wood.

Florida Stormwater Association
December 5, 2019

Measuring Internal Nutrient Loads and Effective Treatment Options

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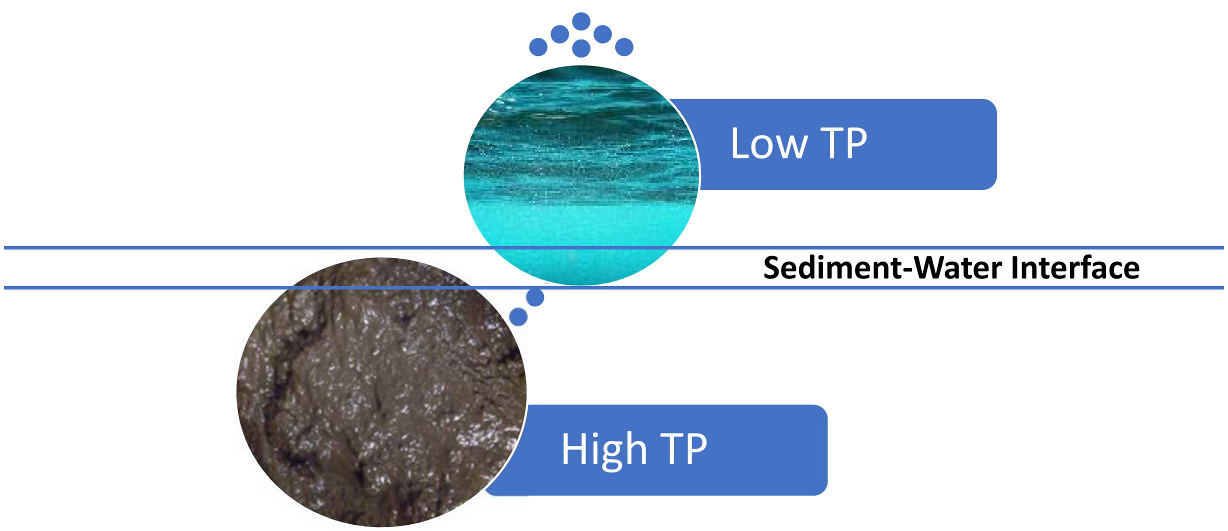
Why do we care about sediment quality?

1) Provides substrate for habitat
2) Can be a source or sink for pollutants
3) **Drives water quality**

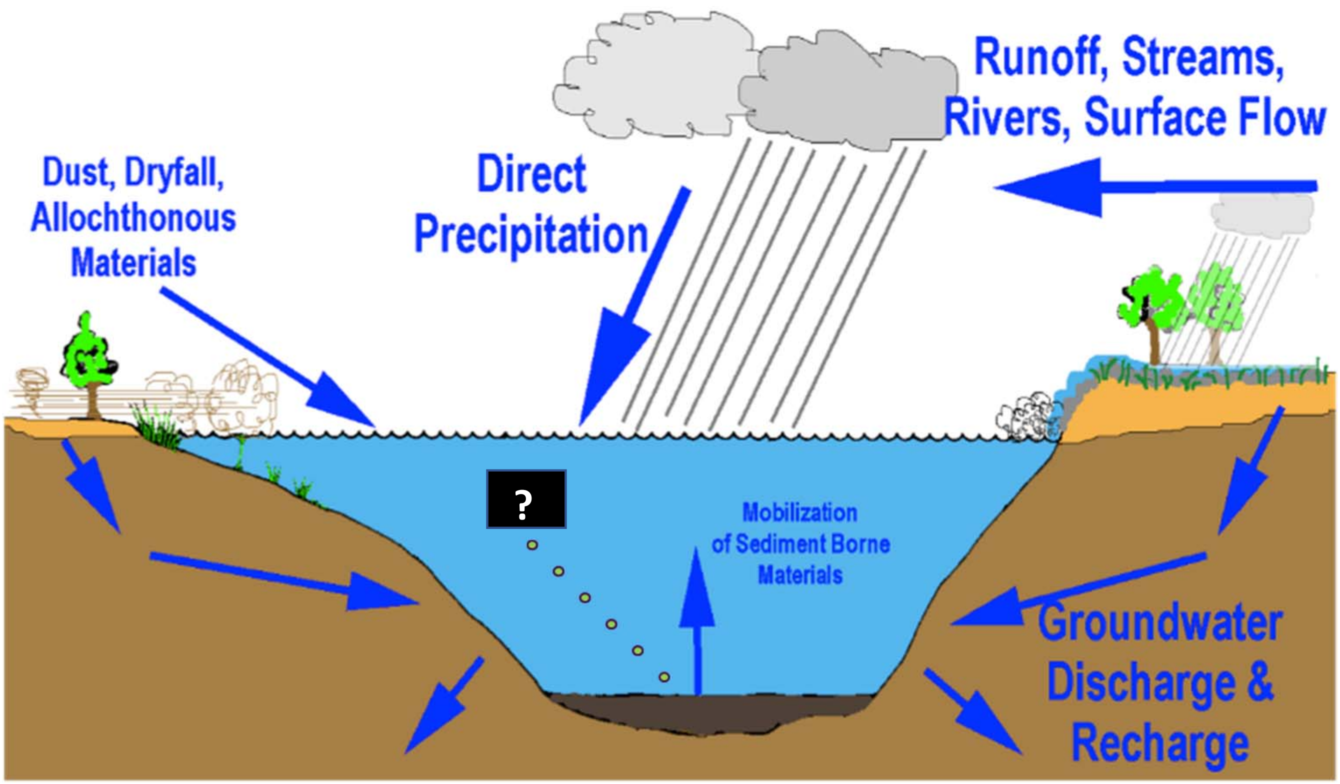
Water Quality Degradation – Sediment Quality

- Internal nutrient release from sediment = **FLUX**
- Flux rates driven by concentration gradient
    - Transfer of dissolved nutrients from sediment (high concentration) to water column (low concentration)



The Problem

- Inputs from various external sources
- Basis for organic sediment deposition and accumulation = **<u>LEGACY</u>**

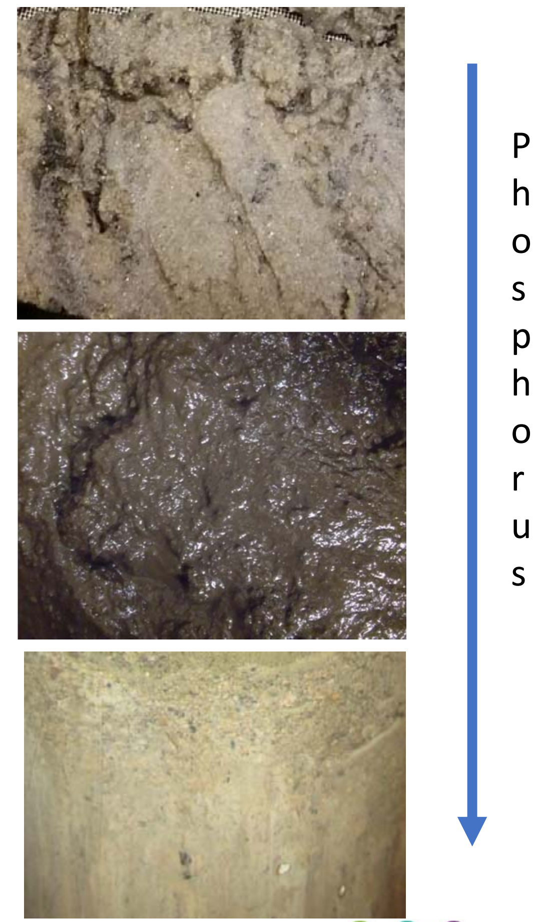


The Problem

- Sustains biologically available nutrient load
- Main cause for internal cycling and algal proliferation
- Not always considered or accounted for in nutrient budgets

Sediment Nutrient Flux

- Diffusive nutrient release from sediment to water column
- Legacy organic accumulation
- Recent and ongoing inputs
- High potential for biologically available nutrients
- Occurs in high muck/nutrient enriched sediment
- Controlled by environmental conditions



Sediment Nutrient Flux

Modeled

- Regionally-specific predictive models developed by Wood to predict pre and post dredging net flux rates and loads

Measured

- Wood Flux Field and Lab SOP (approved by FDEP) to measure site-specific flux and internal nutrient loads
- Assess various treatment alternatives

Assessing Sediment Treatment Alternatives

- Evaluate effectiveness of various treatment alternatives
  - Physical or chemical cap
  - Reduction of flux rate
- Conduct cost-efficiency analysis for treatment alternatives

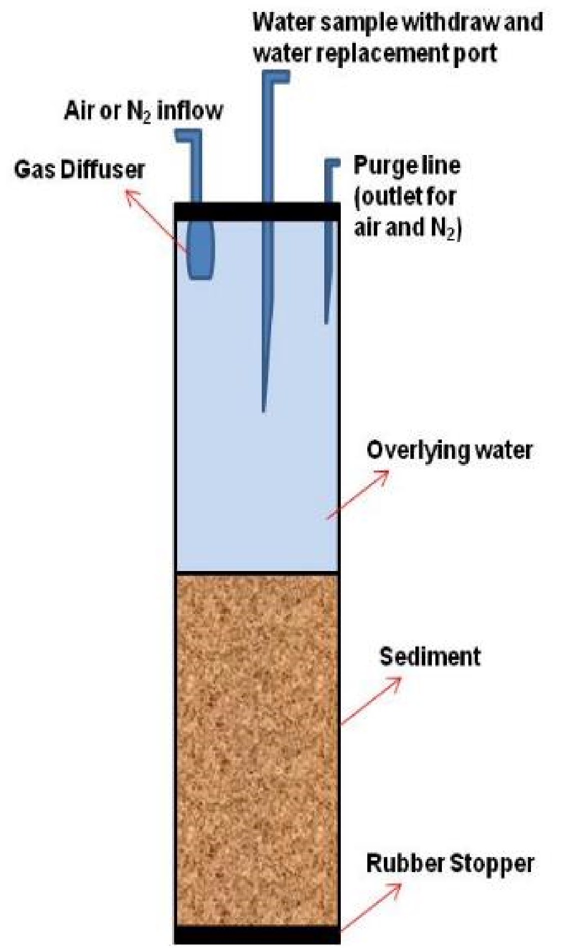
Methods

- Field Collection
  - *In-situ* water quality profile
  - Muck thickness
  - Intact sediment cores
- Laboratory Analyses
  - Pre-screen: sediment physical and chemical content
  - P Fractionation (Sequential extractions) BAP
  - Intact sediment core flux lab incubations

Methods

<u>Considerations for Flux Setup</u>

- Depth of water and sediment profiles
- Time for settling and equilibration process after resuspension
- Frequency and timing of data points
- Length of incubation
- Aerobic, anoxic, quiescent and/or turbulent conditions
- Temperature control
- Sand content

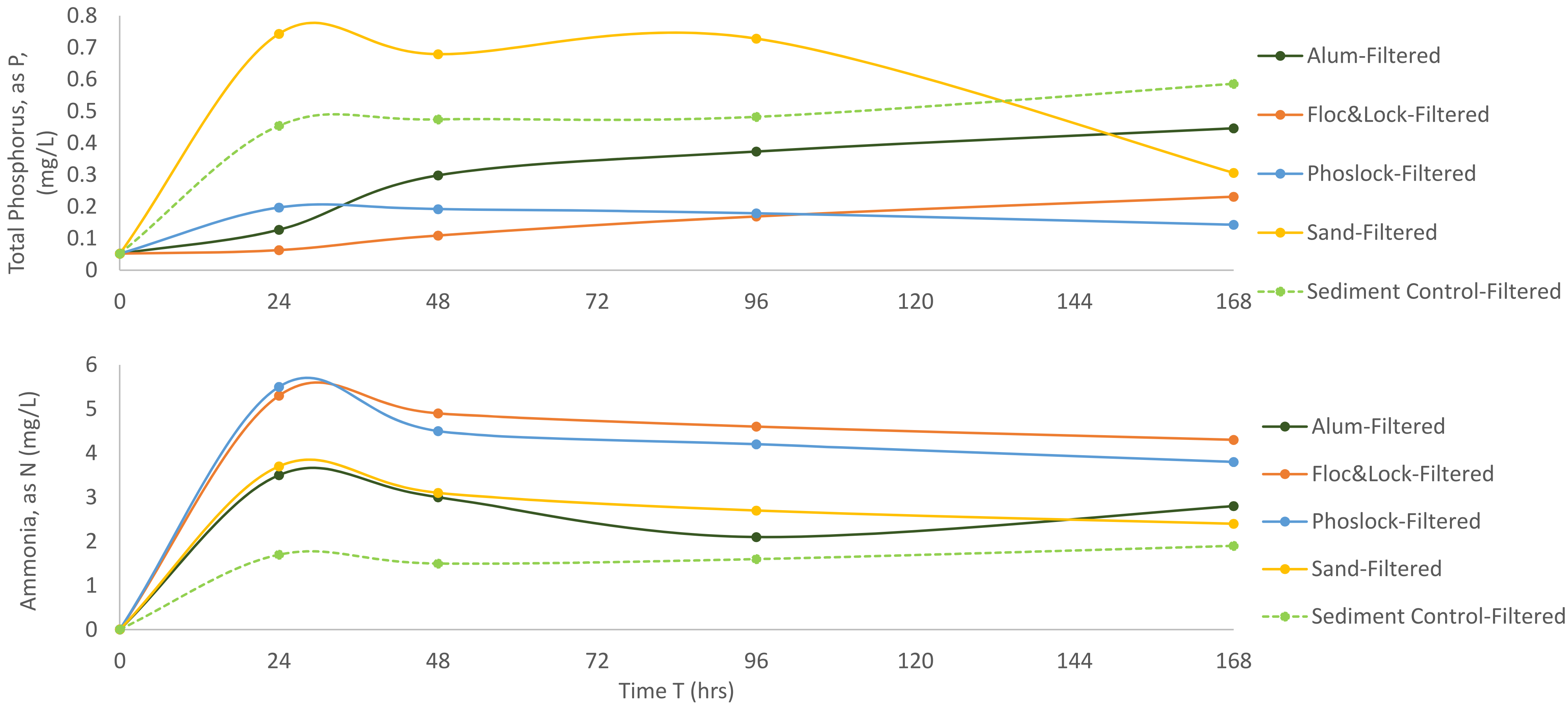


Methods

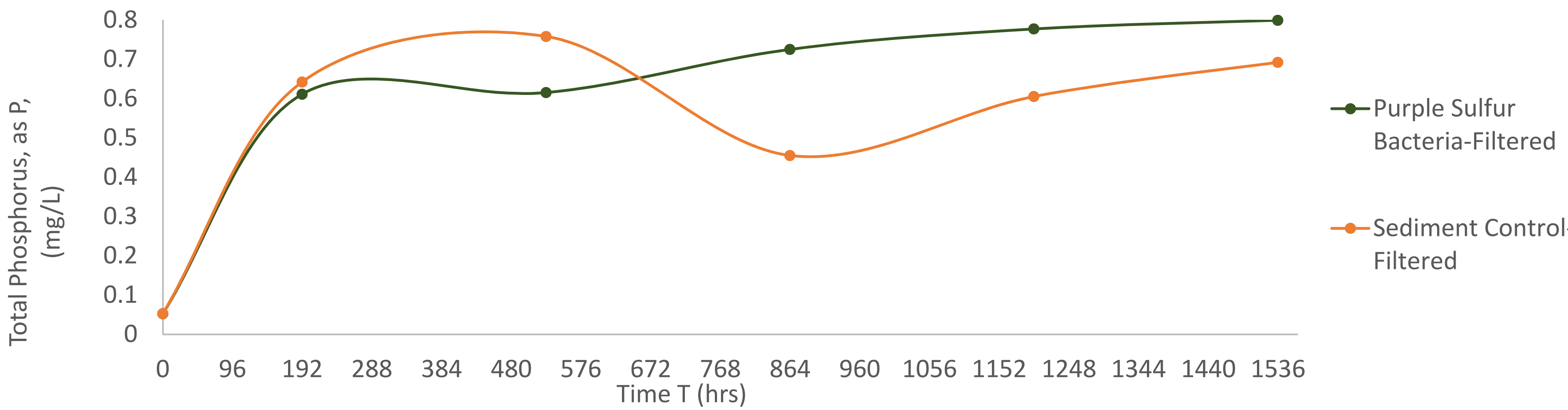
Sediment capping/treatment alternatives

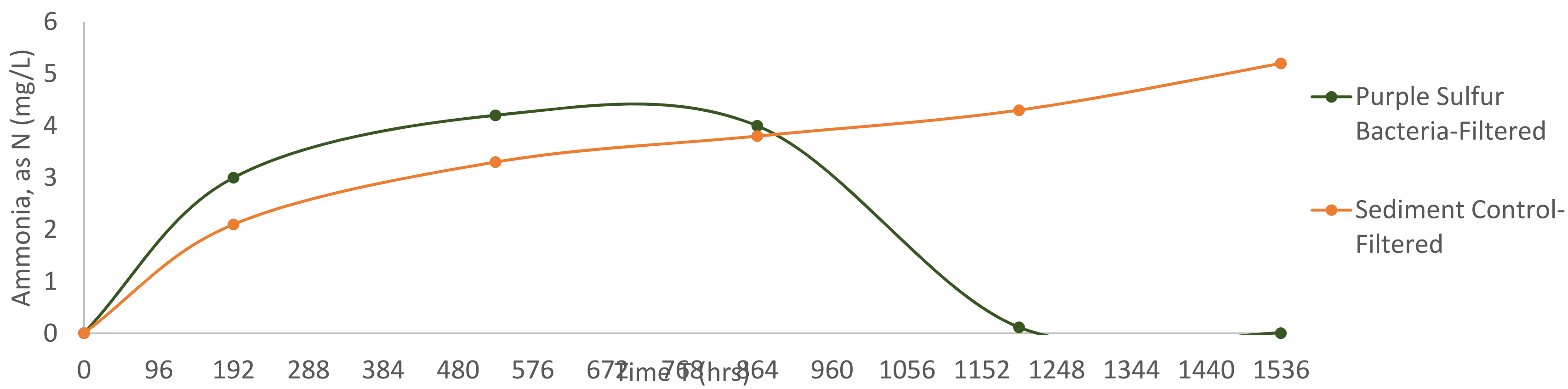
- Phoslock® Full Strength Dose
- Alum Full Strength Dose
- "Floc&Lock" (Phoslock® and Alum)
- Clean sand
- Purple Sulfur Bacteria
- Oxygenation
- Organic soil / muck

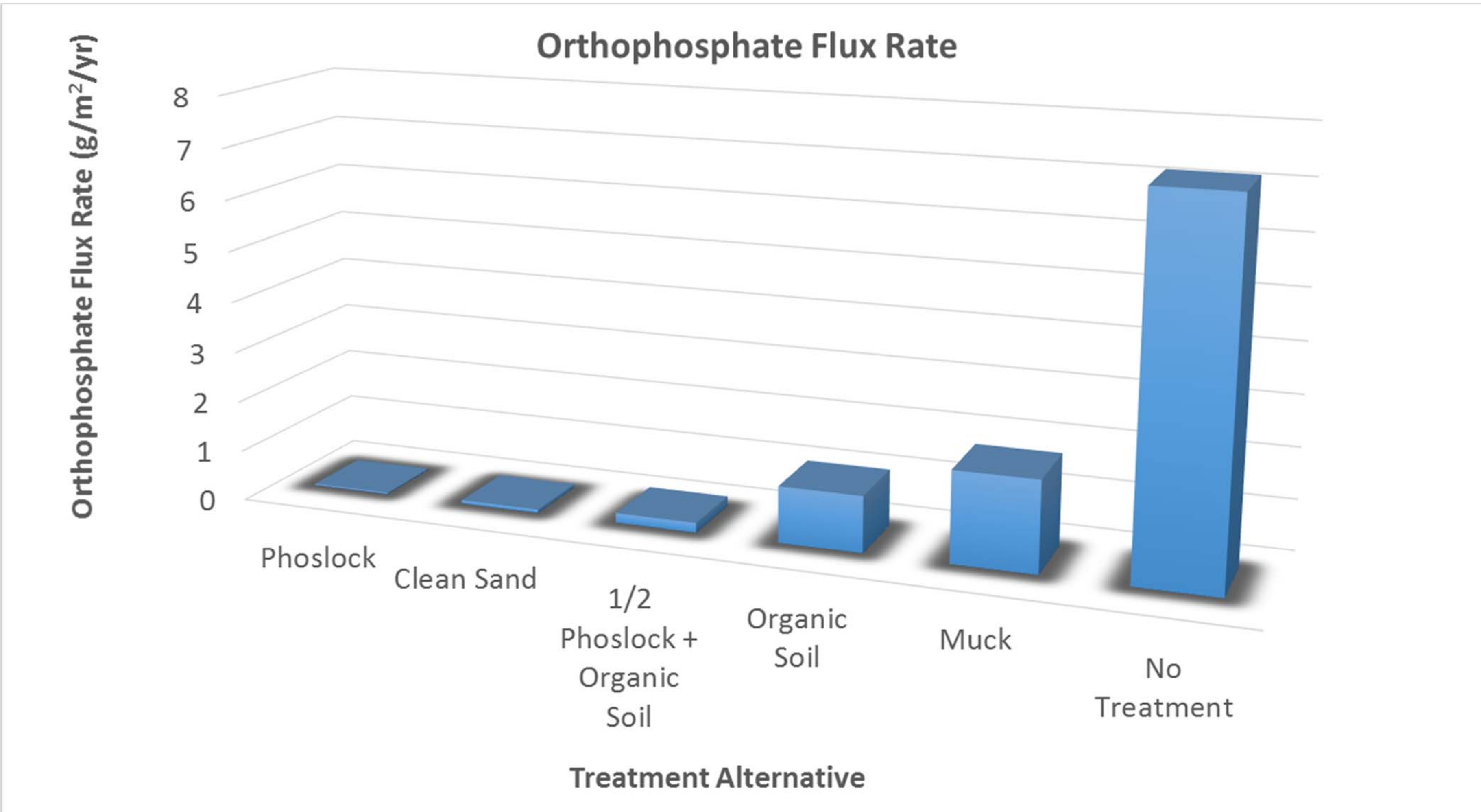
Sediment Flux Results

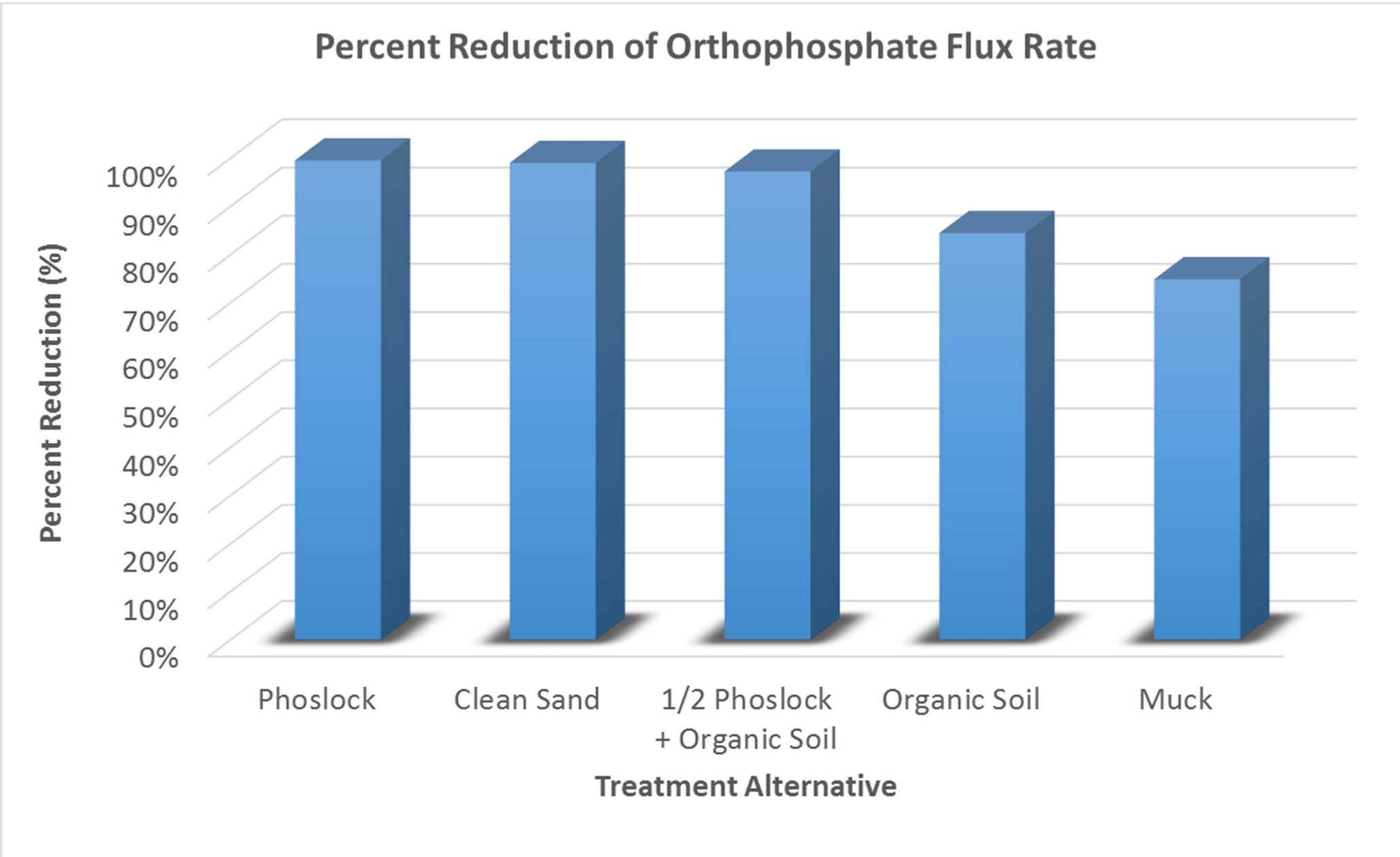


Sediment Flux Results






Orthophosphate Flux Rate
Orthophosphate Flux Rate (g/m2/yr)
8
7
6
5
4
3
2
1
0
Phoslock
Clean Sand
1/2 Phoslock + Organic Soil
Organic Soil
Muck
No Treatment
Treatment Alternative


Percent Reduction of Orthophosphate Flux Rate
Percent Reduction (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Phoslock
Clean Sand
1/2 Phoslock + Organic Soil
Organic Soil
Muck
Treatment Alternative

Flux Rate and Load Calculations

- Use flux rate equation or slope of curve between time and concentration to calculate sediment internal cycling load

$$\mathbf{Flux_{muck} = (Ct - Ci) \times V / A \times delta\ t}$$

- TMDL muck removal project load reduction credit equations

$$\mathbf{Flux_{net} = Flux_{muck} - Flux_{natural}}$$

$$\mathbf{TN\ or\ TP\ Credit = Flux_{net} * total\ area\ dredged}$$

Comparison of Treatment Performance and Cost Efficiency

- Greatest load removal by:
  - Dredging, sand and Phoslock for TP
  - Dredging and sand for TN

Alternative	Estimated Average Performance Efficiency (% Removal)		Estimated Average Load Reduction (lbs/yr)		Estimated Implementation Cost ($)	Estimated Cost/lb TP Removed ($/lb)	Source for Cost Information
	TN	TP	TN	TP			
Sand	35%	59%	1,793.10	1,270.80	$700,346.18	$551.11	Literature derived (Amec Foster Wheeler 2016): $23,345/ac capped, assume 1 ft cap over 30 ac
Phoslock	-63%	86%	-3220.6	1,194.00	$450,000.00	$376.88	Literature derived (Amec Foster Wheeler 2016): $15,000/ac treated, assume 30 ac treated
Floc & Lock	-73%	53%	-3655.8	724.9	$362,450.00	$500.00	Literature derived (Amec Foster Wheeler 2016): $500/lb treated, assume 724.9 lbs TP treated
Alum	11%	44%	548.4	567.2	$180,000.00	$317.35	Literature derived (ERD 2016): $6,000/ac treated, assume 30 ac treated
Dredging	100%	100%	5,031.80	1,378.80	$1,428,000.00	$1,035.68	Based on previous dredging design costs derived for Lake Bonnet Feasibility Study: $42/cy removed for 34,000 cy removed
Oxygenation/ Aeration	15%	15%	754.8	206.8	$45,000.00	$217.58	Provided by aeration vendor: $1200/ac treated, assume 30 ac treated

Comparison of Nutrient Sources

	Estimated Load to Lake		% of Total Load	
Nutrient Source	**TN lbs/yr**	**TP lbs/yr**	**TN**	**TP**
Stormwater Runoff*	843	122.7	14.2%	8.2%
Groundwater Seepage	38.6	3.5	0.7%	0.2%
Sediment Cycling	5,031.8	1,378.8	85.1%	91.6%
Total Load to Lake	**5,913.4**	**1,505**		

Benefits of Site-specific Internal Loads

- Most models have not accounted for internal cycling or have underestimated loads and allocations
  - Nutrient budget models limited by sources readily measured (runoff)
  - Internal loads = net balance of sum of external loads
  - Internal loads not measured directly
- Can use to refine budgets to account for internal cycling
- Use to tailor sediment management design plans with treatment alternatives analysis results
  - Dredge areas that can’t be capped, and cap areas that don’t <u>need</u> to be dredged
- Use to request nutrient removal credits based on nutrient flux rates/loads

Summary

- External legacy and recent nutrient inputs lead to internal loads
- Sediments have capacity to serve as long-term source of nutrients, fueling algal growth and helping to maintain eutrophic conditions
- Internal sediment cycling is often major contributor of total nutrient loads
- Treatment alternatives analysis can provide informative results prior to making $$$ management decisions that do not address the major sources

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