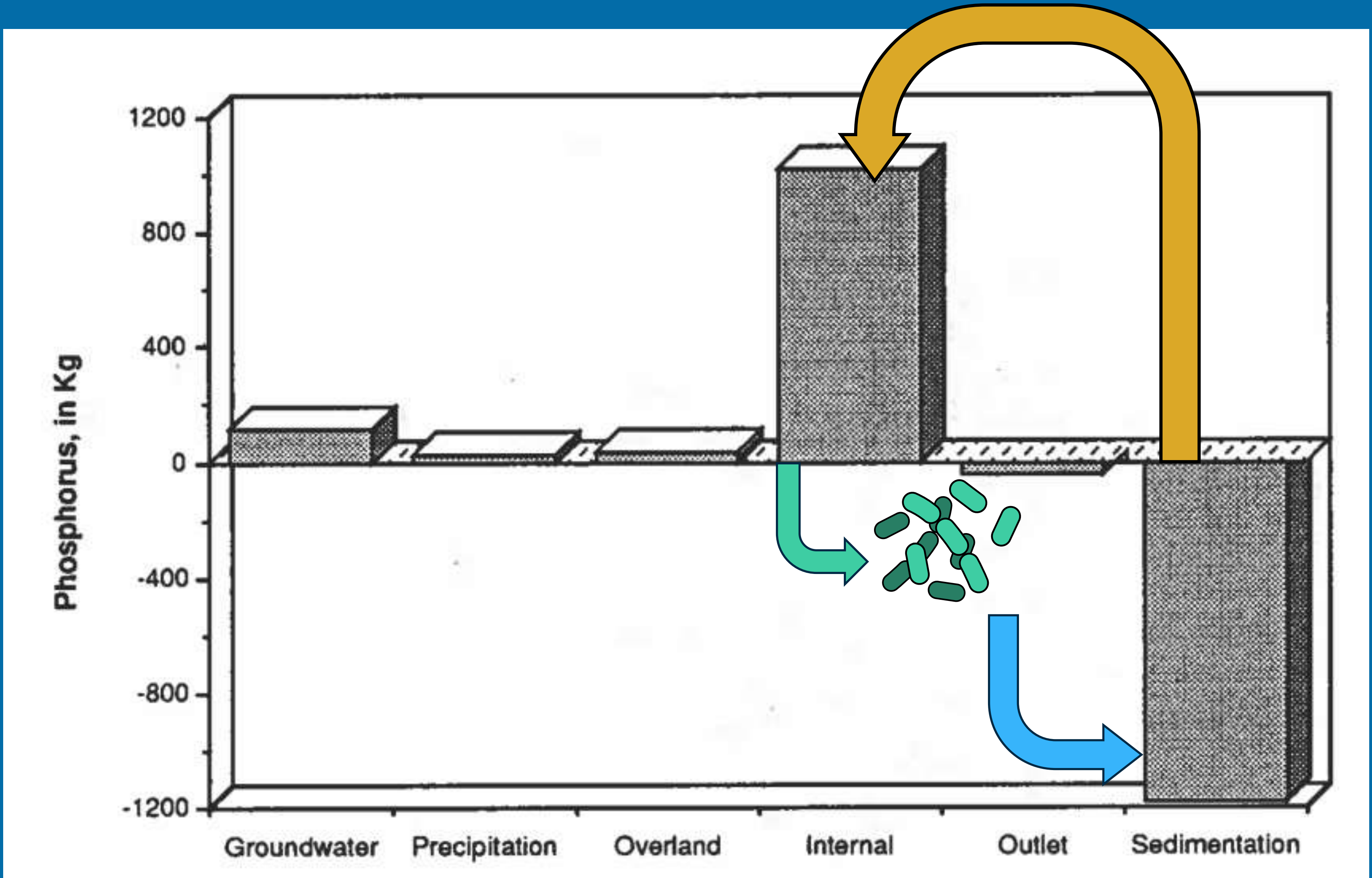


Figure 7-3
PHOSPHORUS LOADING AND LOSSES BY CATEGORY DURING 1990

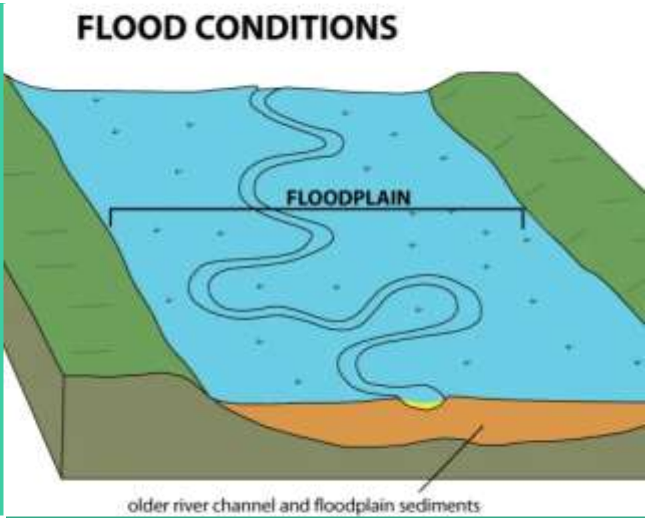
Potential Phosphorus Sources (KCM 1991)

On-Site Septic Systems

>80% on highly permeable soils

Shoreline Runoff

Fertilizers, pesticides, etc. from residences and recreational facilities



Legacy Farming & Logging

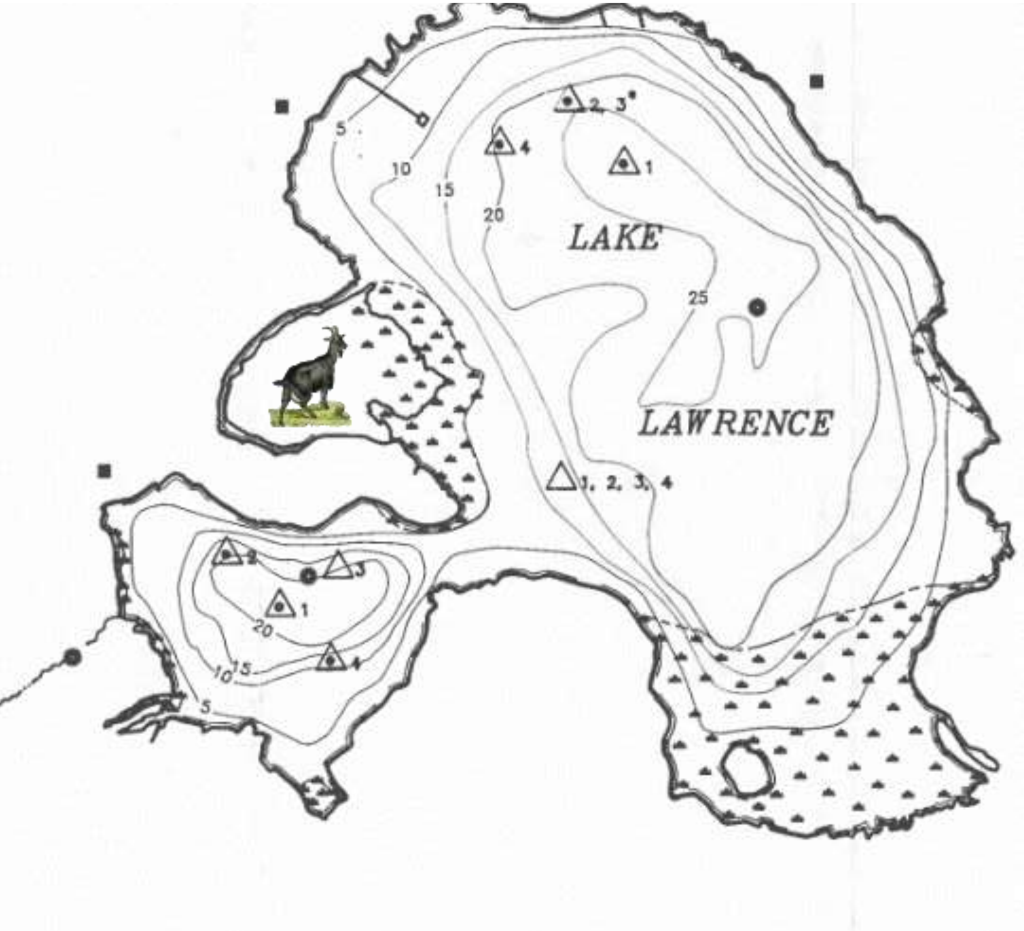
Historical inputs from dairy farms, chicken farms, logging/milling (slabs & sawdust)

Deschutes River Flooding & Sedimentation

Diversion dam allowed river sediment to settle in the lake & lake levels to rise (inundate shores) for >20 years

Inputs from historical river flooding into lake

KCM Recommendations



1 Dredging in both basins*

Prohibitively high cost ($250M in 2022 USD)

2 Harvesting of aquatic plants

3 Sediment covers & grass carp for additional aquatic plant control, as desired

4 Watershed pollution control (education, treatment, BMPs)

*Other measures (e.g., alum treatment) were estimated to be less effective at meeting lake use goals and would not last as long.