Systematic Large-Scale Restoration of Organic Muck-Impaired Waterways

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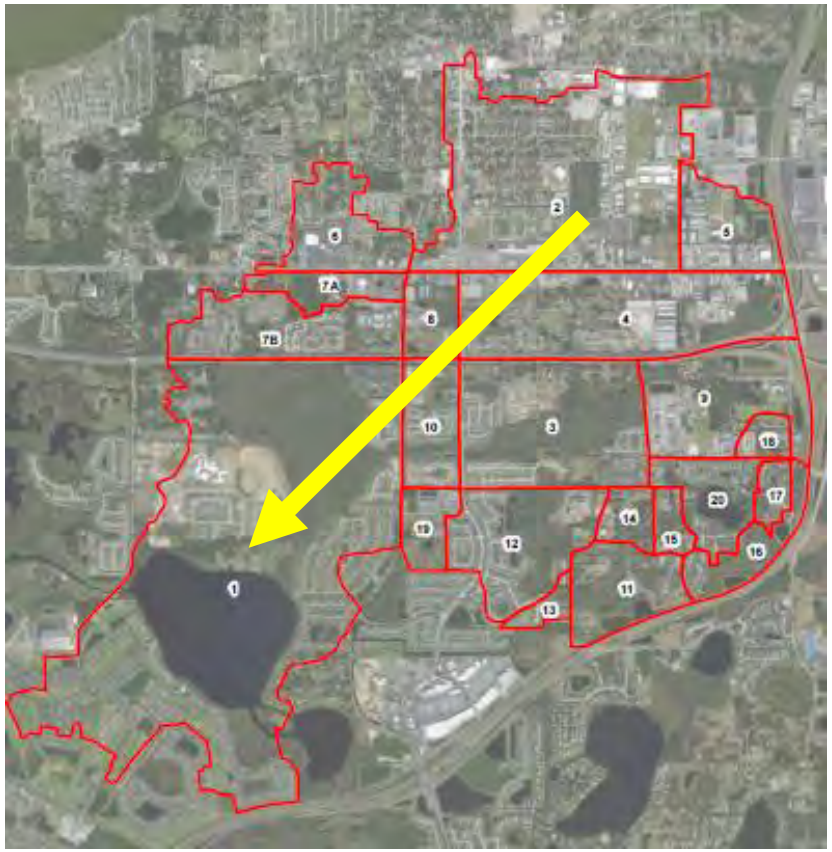
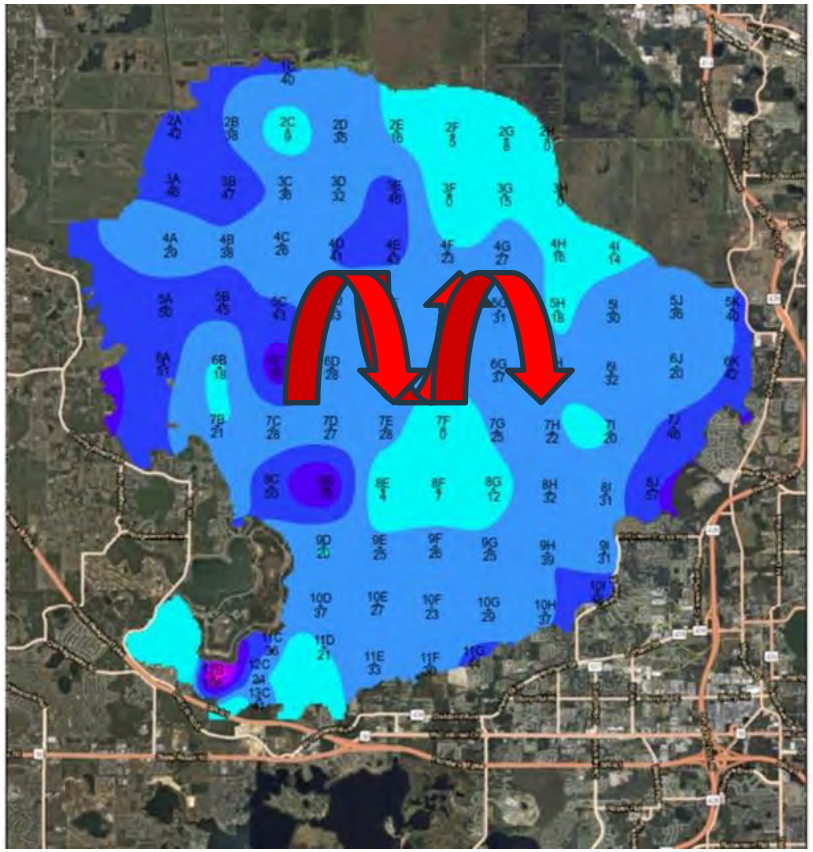
External versus Internal Pollutant Loading

External

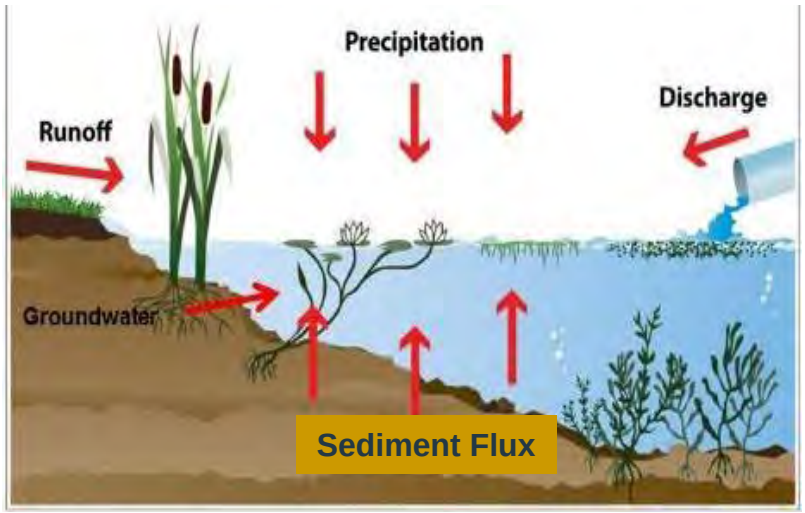


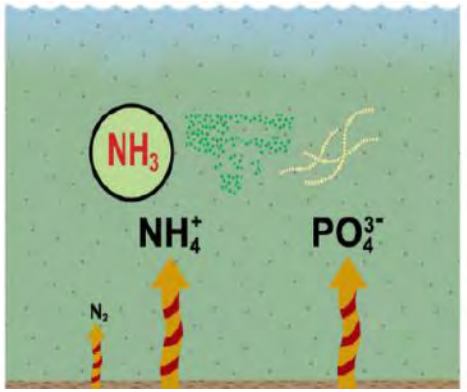
Internal



Differences in Pollutant Loading

- External
  - Basin delineations
  - Soil types
  - Land uses
  - Runoff models
  - Site specific EMCs
  - Flow measurements

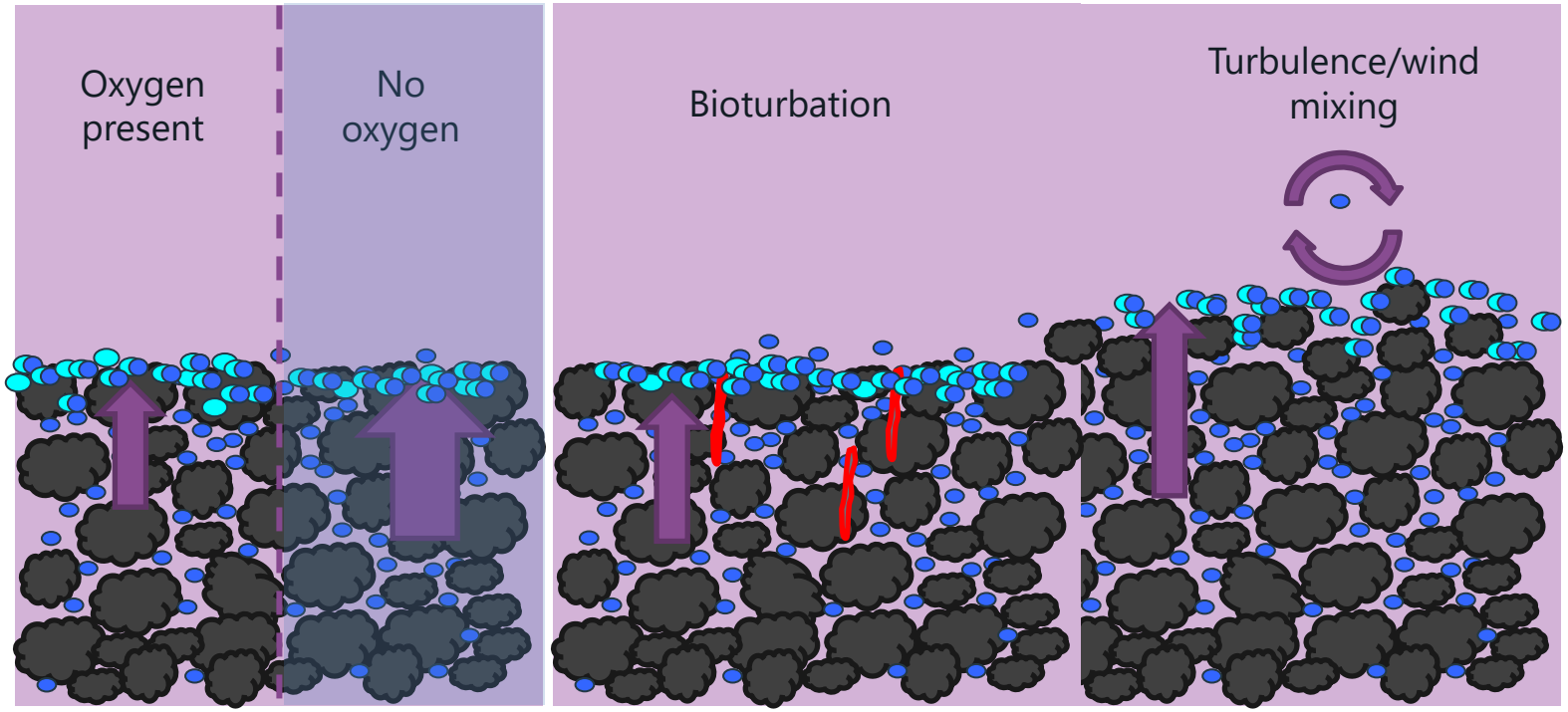




- Internal
  - Legacy load
  - Organic accumulation (muck)
  - Sediment flux
  - Biological availability
  - Physical sediment characterization
  - Redox / dissolved oxygen profiles
  - Water quality response (turbidity, chlorophyll-a, etc.)

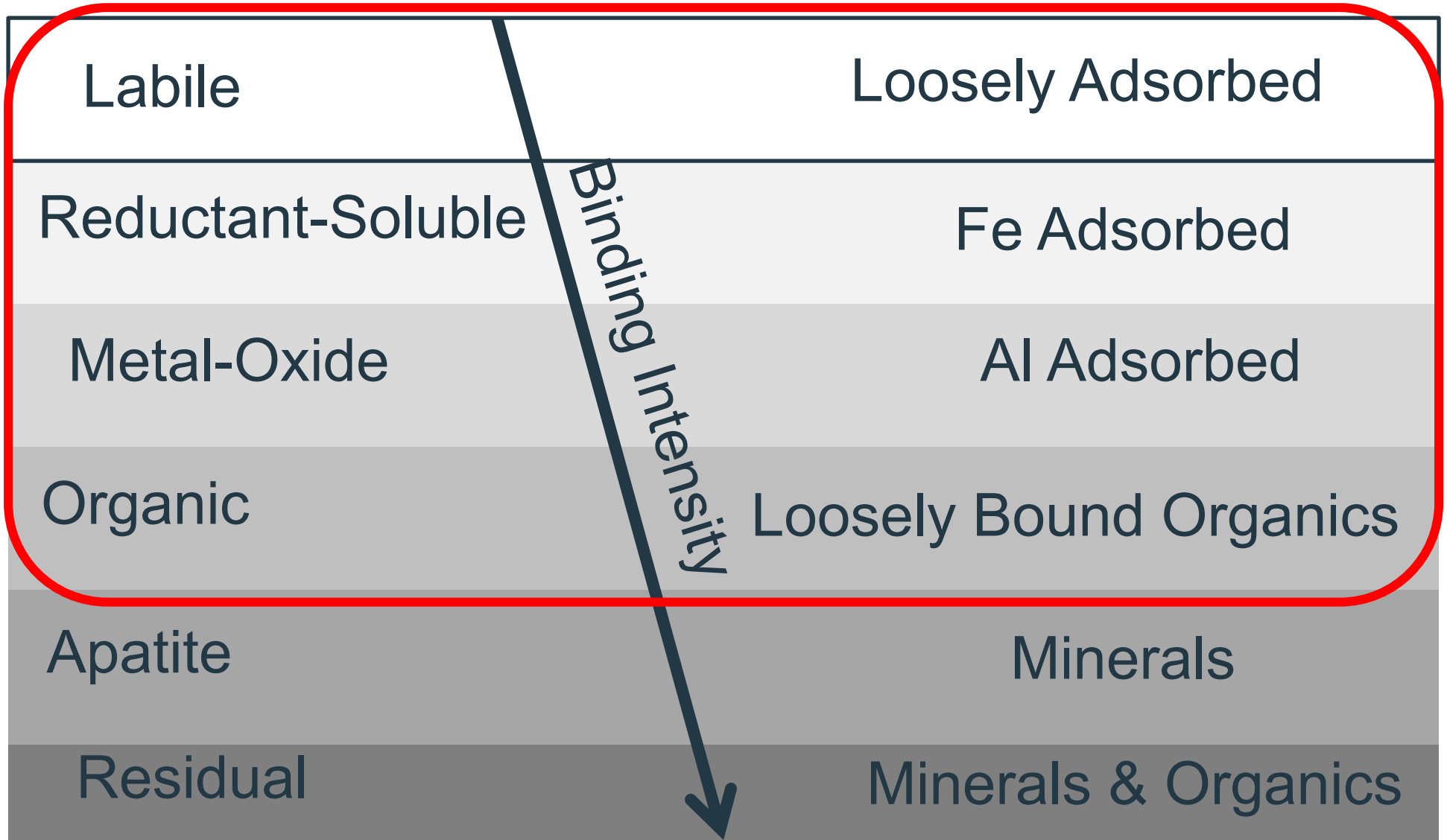
Sediment as a Driver

- Provides substrate for habitat or transports up and out
- Can be a source or sink for pollutants
  - Lability, storage capacity and saturation level
  - Internal cycling rates dependent on conditions
- **Drives water quality that can lead to impairments**



Sediment Phosphorus Fractionation

Nuisance algae may be better able to access internal accumulation



How and When to Pursue a Sediment-Focused Waterbody Management Project

- Waterbody or alternatives analysis studies indicate that sediment cycling generates a significant portion of the pollutant loading
- Untreated stormwater inputs are limited or being addressed
- Upstream sediment transport is limited or has been addressed
- Permitting is feasible
- Funding source has been identified

Sediment Management Plan Formulation

Alternative Development and Analysis

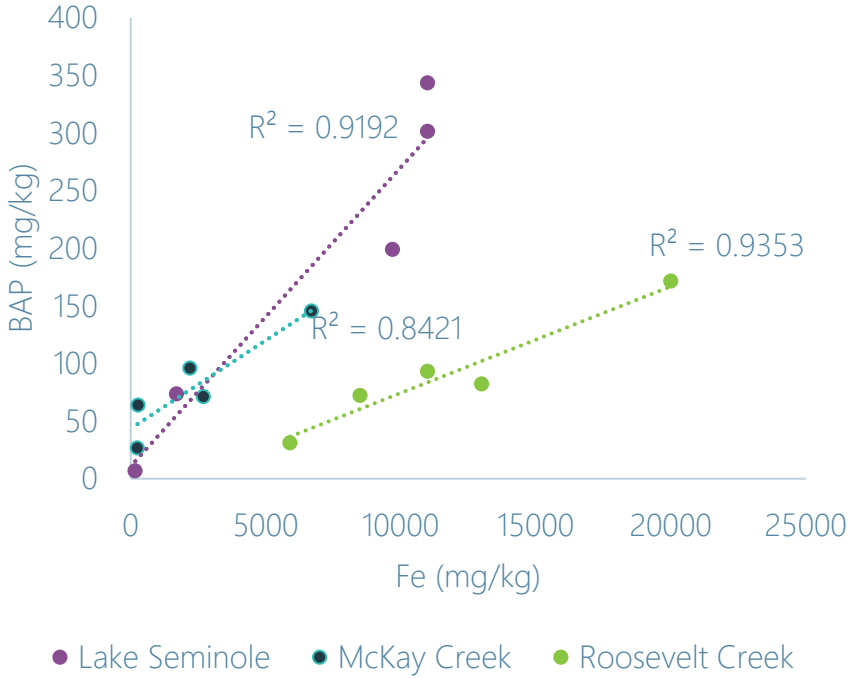
Sediments and Load Reduction Credits

- Water quality credits from managing internal sources
  - **Issue**: most models have not accounted for internal cycling or underestimated in nutrient budgets
  - **Solution**: Measure nutrient sediment flux to estimate load contributions
    - Site-specific is ideal
  - Means of obtaining load reduction credit
    - Sediment removal
    - Sediment inactivation

Estimating Sediment Nutrient Flux and Loads

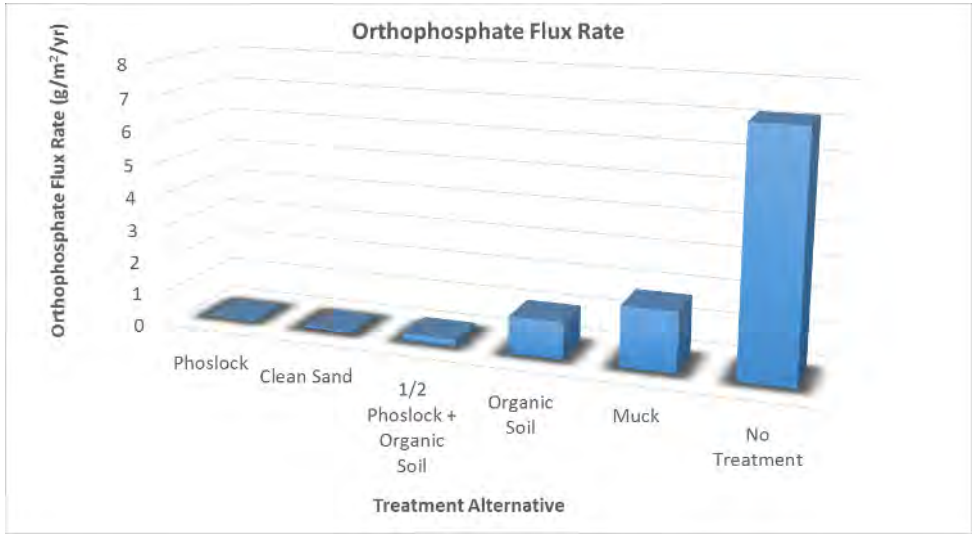
Modeled

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



Measured

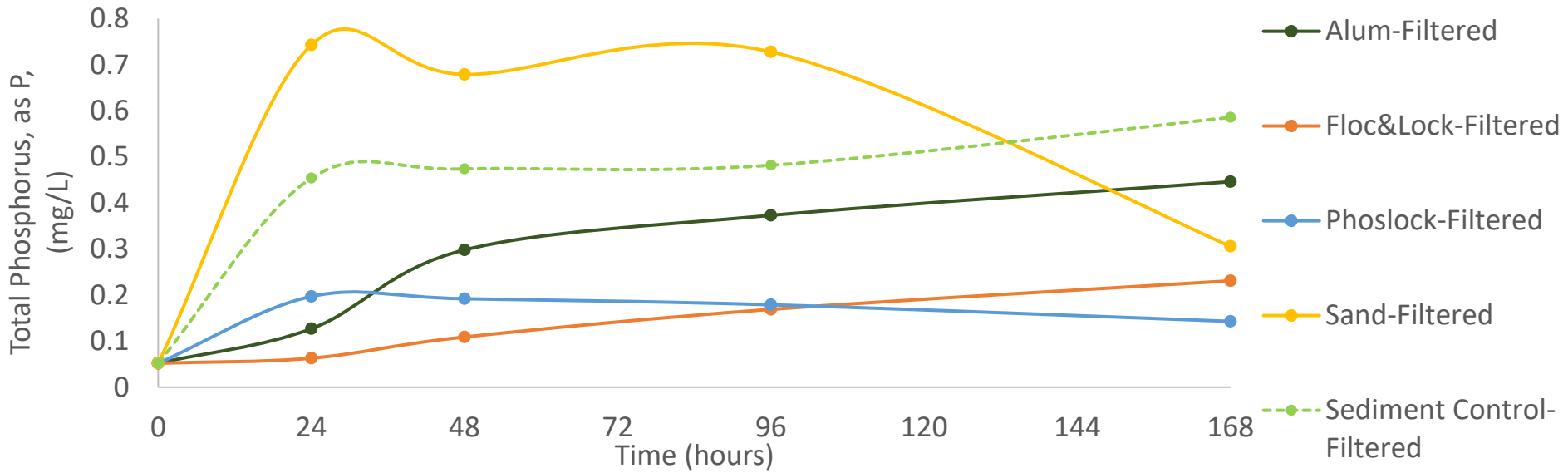
- Wood Flux Field and Lab SOP (accepted by FDEP) to measure site-specific flux and internal nutrient loads
- Assess various treatment alternatives

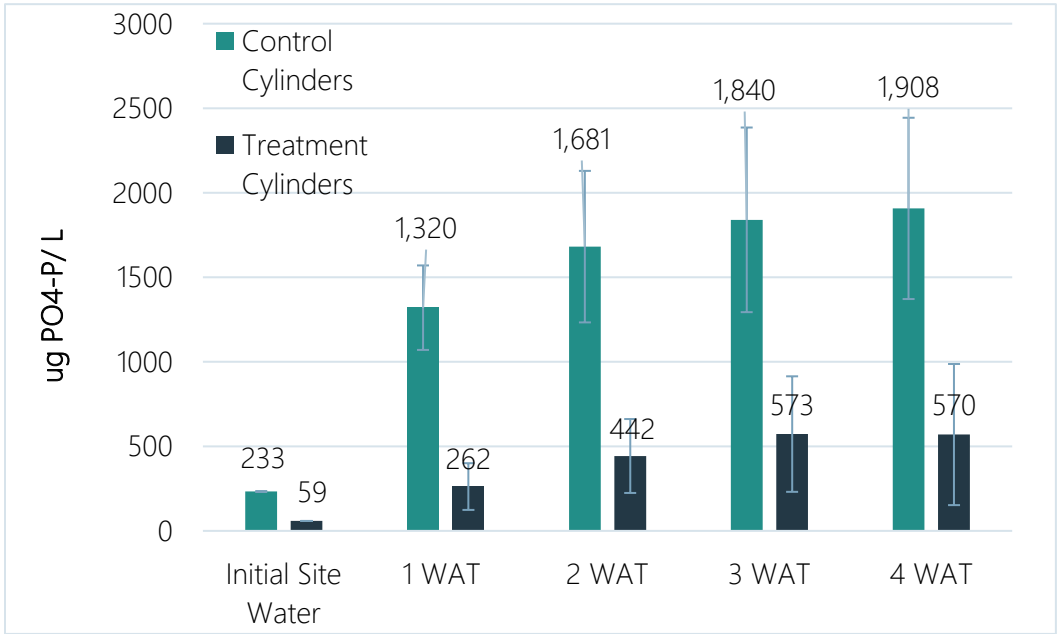


Sediment Restoration Alternatives

- Sediment removal / dredging
  - Mechanical
  - Hydraulic
  - Sump
  - Water injection
- Sediment capping / cover
  - Physical – sand and/or rock (backfill)
  - Chemical treatment alternatives
    - Phoslock®
    - Alum
    - "Floc&Lock" (Phoslock® and Alum)
    - Biological (e.g. Purple Sulfur Bacteria)
    - Oxygenation
    - Organic soil / muck
    - Others TBD

Treatment Alternatives Analysis





Treatment alternatives analysis can provide informative results prior to making $$$ management and restoration decisions

Planning a Sediment Removal Project

Approach to Sediment Management

No Action
- Natural Attenuation

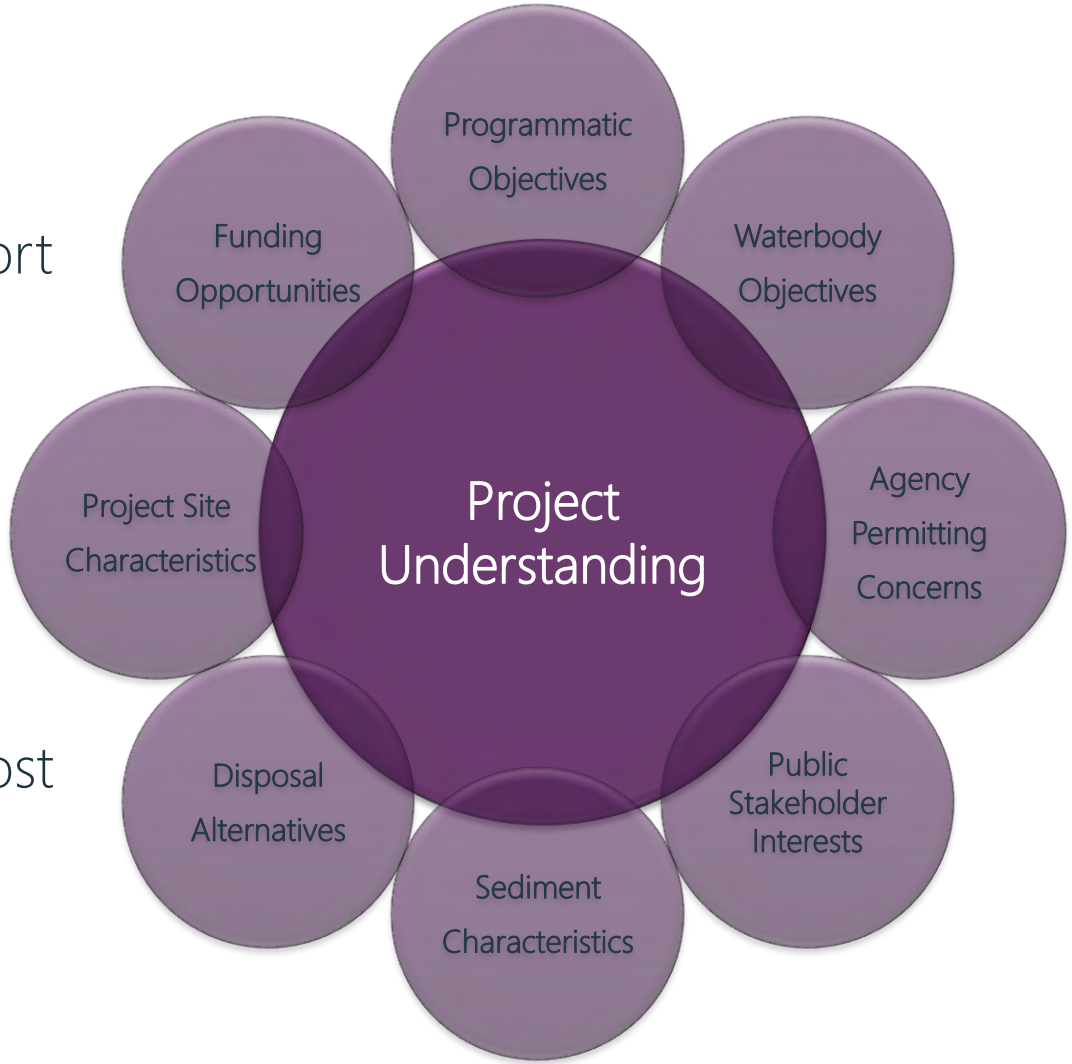
Cap/Inactivate
- Sand
- Mats
- Alum
- Phoslock®
- Others

Dredge/Dewater
- Mechanical
- Hydraulic

DMMAs
Geotextile tubes
Subaqueous
Wastewater plant
Islands
Relocation

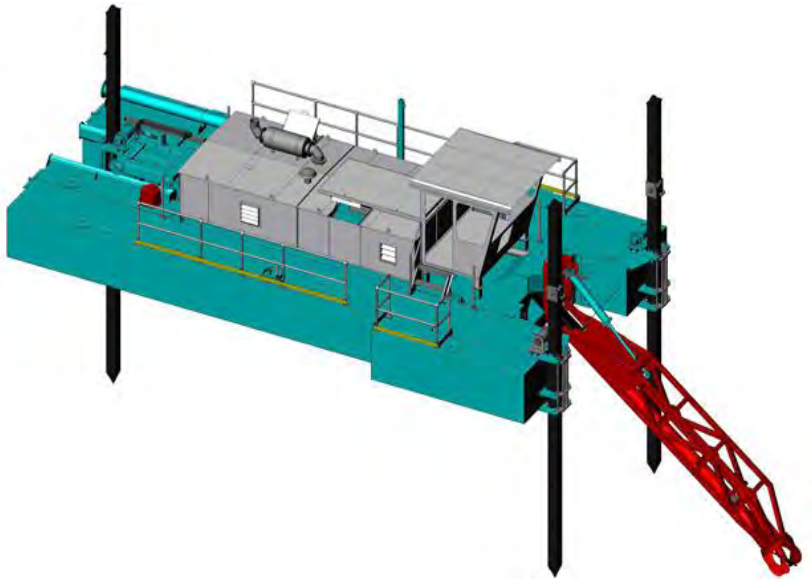
Environmental Muck Dredging's Unique Challenges

- Permitting/Disposal Constraints
- Data Collection
- Stakeholder/Public Support
- Planning & Design
- Dredging, Dewatering, & Disposal Design
- Sediment & Water Quality Issues
- Available Budget
  - Minimize Dredging Cost
  - Maximizing Environmental Restoration Benefit

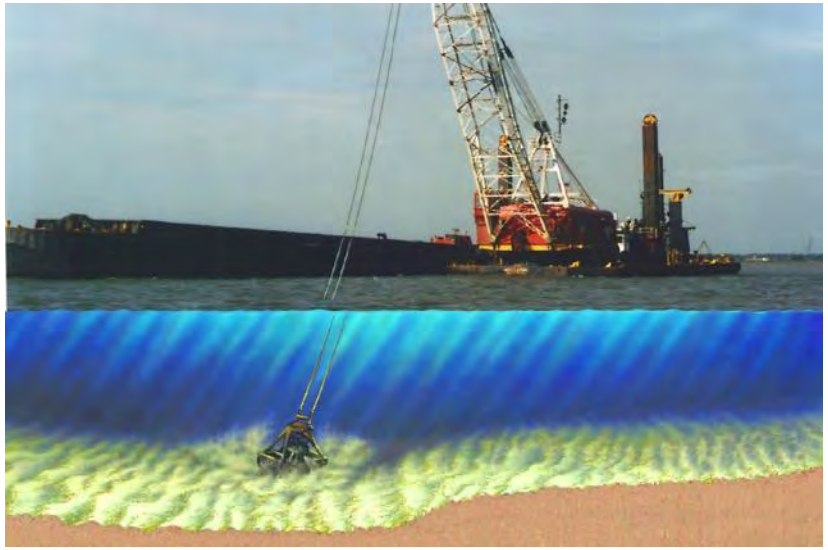


Common Dredge Types

Hydraulic



Mechanical



Rotating Auger Cutter Head

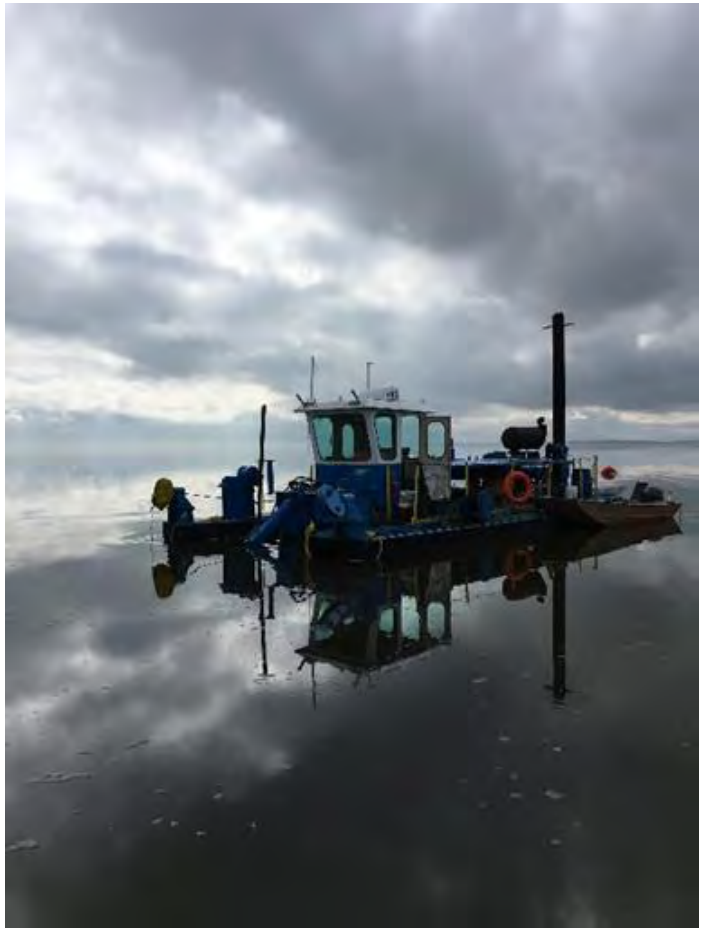
Vacuum Suction Head Only

Planning a Dredge Project

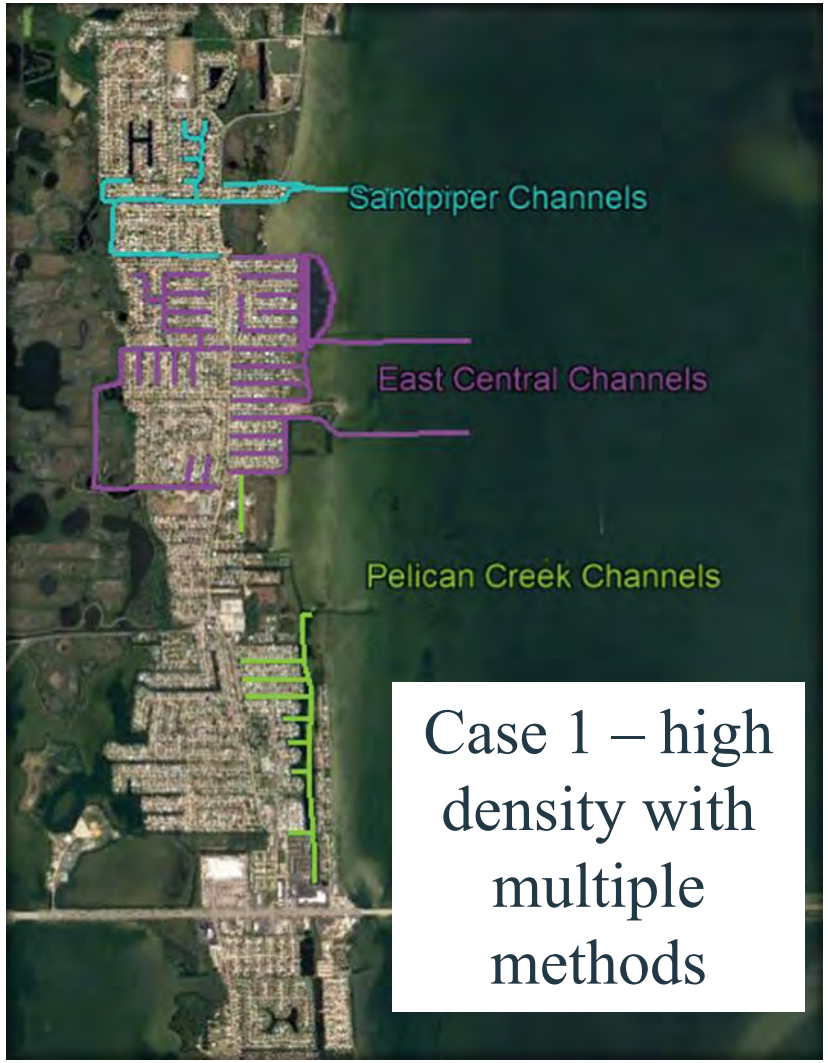
Sediment characteristics (physical and chemical) define boundaries of reasonable end use.

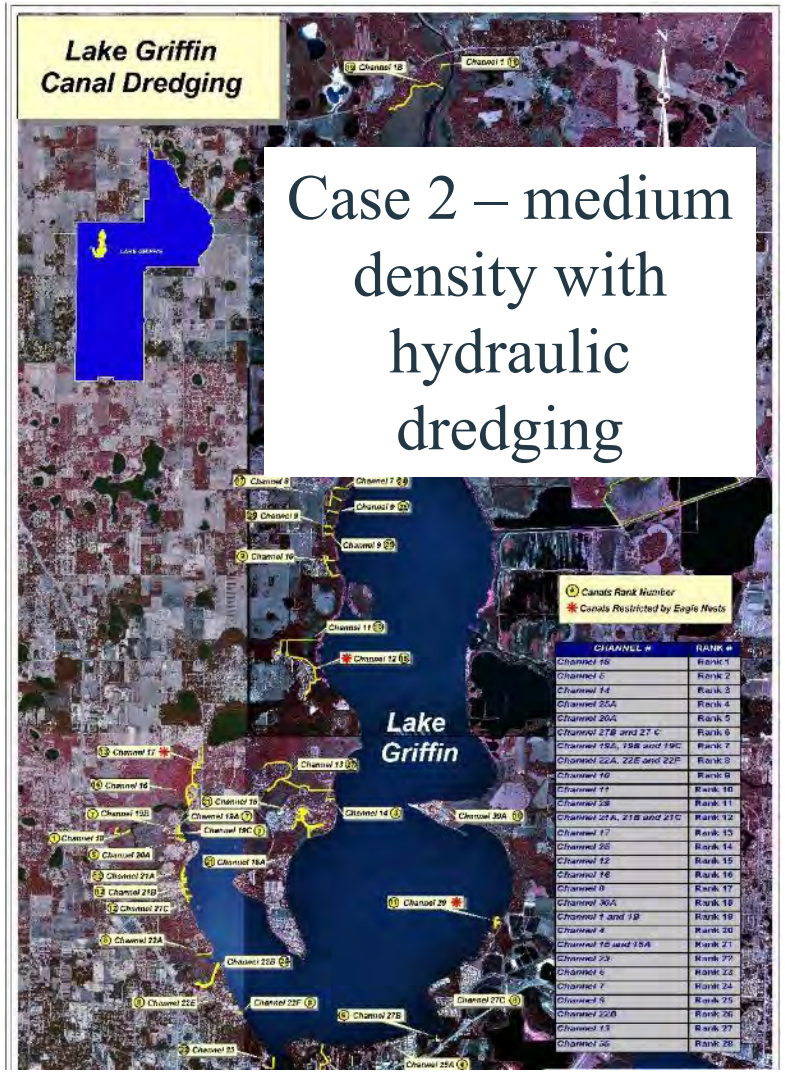
The End (placement, beneficial reuse) defines the means & methods for land-based needs, transport, & dredging method (hydraulic, mechanical).

The End Drives Cost!

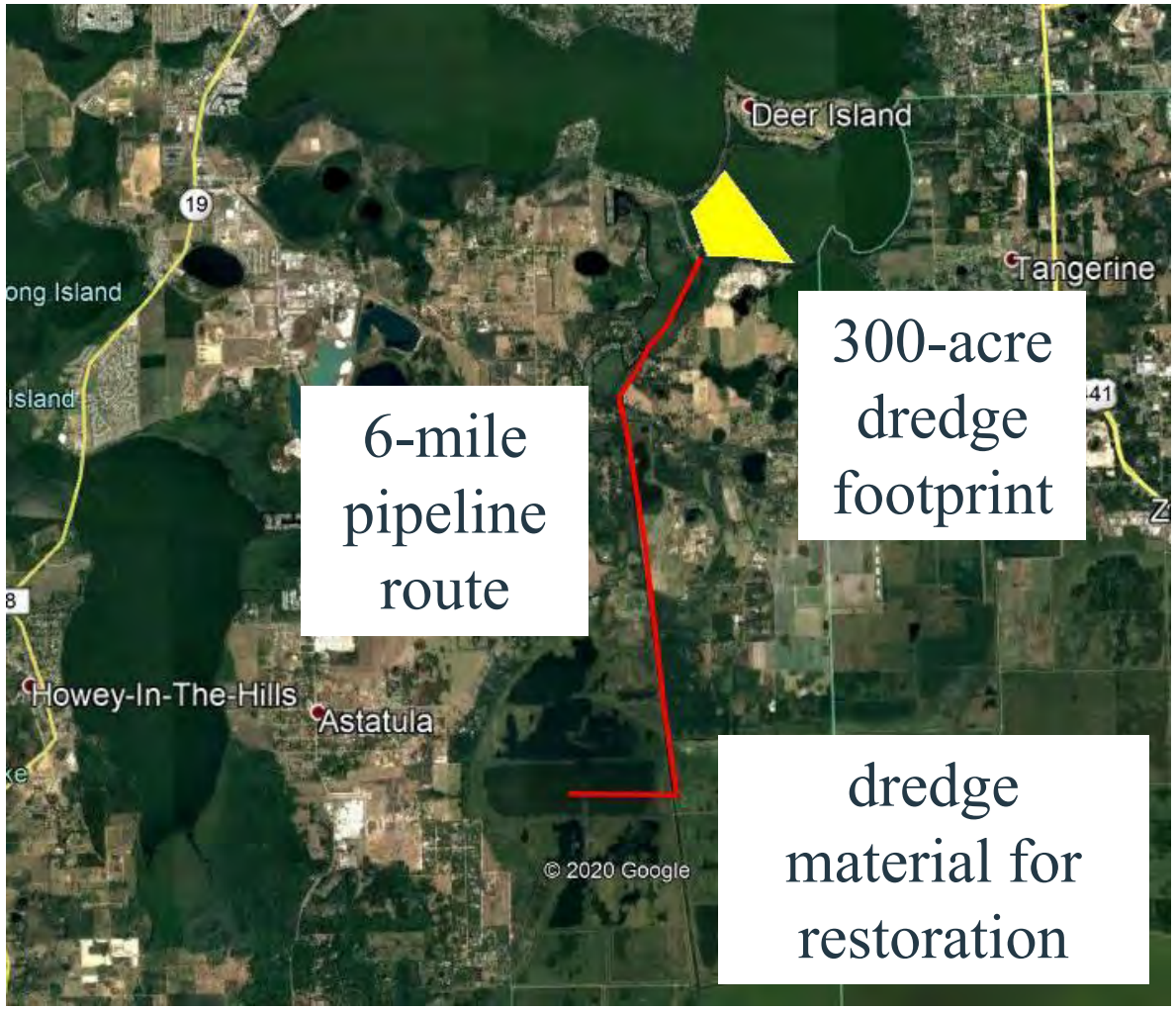


Two Canal Dredge Projects – Very Different Methods

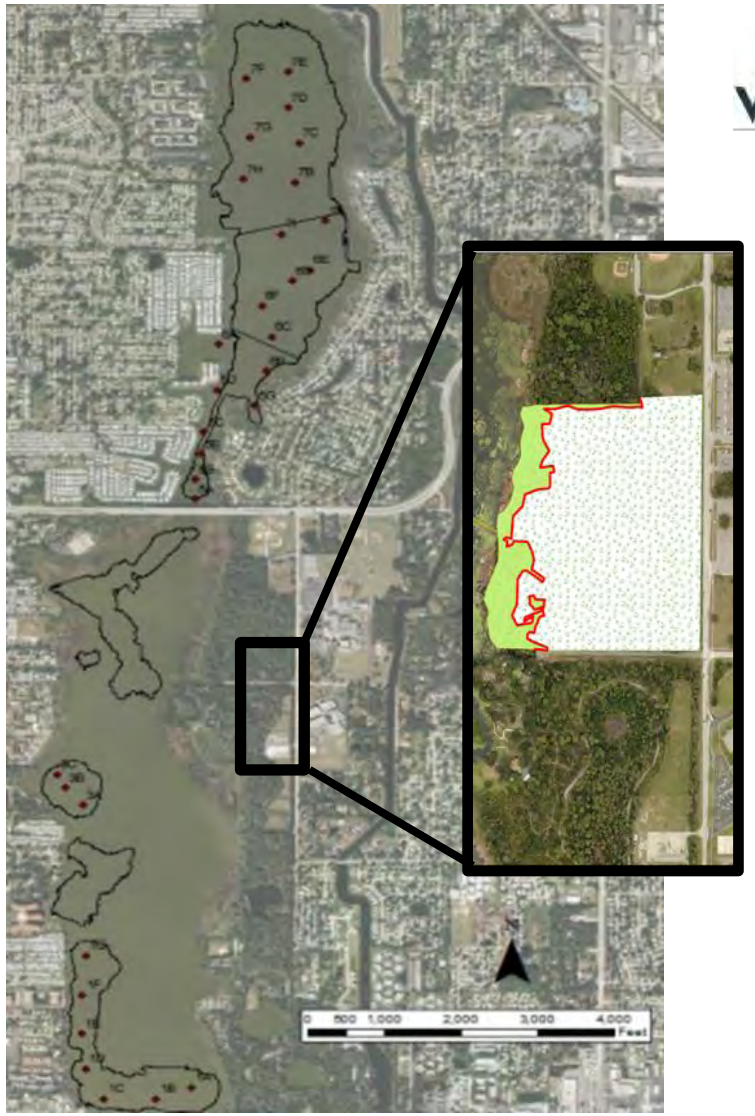




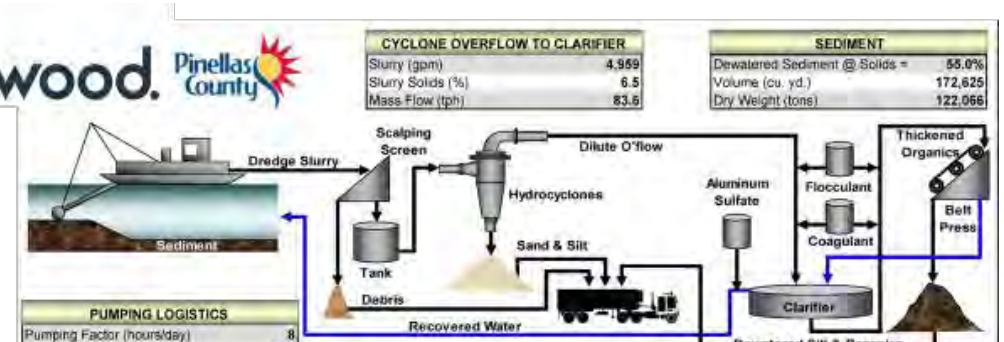
Case 3: Hydraulic Dredging Provides Efficiency



Case 4 – Economic Hydraulic Dredging to DMMA



wood. Pinellas County



CYCLONE OVERFLOW TO CLARIFIER	
Slurry (gpm)	4,959
Slurry Solids (%)	6.5
Mass Flow (tph)	83.6

SEDIMENT	
Dewatered Sediment @ Solids =	55.0%
Volume (cu. yd.)	172,625
Dry Weight (tons)	122,066

PUMPING LOGISTICS	
Pumping Factor (hours/day)	8
Dredging Rate (acres/day)	1.27
Dredging Duration (days)	174
Slurry (gpm)	5,000
Slurry Solids (%)	7.5
Tons/Hour (dry)	98
Yards/Day (in situ)	5,770

CYCLONE UNDERFLOW	
Slurry (gpm)	41
Slurry Solids (%)	75.0
Mass Flow (tph)	14.4
Volume (cu. yd.)	17,594
Dry Weight (tons)	20,994

CLARIFIER OVERFLOW WATER	
Return Water (gpm)	4,216

AVERAGE SEDIMENT	
Sediment Removal (cu. yd.)	1,000,000
Sediment Thickness (ft.)	2.82
In Situ Solids (% weight)	15.0
Average Specific Gravity	2.20
Dry Bulk Density (lbs./cu.ft.)	10.2
Dry Weight (tons)	137,620

Distribution	+200	Clay/Silt	Organics
(%)	12.5	60.0	27.5
(Tons)	17,202	82,572	37,845

AVERAGE OVER-CUT	
Bottom Removal (cu. yd.)	3,549
Bottom Thickness (ft.)	0.01
In Situ Solids (% weight)	85.0
Average Specific Gravity	2.68
Dry Bulk Density (lbs./cu.ft.)	113.5
Dry Weight (tons)	5,440

Distribution	+200	Clay/Silt
(%)	90.0	10.0
(Tons)	4,896	544

TOTAL DREDGED MATERIAL	
Total Area to Dredge (acres)	220.00
Required Removal (cu. yd.)	1,003,549
Total Thickness (ft.)	2.83
In Situ Solids (% weight)	15.5
Average Specific Gravity	2.22
Dry Bulk Density (lbs./cu.ft.)	10.6
Dry Weight (tons)	143,060

Distribution	+200	Clay/Silt	Organics
(%)	15.4	58.1	26.5
(Tons)	22,099	83,116	37,845

No available restoration area so dredge material management area was designed creating public space and saving millions over landfilling

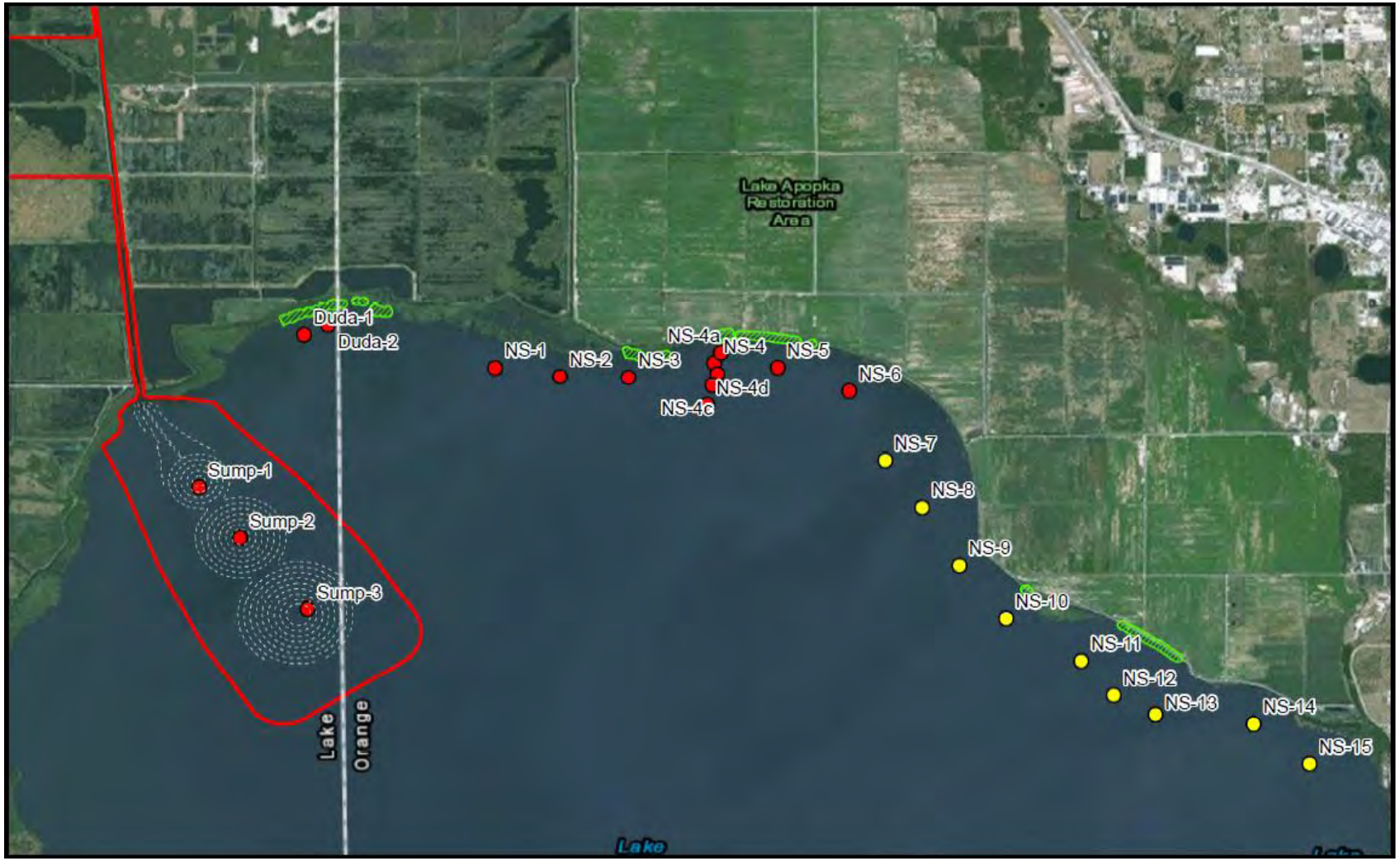
Beneficial Reuse

- Agricultural applications are rarely feasible due to cost and chemistry
- Dredge sediments can sometimes be utilized very effectively to cover former agricultural “hot-spots” and facilitate restoration
- Hydraulically dredged sediments can effectively be pumped many miles away
- DMMAs can be re-purposed after use for creation of public recreation areas
- Geotextile tubes can be used to stabilize shorelines

Strategic Dredging Methodology

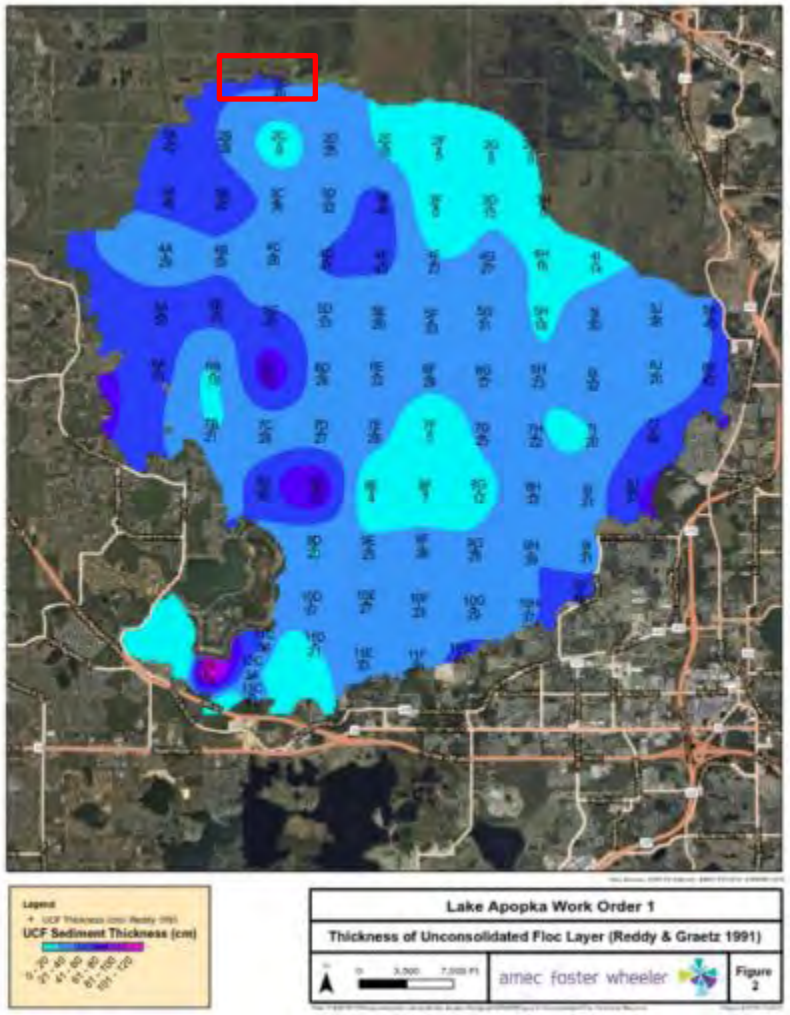
Identify the Sediment Causing the Problem

Sediment Sampling and Characterization



Targeting Unconsolidated Flocculant (UCF) Sediment

- Targeted removal of UCF could address issues including resuspension, disposal, and increased depth as a result of conventional dredging
- Additional technologies include sump (sediment trap) construction, UCF pumping, and thin layer placement (TLP)



Targeted Dredging vs. Sump Pumping

- Dredge operator + support team
- Booster pumps
- Multiple Permits
- Avoidance areas
- Navigational hazards

- Traditional dredging initially
- Automation
- Fixed location
- One permit

Targeted UCF Pumping Challenges and Solutions

Challenges

- Dredges aren’t precision instruments
- Dredges normally operate blind
- Dredgers don’t normally understand why we want to target UCF sediment
- Difficult to tell when the dredge is removing UCF or CF sediment by looking at the discharge

Solutions

- Utilize special suction head design
- Real time TSS feedback to operator
- Operator training
- Core sampling and new methods

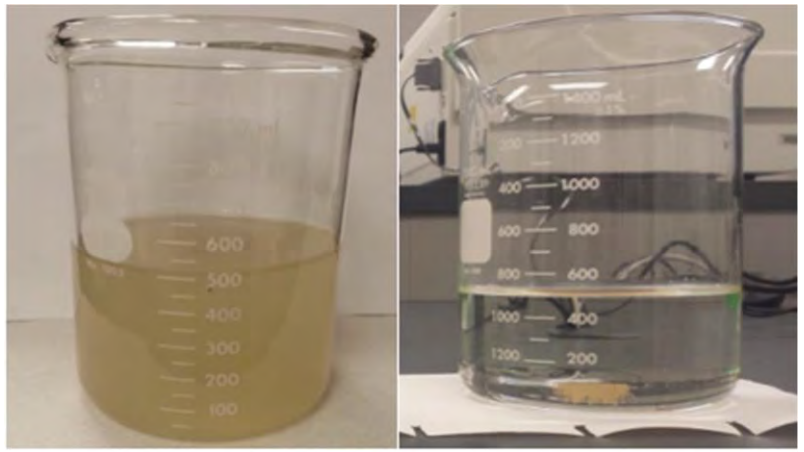
Real Time Turbidity Monitoring

Dredge Effluent Treatment

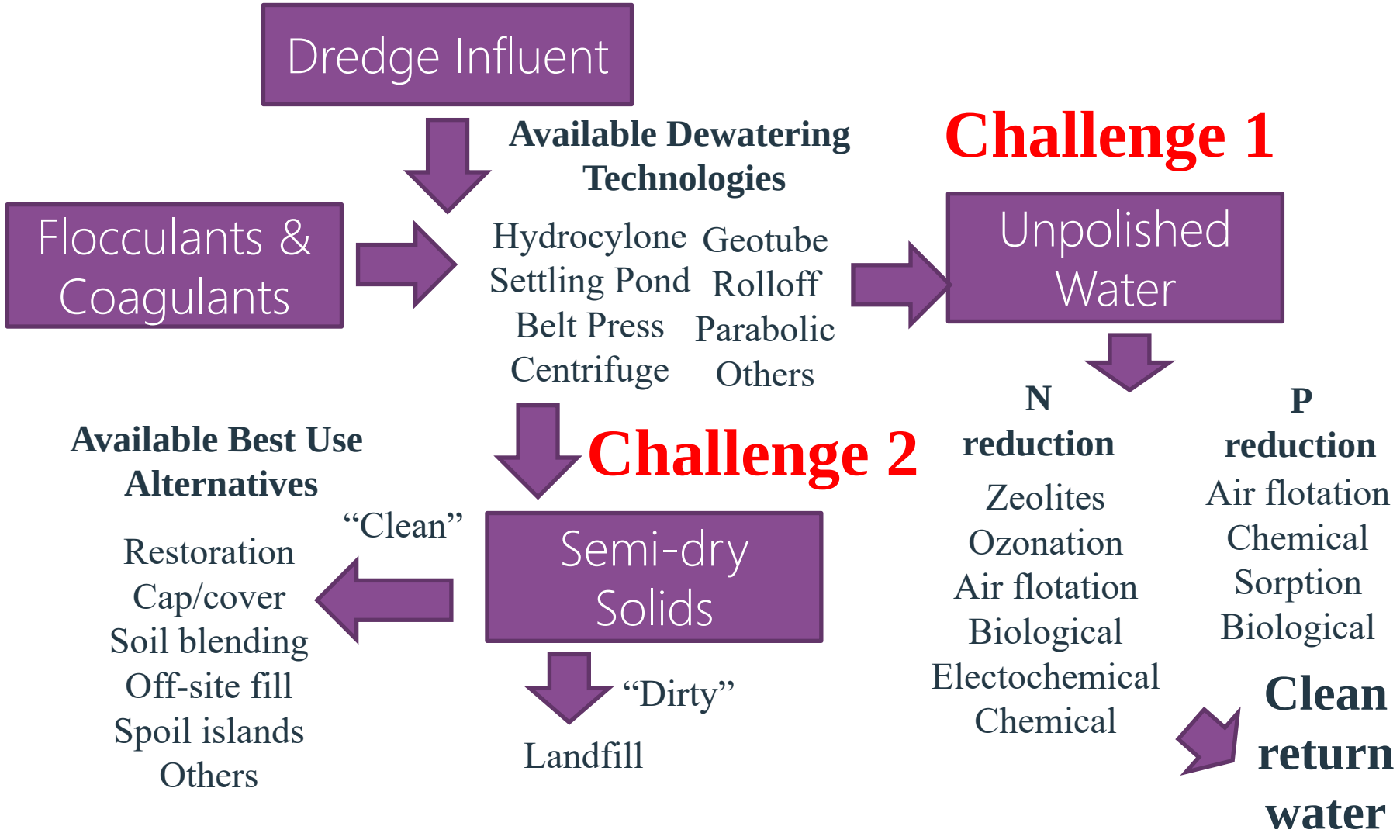
Water Quality in Dredge Effluent

Challenges

- N and P are not often addressed in dredge return water and there are no regulatory limits
- Dissolved nutrients (N and P) are of primary concern because they are highly available to algae
- Dissolved nutrients are the most challenging to remove
- Hydraulic dredge operations increase the amount of water requiring treatment
- Nutrient reduction processes become the limiting factor for the entire operation unless the proper technology and capacity is selected



Dredge Process Stream for IRL Projects



Summary

- Internal loading from organic sediments can be a significant source of water quality impairments
- Understanding and quantifying internal loading is critical
- Sediment capping and chemical inactivation can result in significant load reduction under certain conditions
- Dredging projects can be designed to remove sediments contributing to internal loading sources and often address multiple issues simultaneously
- Strategic dredging can provide considerable savings over traditional “all-or-nothing” dredging
- Nutrient control in return water is an emerging concern particularly in impaired waters

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