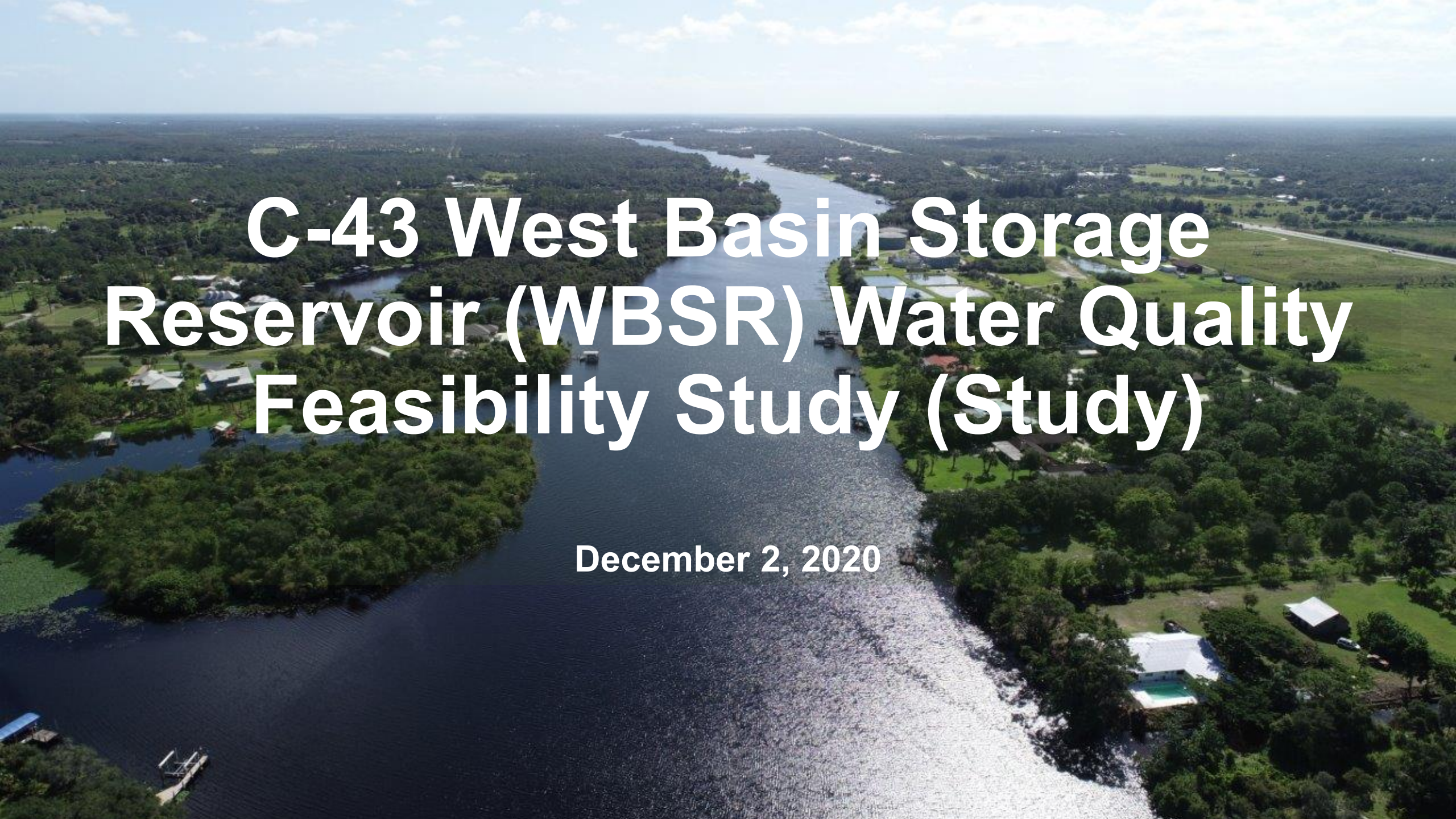


C-43 West Basin Storage Reservoir (WBSR) Water Quality Feasibility Study (Study)

December 2, 2020

Meeting Format

1) Zoom Meeting Functions

   I. Question and Answer (Q&A) – Type in Questions

   II. Raise Your Hand for Comments at end of Q&A session

   Note: If you call in only (not on the internet) press *9 to raise and lower hand and *6 to mute or unmute.

2) Public input using “Menti” Interactive Tool at end of presentation

Meeting Goals

1) Overview of Study Goals and Objectives
2) Update on FINAL Feasibility Study & Recommendations
   - ➢ Criteria Evaluation and Ranking of Technologies
   - ➢ Cost Benefit Analysis
3) WQATT Pilot Study
4) Next Steps
5) Obtain Public Input
   - ➢ Questions and Answers using “Menti” Interactive Tool

Working Group Members

- South Florida Water Management District (SFWMD)
- Florida Department of Environmental Protection (DEP)
- Hendry County
- Lee County
- City of Cape Coral
- City of Sanibel
- Lehigh Acres Municipal Services Improvement District (LAMSID)

C-43 WBSR Consultant Team

- J-Tech – A joint venture between Jacobs Engineering and Tetra Tech, Inc.
- Wetland Solutions, Inc (WSI)

J-Tech
An alliance of Jacobs and Tetra Tech

Wetland Solutions Inc

Project Background

Georgia Vince, J-Tech

Executive Order 19-12, January 10, 2019

- Greater protection of Florida's environment and water quality
- Harmful algal blooms
- Provide additional treatment and improve the quality of water leaving the C-43 WBSR

C-43 WBSR Study Objectives

- Primary Objective: Identify opportunities to provide additional treatment and improve water quality leaving the C-43 Reservoir
- Evaluate treatment options
- The goal of the Study was to identify at a minimum three alternatives

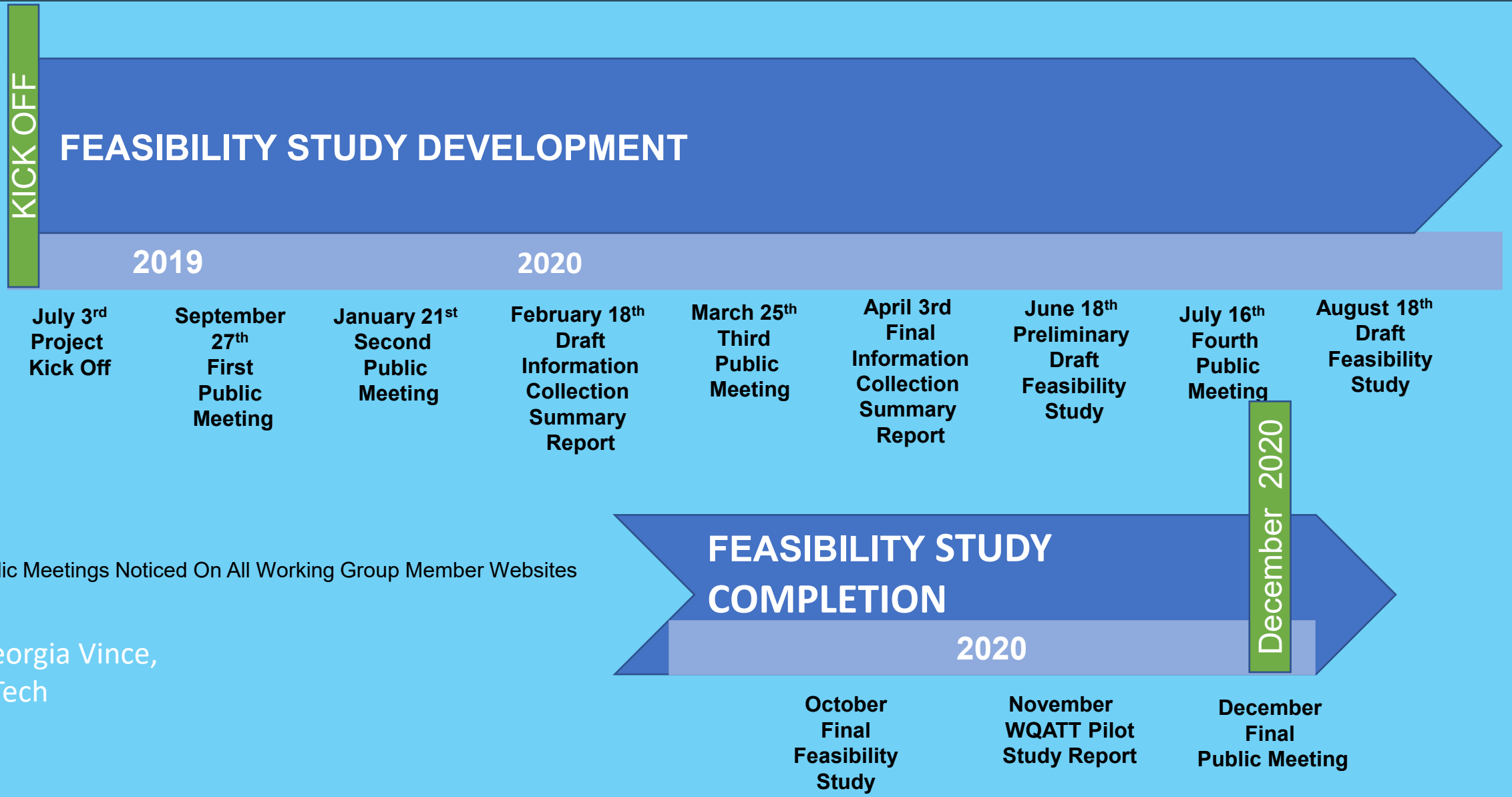
Study Factors Evaluated

- Pre-treatment (prior to entering C-43 WBSR)
- In-reservoir treatment
- Post-storage treatment
- Cost-effective and technically feasible technologies
- Conventional and/or innovative treatment technologies
- Biological, chemical, and physical water quality treatment technologies
- Scalable and “available” for long-term technologies
- Compatibility with the objectives of the C-43 WBSR Project

Study Constraints

- Cannot affect the congressionally approved C-43 WBSR Project purposes, benefits, infrastructure, construction schedule, or operation
- Available project lands have not been specifically identified for the Study
- The C-43 WBSR and the selected treatment component(s) are not intended to achieve compliance with the Caloosahatchee River and Estuary Total Maximum Daily Loads (TMDLs)

Project Schedule

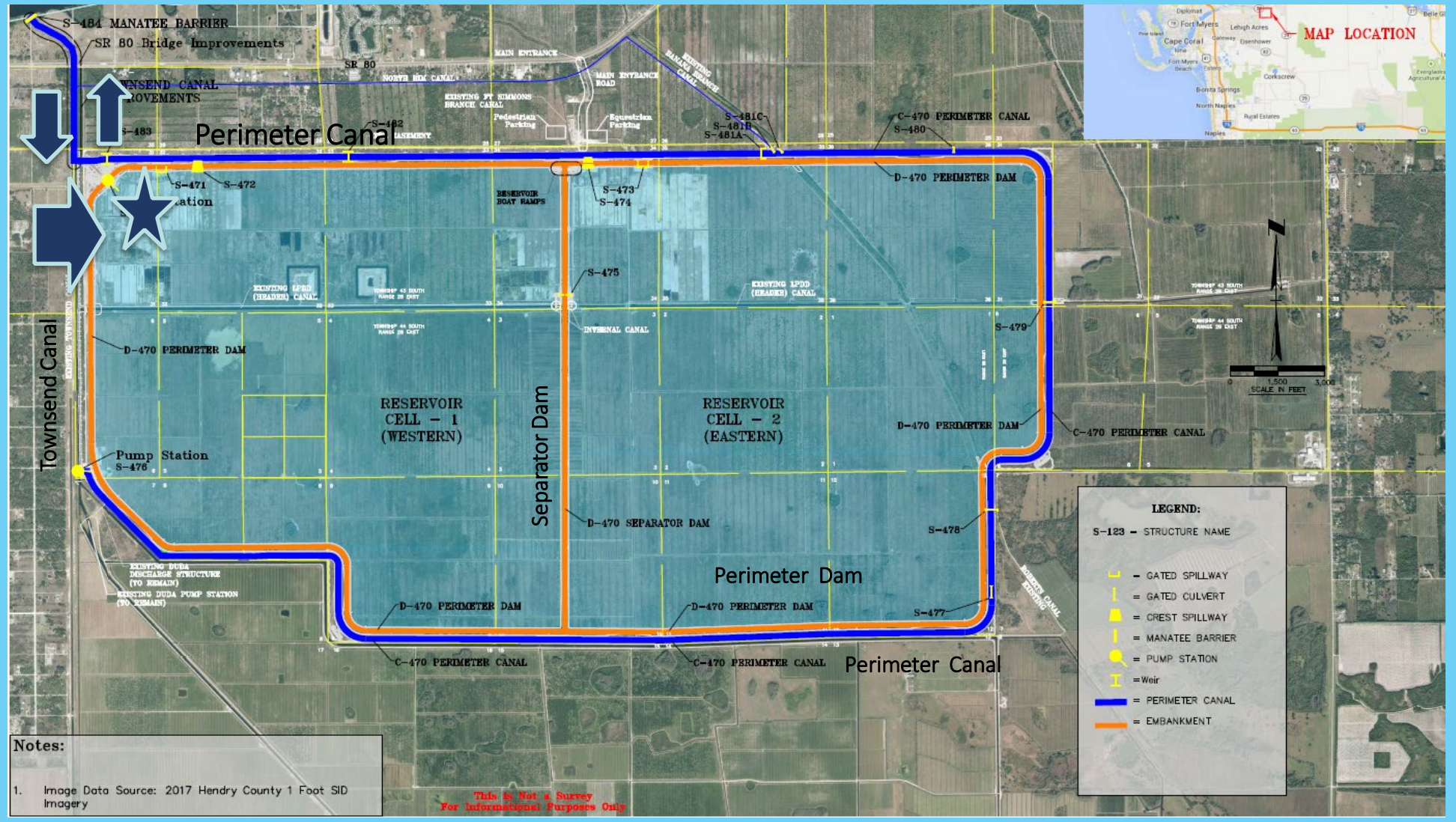


Public Meetings Noticed On All Working Group Member Websites

Georgia Vince,
J-Tech

Georgia Vince,
J-Tech

C-43 West Basin Storage Reservoir

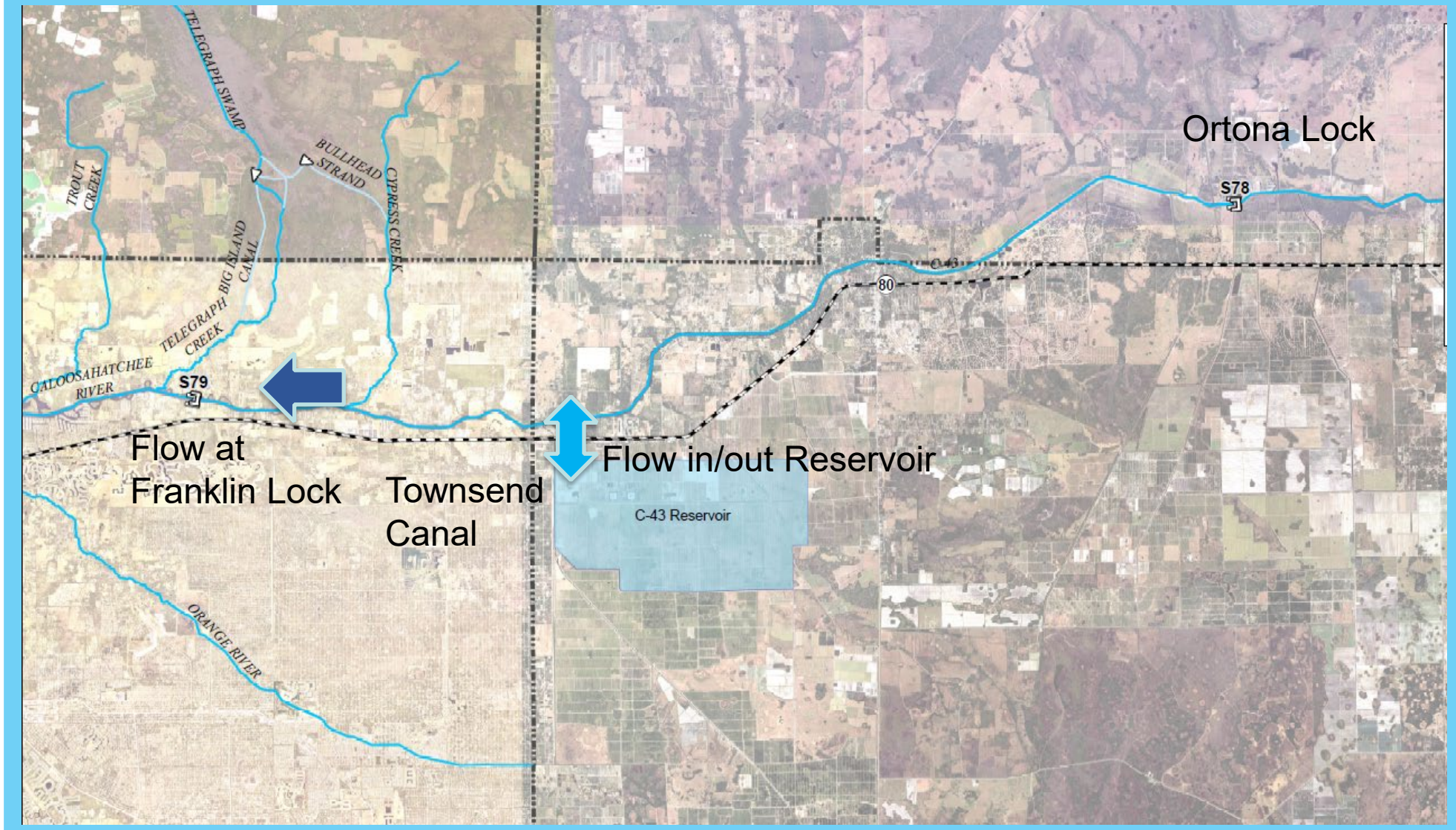


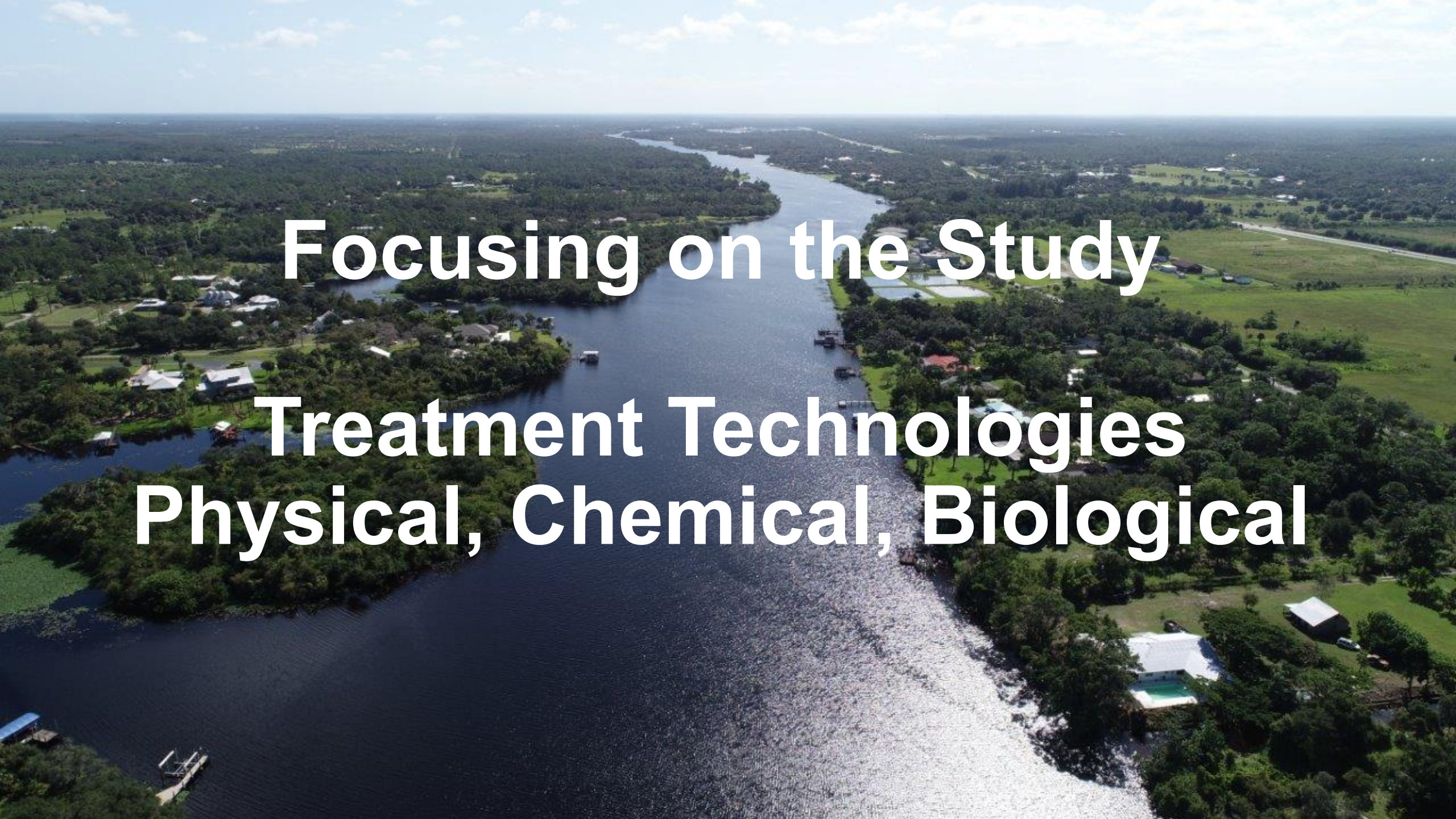
C-43 WBSR

- C-43 Reservoir project is a component of the Comprehensive Everglades Restoration Plan (CERP)
- Funded by annual state of Florida legislative appropriations and U.S. Army Corps of Engineers will credit all eligible project costs
- Captures excess basin runoff and Lake Okeechobee releases
- Improves quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary, to help maintain proper salinity levels
- Maintains water supply for existing legal users

Georgia Vince, J-Tech

C-43 WBSR Operations




Focusing on the Study
Treatment Technologies
Physical, Chemical, Biological


Marcy Frick, J-Tech

Treatment Technology Focus

Nitrogen

- Dissolved Organic Nitrogen
- Dissolved Bio-available Organic Nitrogen
- Dissolved Inorganic Nitrogen (Ammonia, Nitrate, Nitrite)
- Total Nitrogen (TN)

Phosphorus

- Particulate Phosphorus
- Soluble Reactive Phosphorus
- Total Phosphorus (TP)

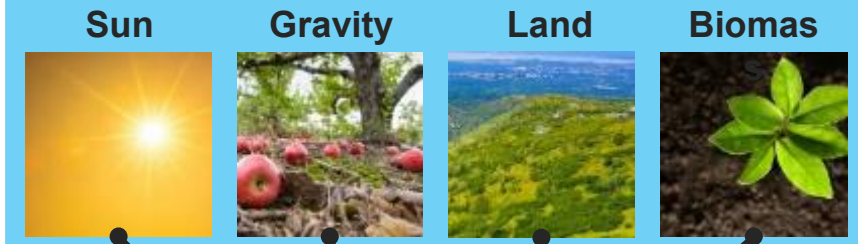
Total Suspended Solids (TSS, Algae, Particulates)

Marcy Frick,
J-Tech

How to Treat?

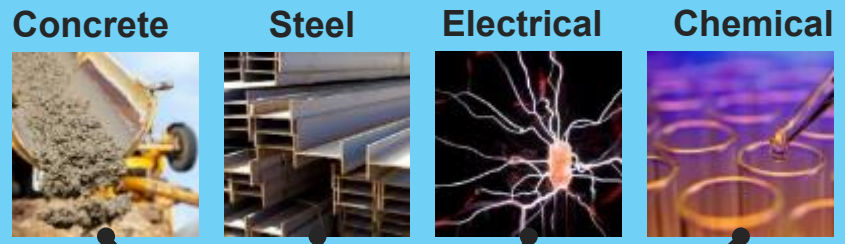
Natural and Conventional Treatment Approaches

Natural Systems



Water Treatment $

Conventional Systems



Water Treatment $ $ $

Information Collection Summary Report

Performed literature review and assessed available technology based upon information sources:

- DEP Technology Library (http://fldeploc.dep.state.fl.us/tech_portal/tech_library_intro.asp)
- Working Group experience and case studies
- Other professionals with similar project experience
- Technology vendor submittals
- Public input
- Final Report made available April 3, 2020
- Study Website: https://www.sfwmd.gov/content/c43waterqualitystudy

Technology Evaluation

- Florida Case Study & Data Quality
- Nutrient Reduction
  - Scalable
- General Land Area
  - Compatible with C-43 WBSR system
- Treatment Residuals
- Energy Requirements
- Schedule for Implementation
- Operations & Maintenance (O&M) Requirements
- Costs: Capital, O&M, and Cost-benefit
- Regulatory Constraints
  - Cannot cause harm

Treatment Technology Highlights


Chris Keller, WSI

Constructed Treatment Wetlands

- Nutrient uptake, transformation, burial
- Many Florida applications
- Well-studied, good performance data
- 20-40% TN, 75-90% TP, >90% algae
- Large land area required
- Large capital cost
- Lower O&M cost
- Long-term residual accumulation
- Power for pump stations
- Pre-and post-storage


Stormwater Treatment Area




Chris Keller, WSI

Sand Filtration

- Gravity separation of solids
- Several Florida applications
- Well-studied, good performance data
- 20-40% TN, 25-50% TP, >90% algae
- Large land area required
- Large capital cost
- Lower O&M cost
- Upper sand layer replacement (3-5 years)
- Power for pump stations
- Pre- and post-storage application

Aquifer restoration and recovery project, Mosaic


Chris Keller, WSI

Hybrid Wetland Treatment Technology (HWTT)

- Coagulation of nutrients, solids separation, wetland uptake, and sedimentation
- Several Florida applications
- Well-studied, good performance data
- 50-60% TN, 80-90% TP, >90% algae
- Reduced land area required
- Reduced capital cost
- Greater O&M cost than wetlands
- Residual (floc) removal and disposal
- Power for pumps, dosing, mixing
- Pre- and post-storage application


HWTT, Nubbin Slough

Coagulant Treatment (Alum)

- Coagulation of nutrients by particle charge neutralization and solids sedimentation in offline lagoons or within reservoir
- Multiple Florida applications
- Well-studied, good performance data
- 50-70% TN, 50-90% TP, >90% algae
- Reduced land area required
- Reduced capital cost
- Greater O&M cost
- Residual (floc) removal and disposal
- Power for pumps, dosing, mixing
- Pre- and post-storage; in-storage

Nutrient Reduction Facility
Lake County, FL

ElectroCoagulation

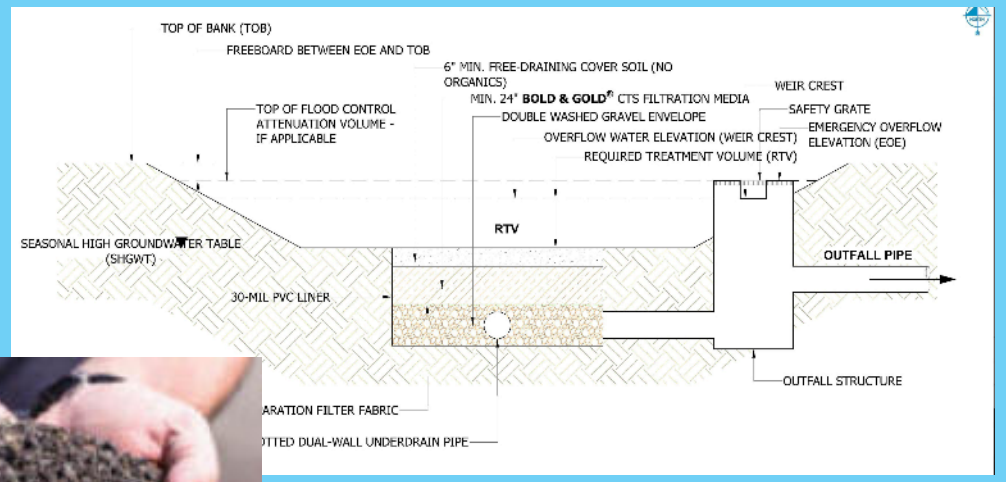
- Coagulation of nutrients by electrode particle charge neutralization and solids sedimentation
- Limited Florida case studies
- Limited performance data
- 60-90% TN, >90% TP, >90% algae
- Low land area required
- High capital cost
- High O&M cost
- Lower residual amount but still require disposal
- Power for electrodes, pumps, dosing, air
- Pre- and post-storage application

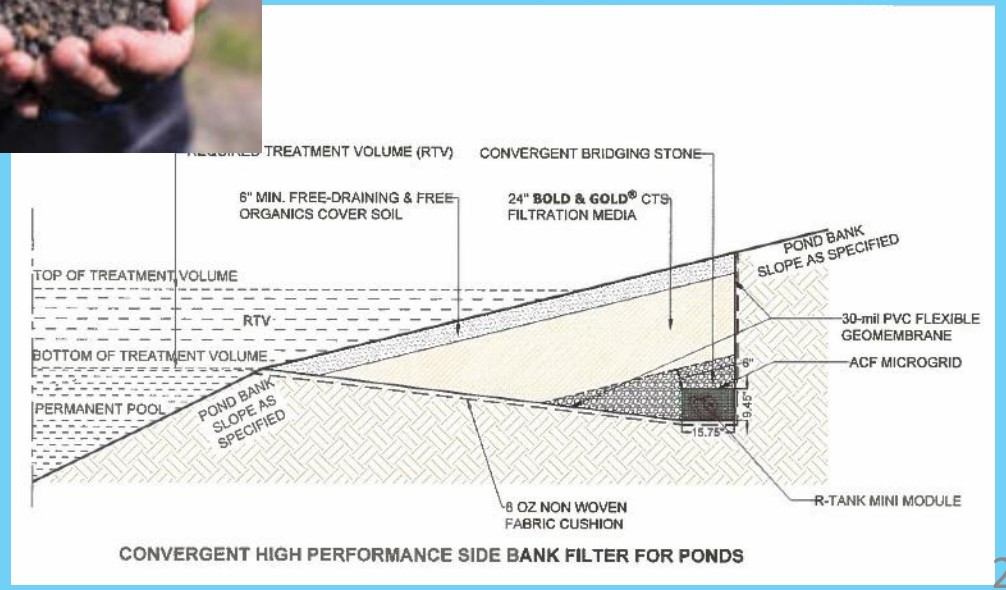
Powell Water Systems

Jim Bays,
J-Tech

Bold & Gold®

- Sorption of nutrients to engineered media and filtration of solids in basin or basin side walls
- Many Florida applications
- Good performance data
- 75-95% TN, 50-90% TP
- Low land area required
- Moderate capital cost
- High O&M cost
- Spent media must be replaced (15 years)
- Pre- and post-storage application





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Feasibility Study Technology Ranking

Technology Ranking

Attribute Ranking (high to low)	Weight (1-5)	Justification
Scalable	5	Experience with technology at a similar scale
Confidence in Performance Estimates	5	Must have a high confidence in removal estimates provided
Available Florida Case Study	4	Reduced risk based on reliability of data with Florida case studies; however, this Study supports innovation
Residuals Production	4	Preference for technology that does not produce residuals or require management
Habitat	3	Ancillary benefits to fish and wildlife by providing habitat
Ecosystem Services	2	Ancillary benefits to humans by providing recreational and aesthetic benefits
Energy Efficiency	2	Preference for technology with lower carbon footprint
Land Requirements	2	Relative footprint area needed to provide for water quality treatment
O&M	2	Preference for technologies with less complexity of operations and less operator involvement
Schedule of Implementation	1	Time needed to construct and implement the treatment technology

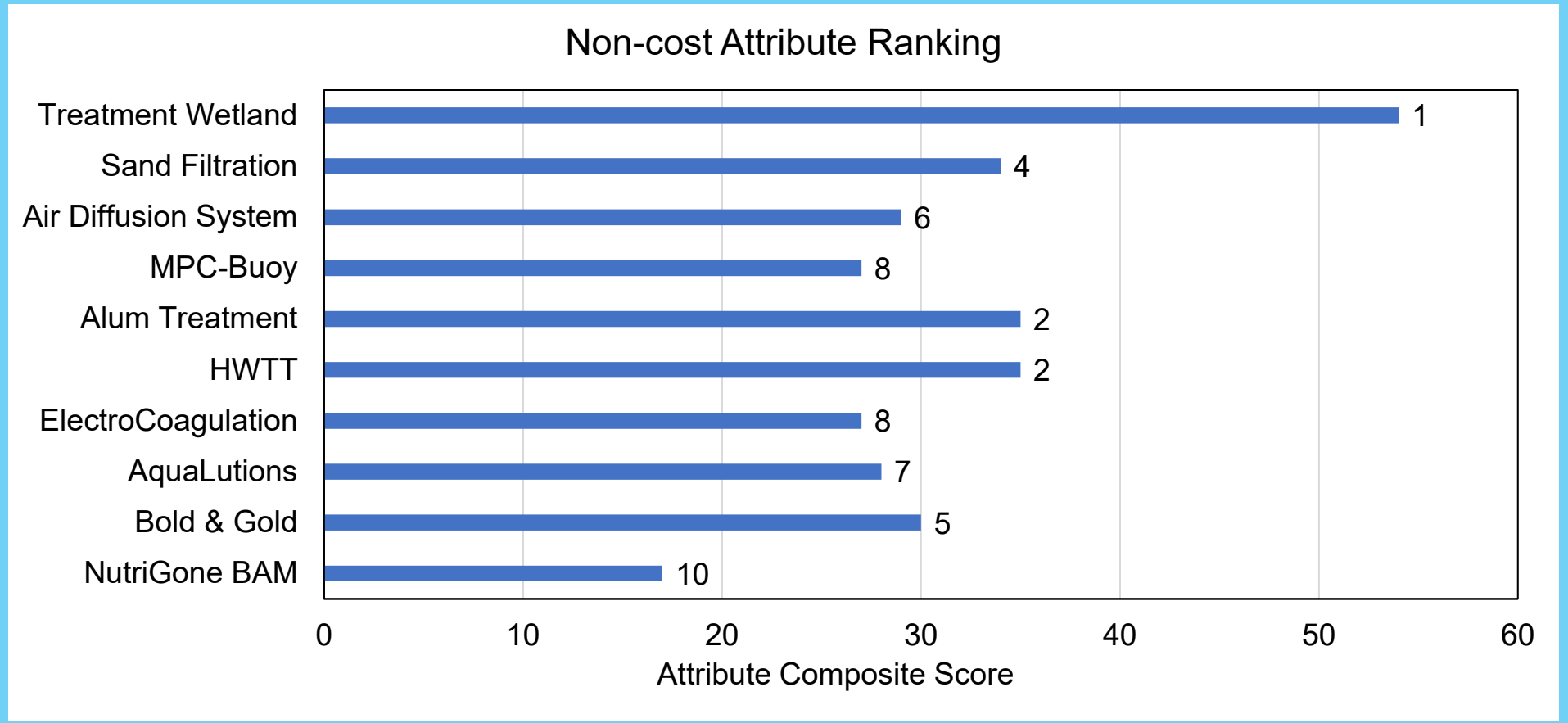
Technology Ranking

Technology Scoring	Attribute										Score	Rank (Lower = Better)
	Scalable	Confidence in Performance Estimates	Available Florida Case Studies	Residuals Production	Habitat Value	Ecosystem Services	Energy Efficiency	Land Requirements	O&M	Schedule of Implementation		
Weight -->	5	5	4	4	3	2	2	2	2	1		
Treatment Wetland	2	2	2	2	2	2	2	0	2	0	54	1
Sand Filtration	1	1	1	2	1	0	2	0	2	1	34	4
Air Diffusion System	1	0	1	2	0	0	1	2	2	2	29	6
MPC-Buoy	1	0	0	2	0	0	2	2	2	2	27	8
Alum Treatment	1	2	2	0	1	0	1	2	1	1	35	2
HWTT	0	2	2	1	1	2	1	1	1	0	35	2
ElectroCoagulation	0	2	1	2	0	0	0	2	0	1	27	8
AquaLutions	1	2	1	1	0	0	1	1	0	1	28	7
Bold & Gold®	0	1	2	2	0	0	1	1	2	1	30	5
NutriGone ™	0	0	1	2	0	0	1	1	0	1	17	10

Scoring										
2	Proven at similar scale	High	n >= 5	No residual mgmt req	High	High	Highly eff	Low	Low	Short
1	Proven at moderate scale	Medium	1 < n < 5	Mod	Medium	Medium	Mod eff	Medium	Moderate	Moderate
0	Proven at small scale	Low	0	Large residual mgmt req	Low or None	Low or None	Low eff	High	Intensive	Long

Chris Keller, WSI

Non-Cost Attribute Ranking




Chris Keller, WSI

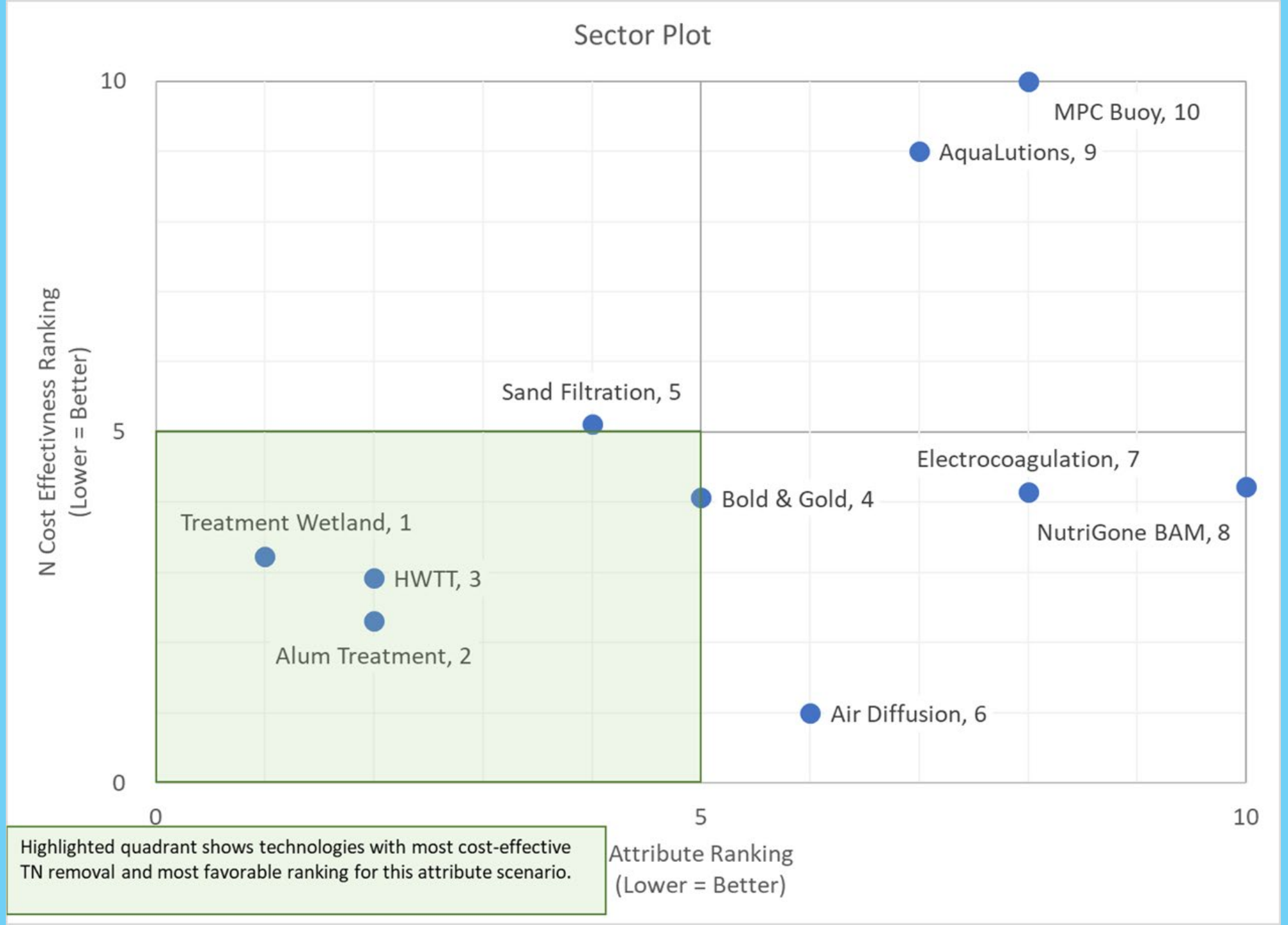
Design Criteria

- TN reduced from 1.5 mg/L to 1.0 mg/L
- TP reduced from 0.16 mg/L to 0.08 mg/L
- TSS reduced from 20 mg/L to 10 mg/L
- Flow = 457 cfs

Cost Effectiveness

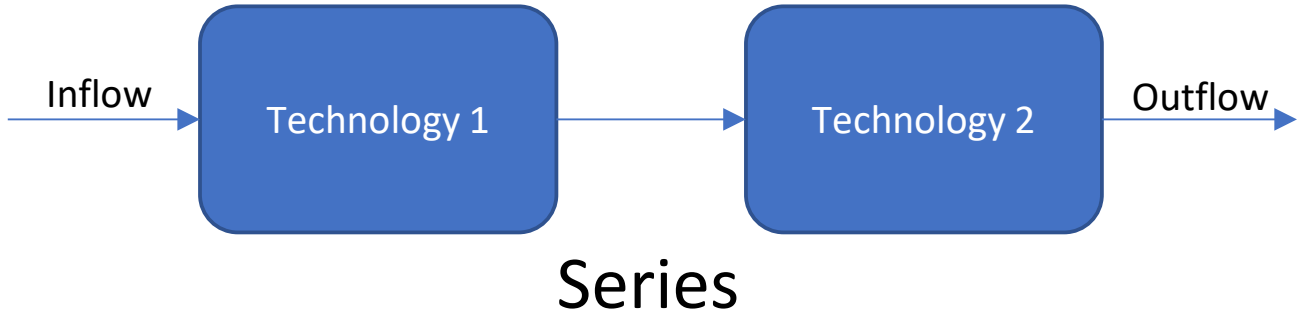
Technology	Attribute Ranking (Lower = Better)	TN Cost Effectiveness Ranking (Lower = Better)	TP Cost Effectiveness Ranking (Lower = Better)	TSS Cost Effectiveness Ranking (Lower = Better)	Overall
Alum Treatment	2	2.3	1.0	2.5	1
Treatment Wetland	1	3.3	2.1	3.6	2
HWTT	2	2.9	1.4	3.2	3
Bold & Gold®	5	4.1	2.9	4.5	4
Sand Filtration	4	5.1	4.0	5.7	5
Air Diffusion System	6	1.0	10.0	1.0	6
ElectroCoagulation	8	4.6	3.0	4.6	7
NutriGone ™	10	4.7	3.0	4.7	8
AquaLutions	7	9.0	8.0	10.0	9
MPC-Buoy	8	10.0	10.0	1.3	10


Chris Keller,
WSI

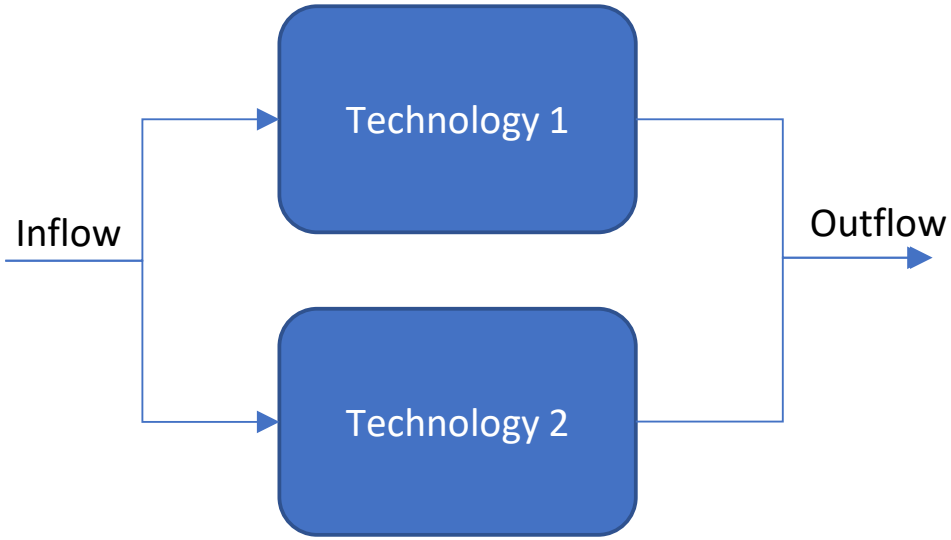

Sector Plot
10
5
0
0
5
10
N Cost Effectivness Ranking
(Lower = Better)
Attribute Ranking
(Lower = Better)
MPC Buoy, 10
AquaLutions, 9
Sand Filtration, 5
Electrocoagulation, 7
Bold & Gold, 4
NutriGone BAM, 8
Treatment Wetland, 1
HWTT, 3
Alum Treatment, 2
Air Diffusion, 6
Highlighted quadrant shows technologies with most cost-effective TN removal and most favorable ranking for this attribute scenario.

Identification of Alternatives

- In series
- In parallel



Series



Parallel

Chris Keller,
WSI

Technology Compatibility

Downstream Technology	Upstream Technology						
	Treatment Wetland	Sand Filtration	Alum	HWTT	Bold & Gold	ADS	ElectroCoagulation
Treatment Wetland	--	N	Y	Y	Y	Y	N
Sand Filtration	Y	--	N	N	Y	Y	N
Alum Treatment	N	N	--	N	Y	Y	N
HWTT	N	N	Y	--	Y	Y	N
Bold & Gold®	Y	Y	N	N	--	Y	N
ElectroCoagulation	Y	Y	Y	Y	Y	Y	--

Feasibility Study
Cost Benefit Analysis

Identification of Alternatives

From Attribute Ranking:

1. STA
2. Alum
3. HWTT

Considered Combinations of Technologies:

4. Treatment Wetland and Bold & Gold® (1,000\104 acres)
5. Sand Filtration and Bold & Gold® (200\104 acres)

Additional Technologies:

6. ElectroCoagulation

Cost Benefit Analysis

Total Costs vs. Water Quality Benefits

- Costs:
  - Infrastructure (Small, Medium, Large)
  - Construction
  - O&M

Benefits:

- TN Removal
- TP Removal
- TSS Removal

Cost Benefit Analysis

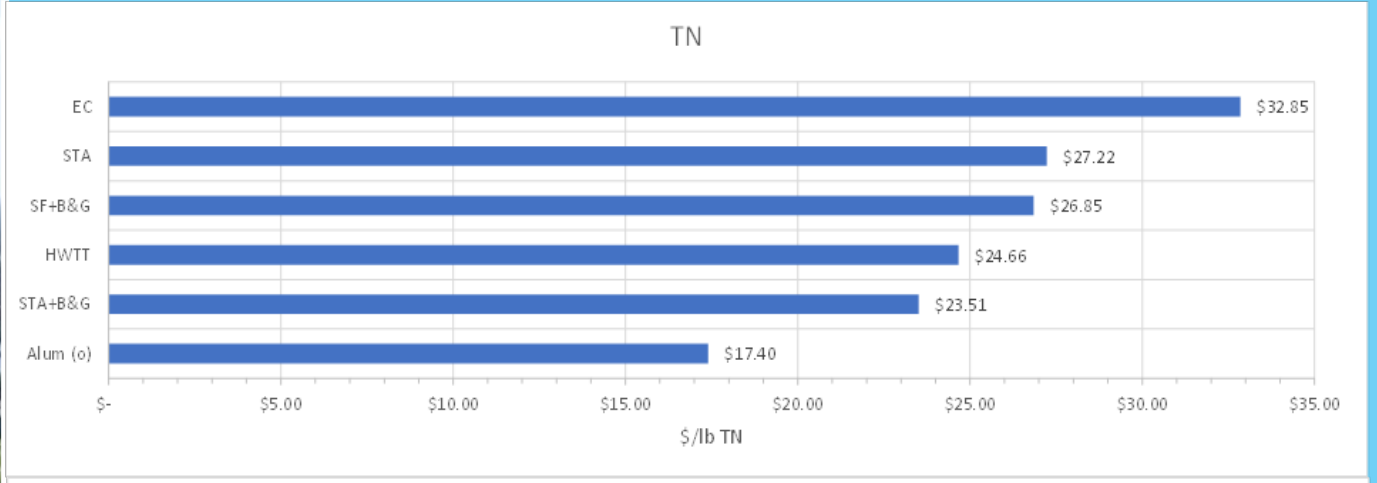
Alternative	Capital Cost ($ millions)	Annual O&M Costs ($ millions/year)	NPV 20-year ($ millions)
Treatment Wetland	$148.1	$2.41	$180.8
Alum Treatment	$51.8	$5.67	$115.5
HWTT	$47.8	$8.53	$163.8
Treatment Wetland with Bold & Gold®	$134.6	$1.58	$156.1
Sand Filtration with Bold & Gold®	$152.4	$1.91	$178.3
ElectroCoagulation	$164.3	$3.96	$218.1

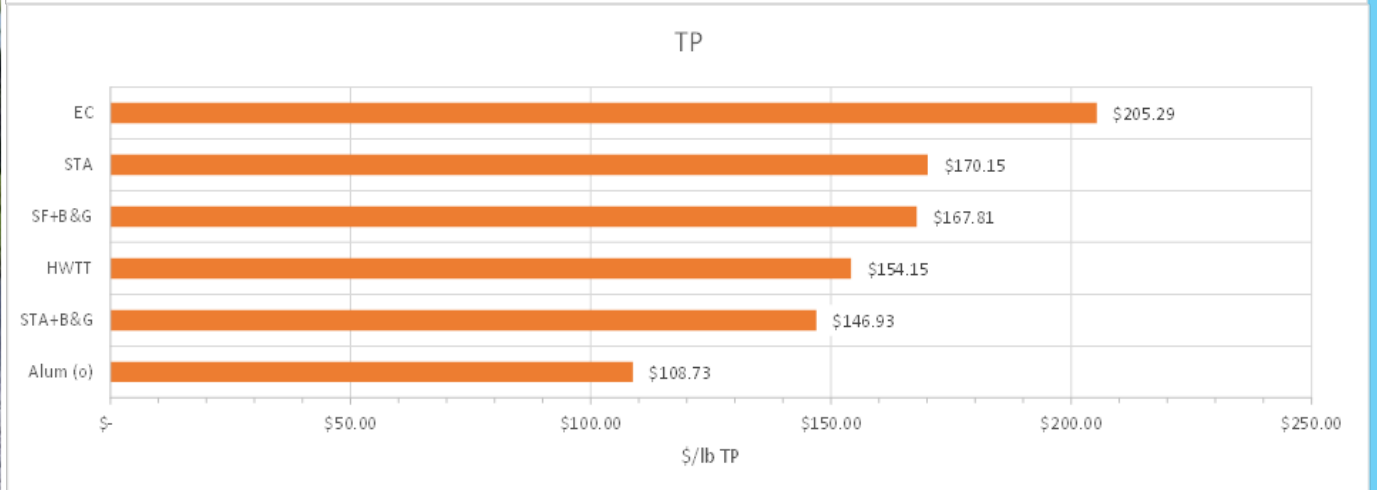

Jim Bays, J-Tech

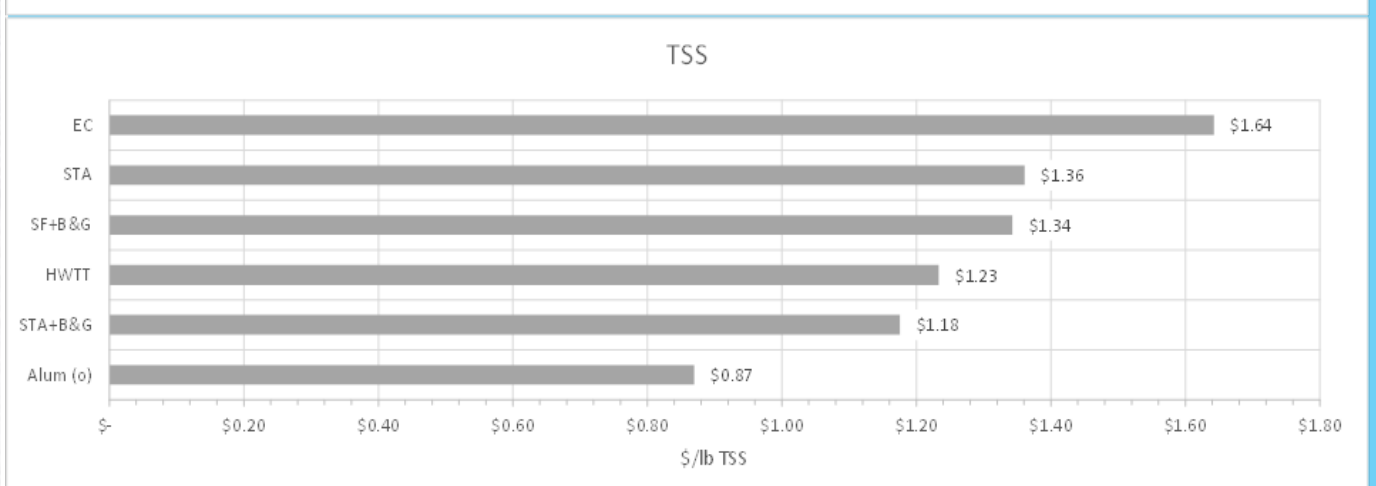
Cost Benefit Analysis

Alternative	Area (ac)	Treated Flow (cfs)	Unit Cost TN Removed (20-year)	Unit Cost TP Removed (20-year)	Unit Cost TSS Removed (20-year)
Treatment Wetland	5,000	457	$27.22	$170.15	$1.36
Alum Treatment	50	457	$17.40	$108.73	$0.87
HWTT	668	457	$24.66	$154.15	$1.23
Treatment Wetland with Bold & Gold®	1,000 Wetland 104 Bold & Gold®	91 Wetland 234 Bold & Gold® 325* Total	$23.51	$146.93	$1.18
Sand Filtration with Bold & Gold®	200 Sand Filter 104 Bold & Gold®	91 Sand Filter 234 Bold & Gold® 325* Total	$26.85	$167.81	$1.34
ElectroCoagulation	150	229*	$32.85	$205.29	$1.64

*Due to different efficiencies of the technologies, the targeted nutrient removal was achieved at lower flow volumes.







Cost Benefit Results

1. Alum
2. STA + Bold & Gold®
3. HWTT
4. Sand Filter + Bold & Gold®
5. STA
6. Electrocoagulation

Recommended Alternatives

1. Alum Treatment
2. Treatment Wetland with Bold & Gold®
3. Hybrid Wetland Treatment Technology (HWTT)
4. Sand Filter with Bold & Gold®

Public Input and Project Website

C43waterquality@sfwmd.gov

https://www.sfwmd.gov/content/c43waterqualitystudy

Questions?

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Water Quality Alternative Treatment Technology (WQATT) - Preliminary Results

Cassondra Armstrong

Purpose of Pilot Study

- C-43 WBSR Water Quality Component Feasibility Study Ranking Results
  - Bold & Gold® CTS
    - *Bioactivated Media (BAM) composed of clay, tire crumb, and sand (CTS)*
    - *Estimated nitrogen removal rates of 70% using UCF retention pond as source water, dominated by NOx*
    - *C-43 source water is dominated by DON, 60-80%*
  - Alum
    - Long history of safely removing nutrients in lakes and ponds

Can these these technologies effectively remove nutrients from C-43 source water?

Pilot Study Components

- Bold & Gold® CTS
  - 6 mesocosm tanks, 2 with Bold & Gold® CTS, 2 with Sand only, 2 controls
  - Continuous flow with C-43 source water for 1 month, flow rate 0.005 gal/min/ft2
  - Near-daily sampling to capture nutrient removal efficiency curve
- Alum, aluminum sulfate
  - Raw water samples collected from 3 locations once a week for 3 weeks to conduct alum dosing study
  - Bench top study to determine dosing rate to achieve maximum floc formation
  - Using optimum dosing rate, measured nutrient removal rate

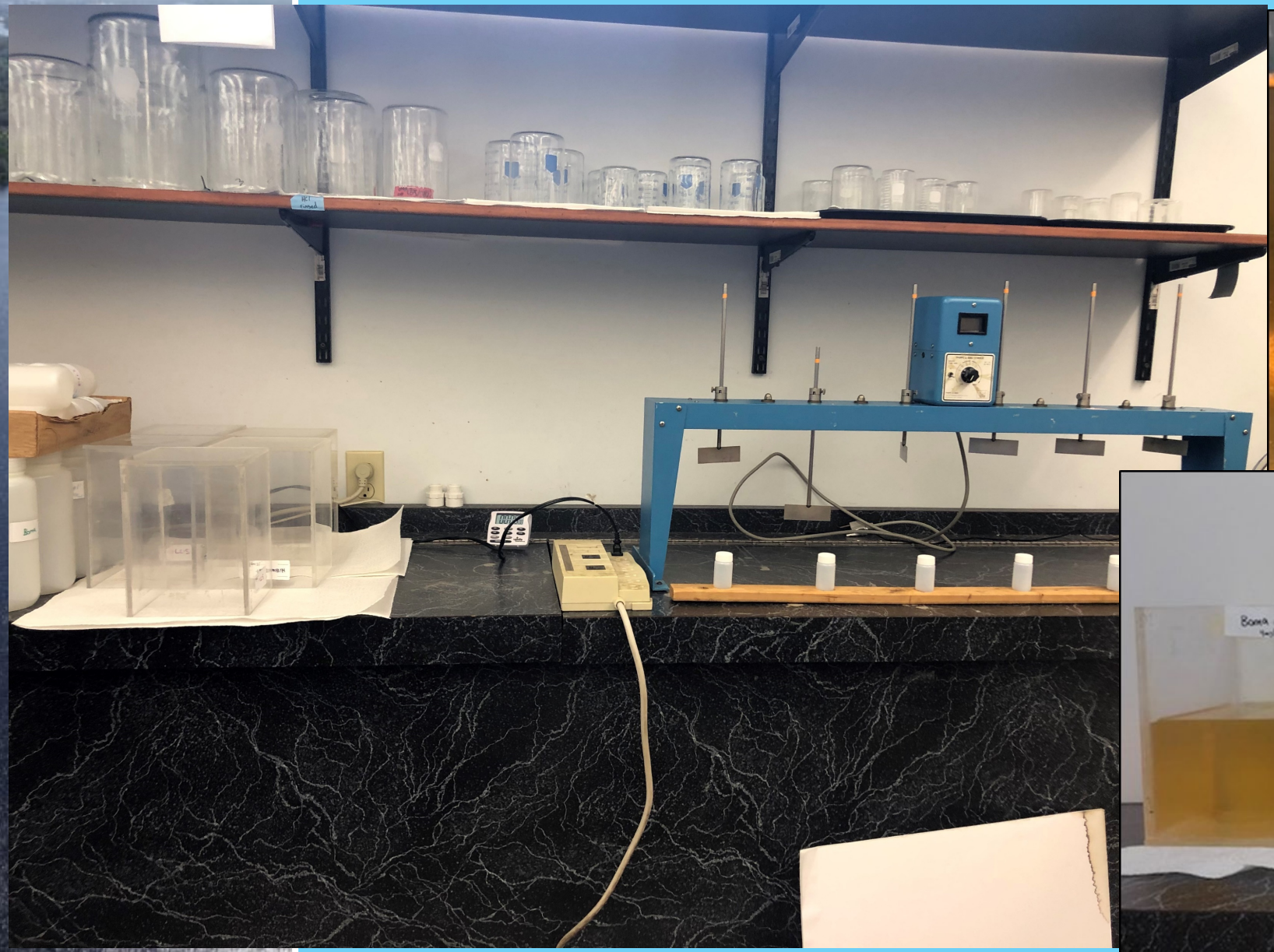
Pilot Study Locations

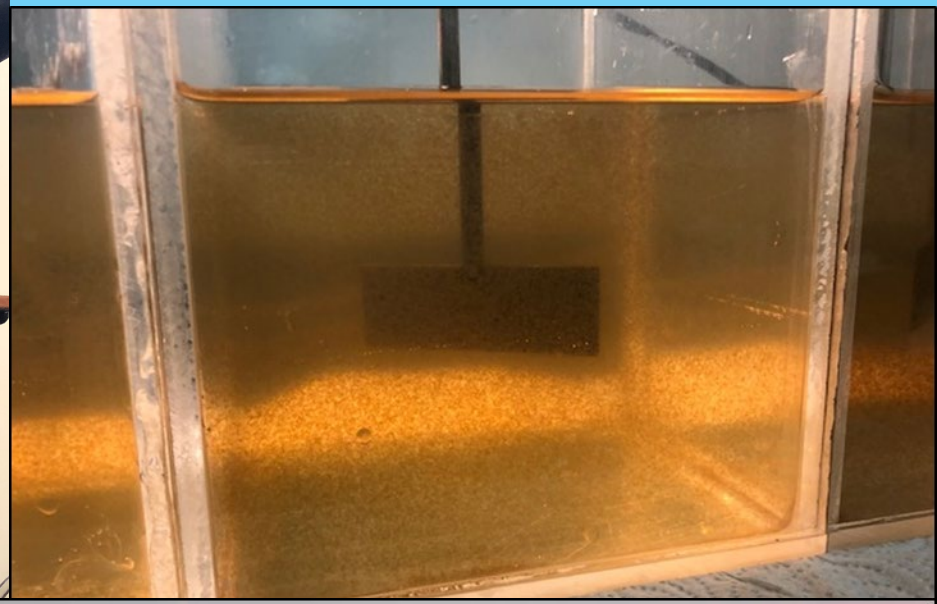
Cassondra Armstrong, SFWMD

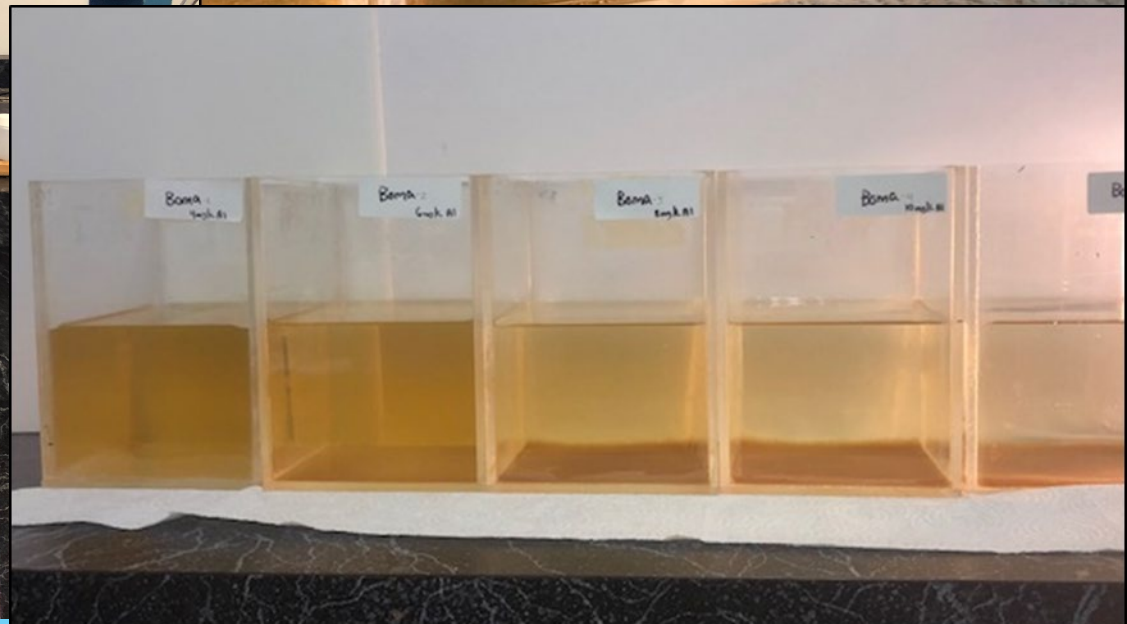
Bold and Gold® CTS Tank Construction

Cassondra Armstrong, SFWMD

Alum Jar Tests

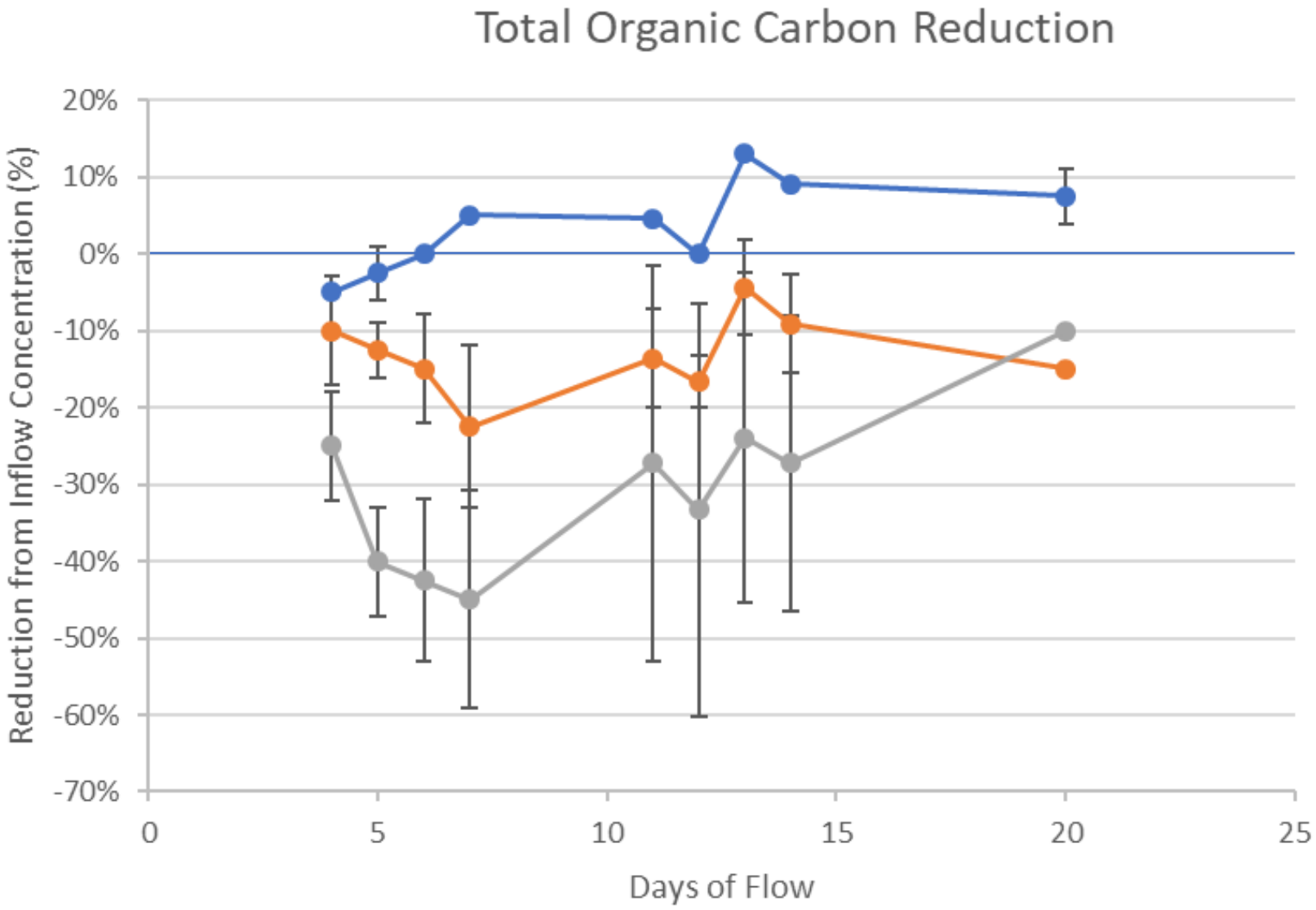






Bold & Gold® CTS

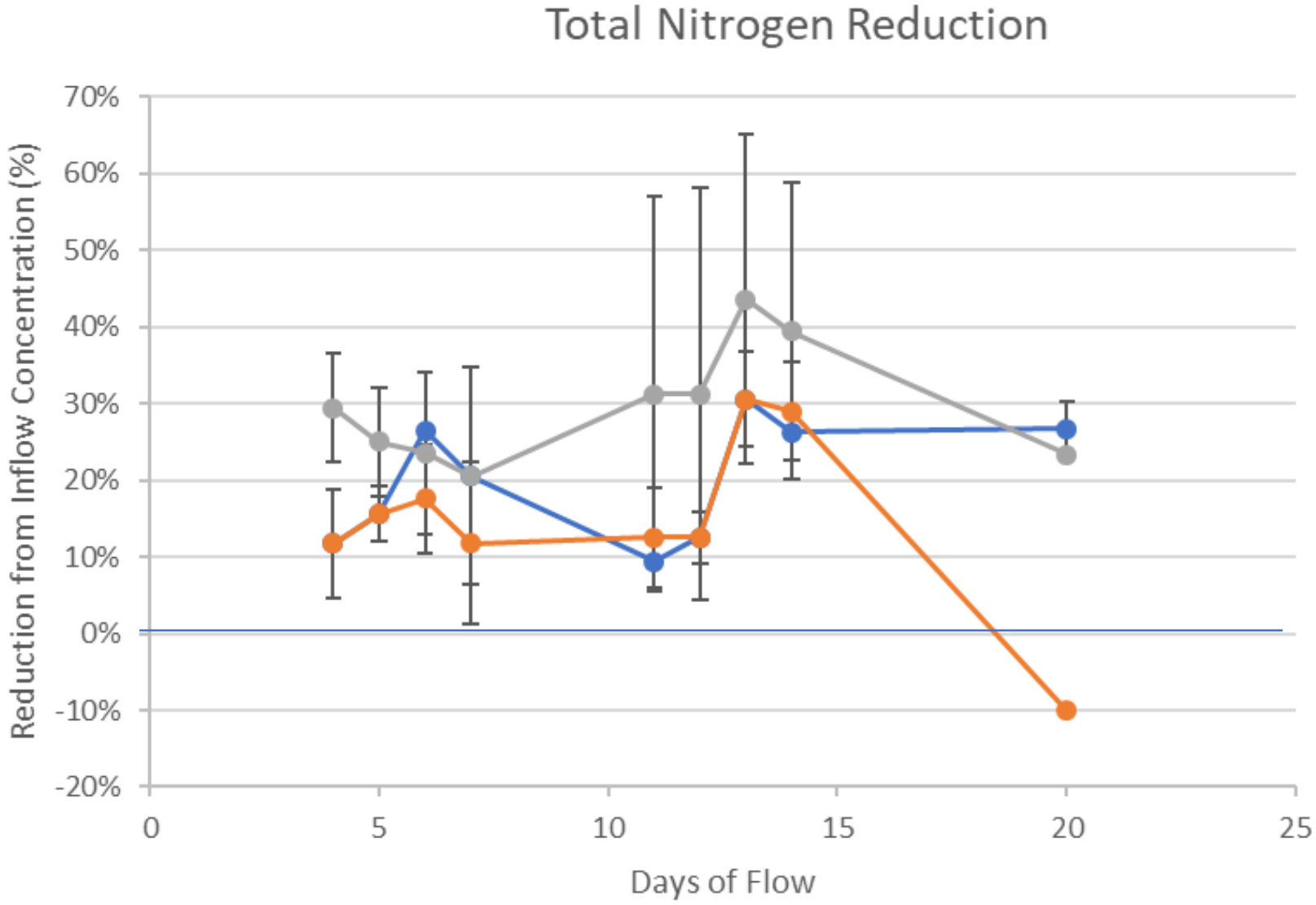
Cassondra Armstrong, SFWMD



Initial TOC concentrations 20-23 mg/L

Bold & Gold® CTS

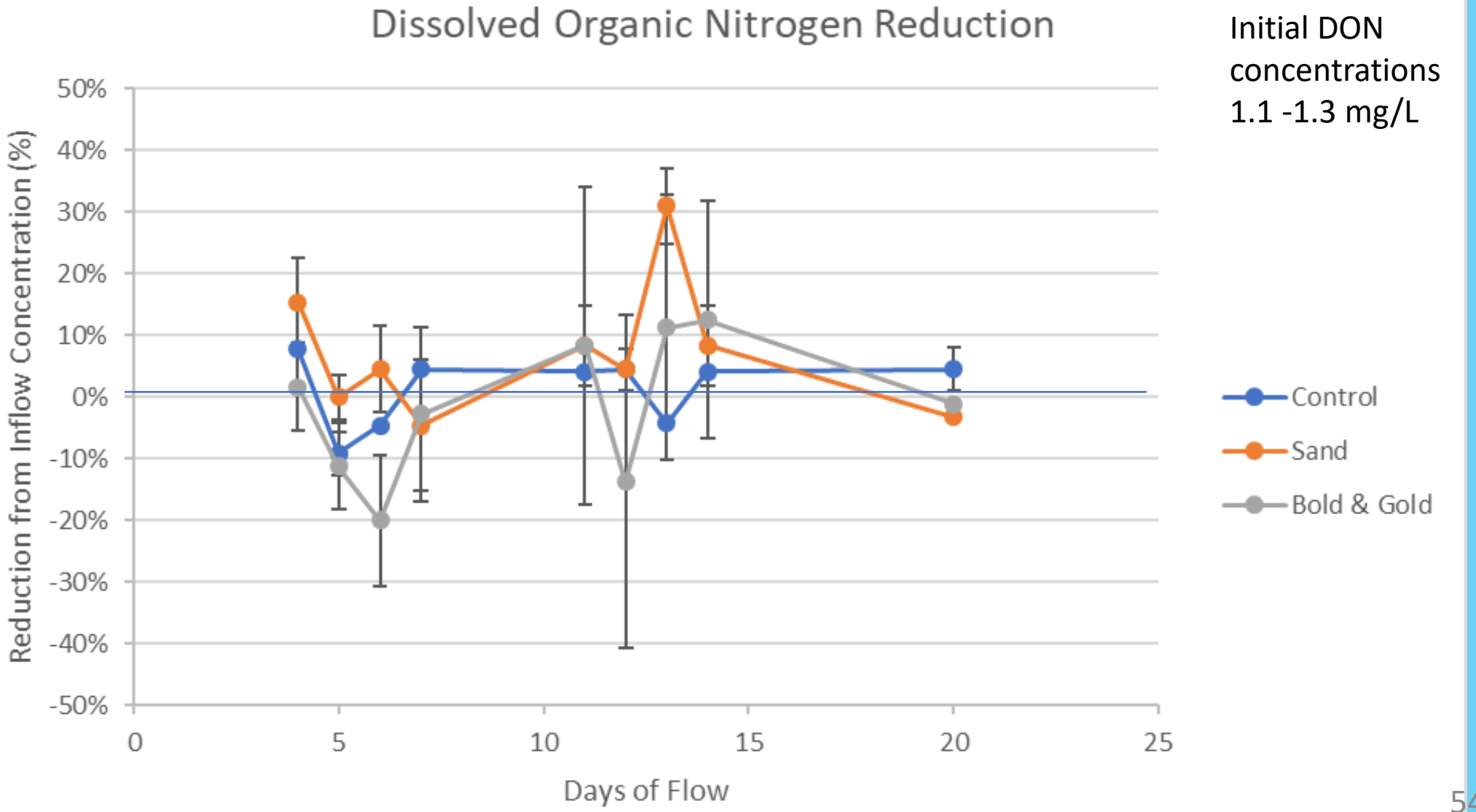
Cassondra Armstrong, SFWMD



Initial TN concentrations 1.5 -1.9 mg/L

Bold & Gold® CTS

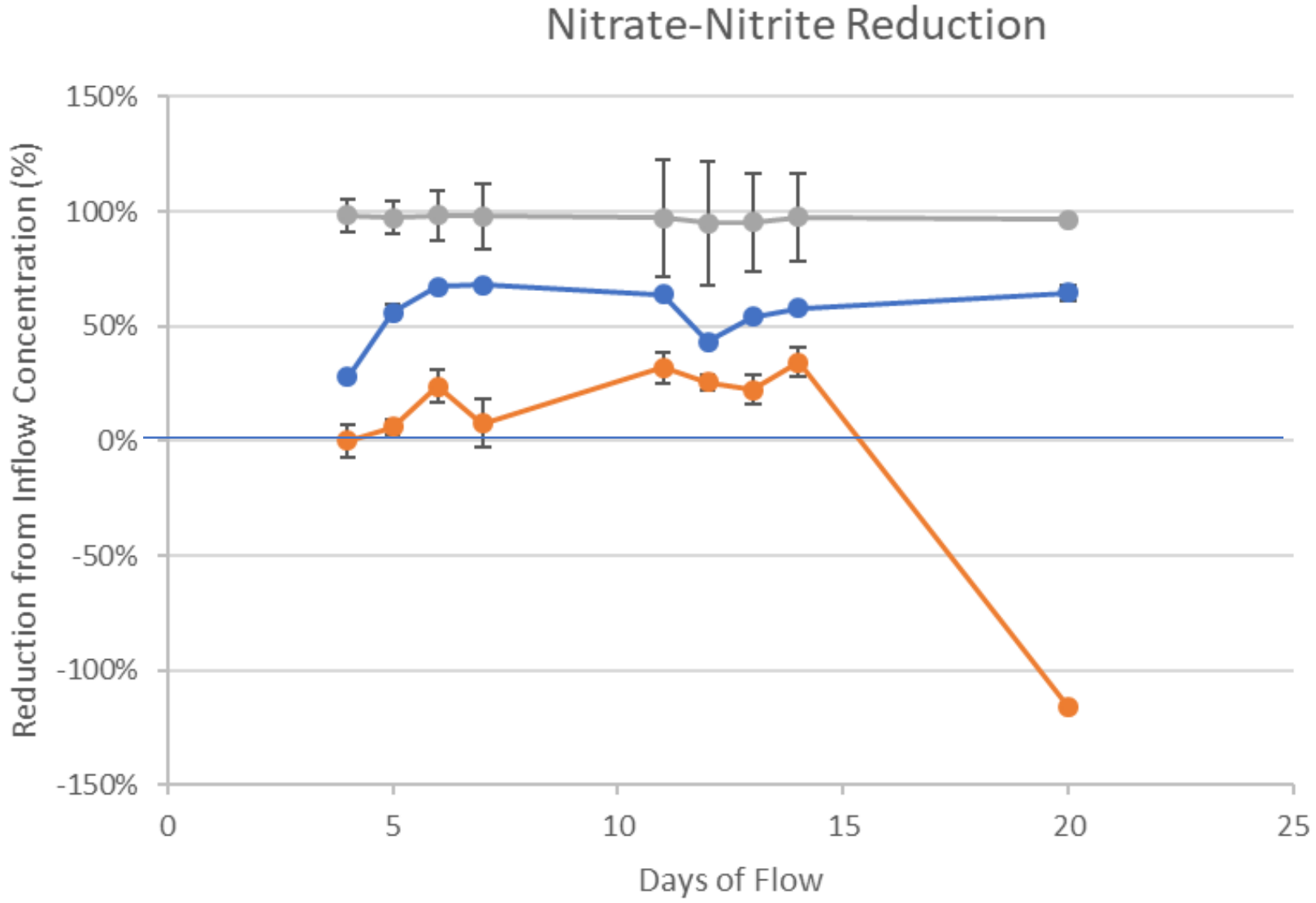
Cassondra Armstrong, SFWMD



Initial DON concentrations 1.1 -1.3 mg/L

Bold & Gold® CTS

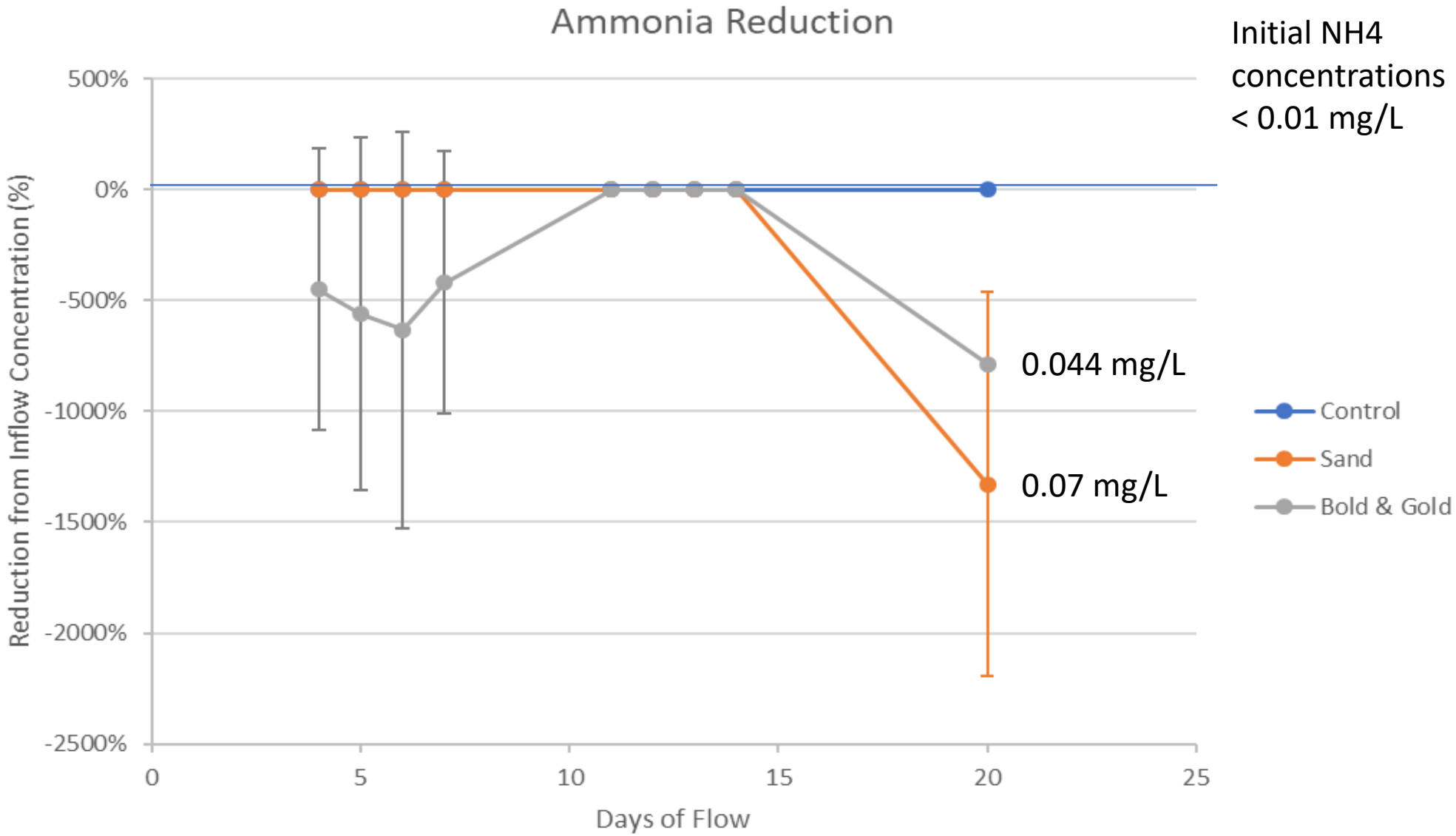
Cassondra Armstrong, SFWMD



Initial NOx concentrations 0.22 - 0.51 mg/L

Bold & Gold® CTS

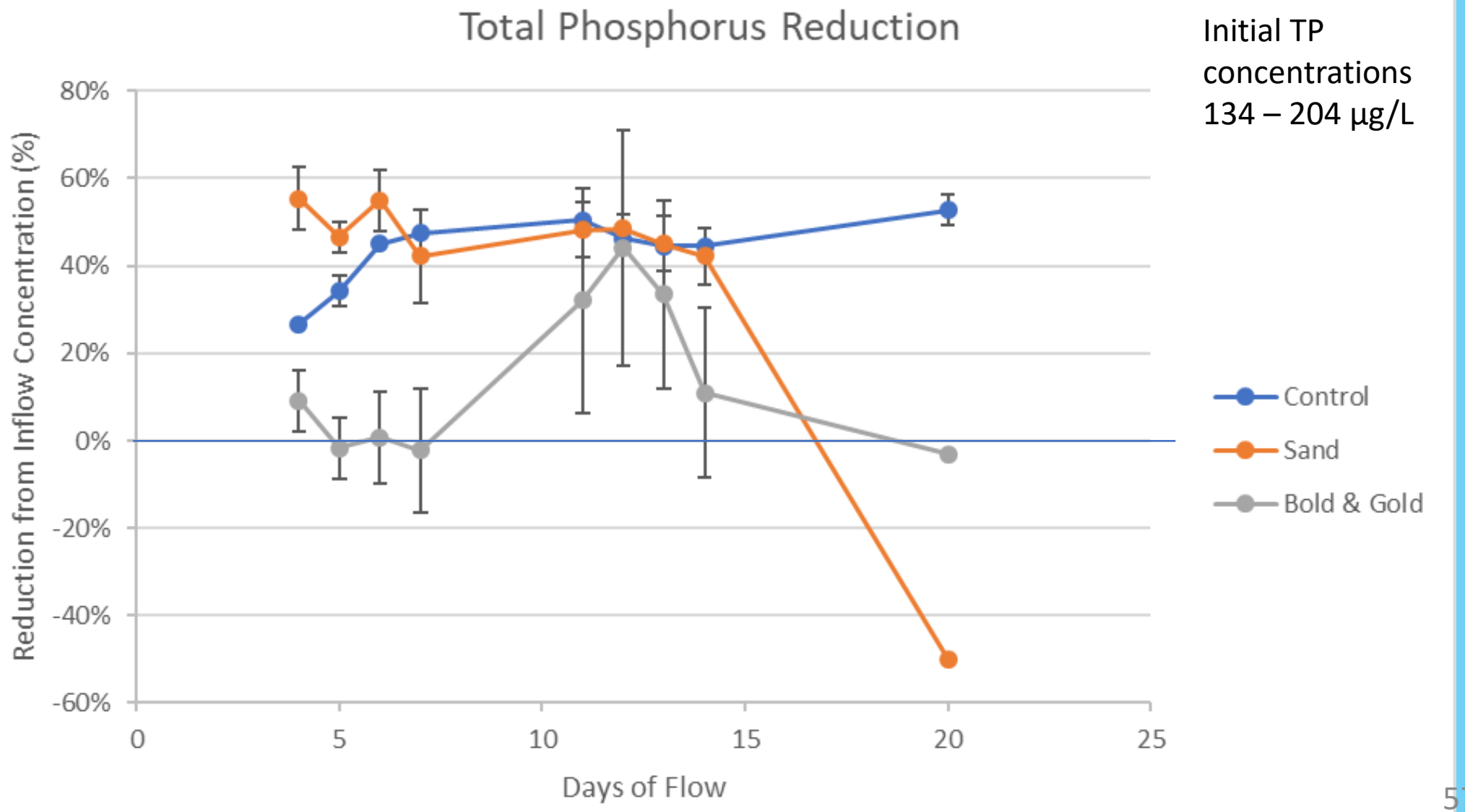
Cassondra Armstrong, SFWMD



Initial NH4 concentrations < 0.01 mg/L

Bold & Gold® CTS

Cassondra Armstrong, SFWMD



Initial TP concentrations 134 – 204 µg/L

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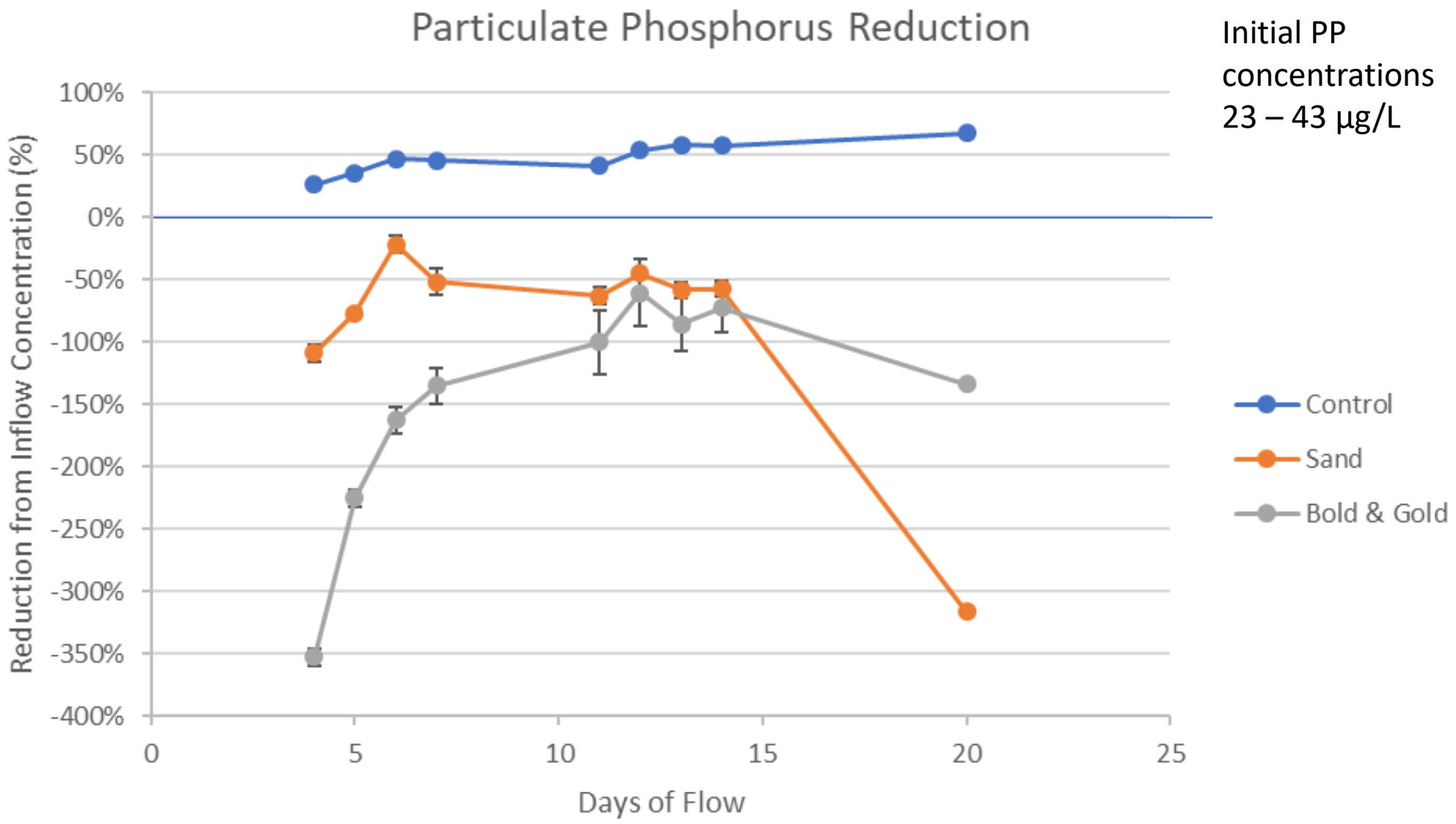

Initial PP concentrations 23 – 43 µg/L

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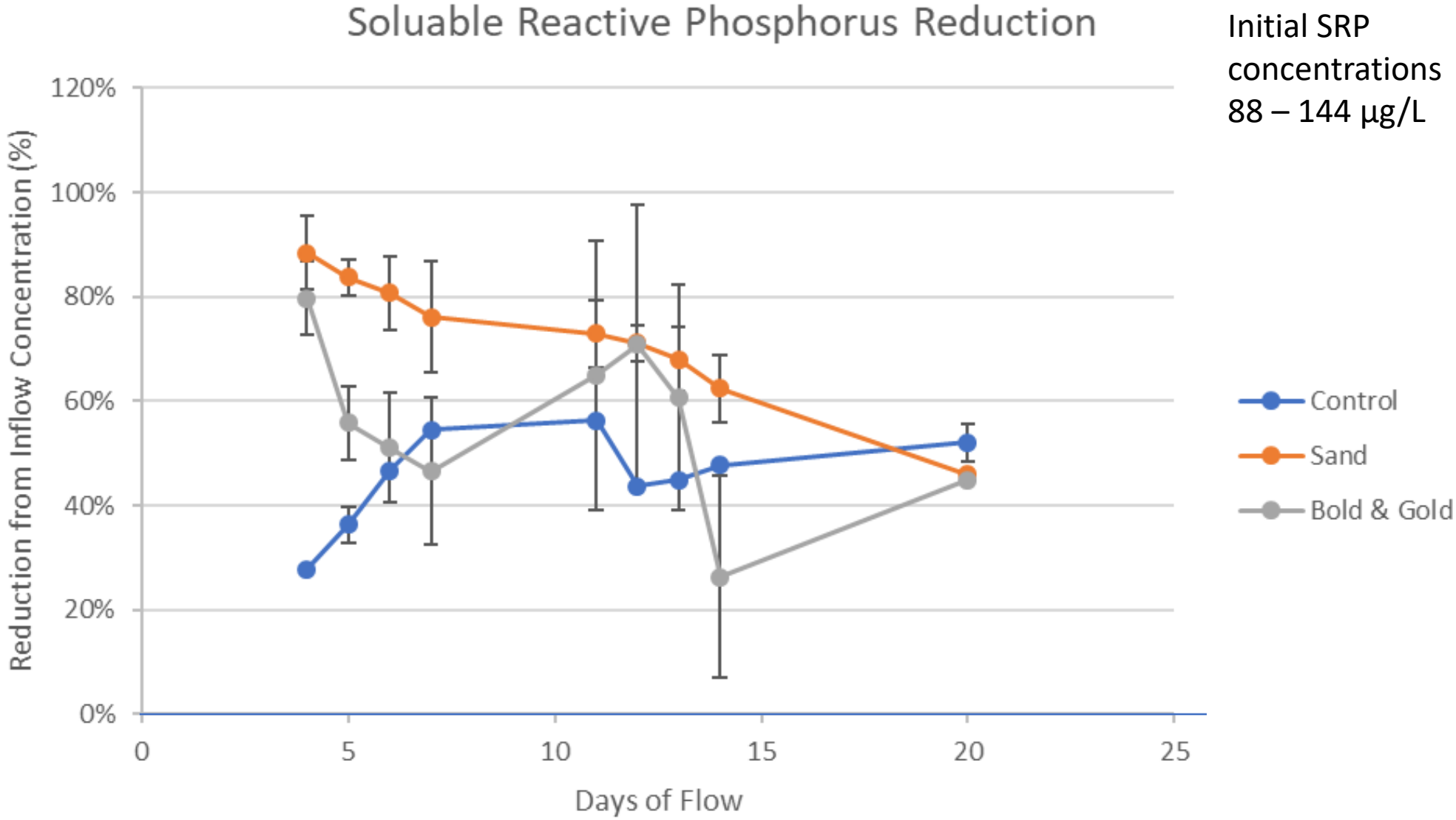

Initial SRP concentrations 88 – 144 µg/L

Aluminum sulfate

Alum Jar Test % Reduction.										
Site	Date	TOC	TN	PN	DON	NOx	NH3	TP	PP	SRP
Boma	9/8/20	54	41	--	57	-10	-25	93	71	99
	9/15/20	48	31	--	60	-2	0	90	58	99
	9/22/20	52	33	--	72	-5	0	94	66	99
Hilliard	9/8/20	50	42	--	43	0	0	67	35	94
	9/15/20	50	37	--	45	-6	-59	91	81	97
	9/22/20	50	27	65	47	-6	-14	92	89	98
S-77	9/8/20	72	56	82	55	-23	-11	95	82	99
	9/15/20	67	61	--	52	-11	-19	90	87	92
	9/22/20	68	57	89	59	-25	-13	94	78	98

Bold & Gold® CTS Conclusions

- Nitrate-nitrite removal almost 100% from the start of the study
- Total Nitrogen removal slightly higher than in control and sand, averaging 30%
- No effective removal of DON
- TOC, NH3, and PP increased in outflow
- May be sensitive to flow disruptions
- 90-days of flow for optimum removal efficiency not yet reached

Cassondra Armstrong, SFWMD

Aluminum Sulfate Conclusions

- Effective removal of C, N, and P from different source waters
- DON removal averaged 54%
- NOx and NH3 concentrations increased
- Alkalinity needed to buffer pH from alum addition, Lake water samples may be limited in the dosing amount

The Pilot Study Continues!

- Bold & Gold® CTS study will continue through September 2021
  - Sample bi-weekly
  - Capture 90-day flow to optimum nutrient removal
  - Capture dry season conditions
  - Capture sub-seasonal variability (temperature, storms, Lake releases)
  - Additional analytes added to assess affect of tire crumb
    - Heavy metals – Zn, Fe, Co, Mg
    - Total PAHs
- Bold & Gold® CTS High-Flow sub-study (February 2021)
  - 0.052 gal/min/ft^2 flow rate for 1 month
  - Weekly sampling
- Alum jar test (February 2021)
  - Replicate previous study in dry season
  - Aluminum chlorohydrate alum sub-study

Questions?

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You will also have an opportunity to type in questions at the end of the presentation using the Menti interactive tool.

WQFS - Next Steps


Kim Fikoski, SFWMD

Next Steps

- Next phase of the project is the C-43 WBSR Water Quality Component (WQC) Siting Evaluation
  - Kickoff is scheduled for December
- Purpose is to further evaluate the four alternatives identified during the Feasibility Study
  - Full-scale STA will also be included based on stakeholder comments
- Deliverables include:
  - Siting Evaluation Report
  - Water quality analysis of project performance
  - Conceptual Design Report
  - WQC Plan Selection


Kim Fikoski, SFWMD

Next Steps

- Public meetings will be held on the Draft Siting Evaluation Report and WQC Plan
- WQC Siting Evaluation will be completed within 9 months
- If funded, the selected WQC Plan will move forward to detailed design under a separate contract
  - Goal of project construction to be completed and online concurrently with full operation of the reservoir

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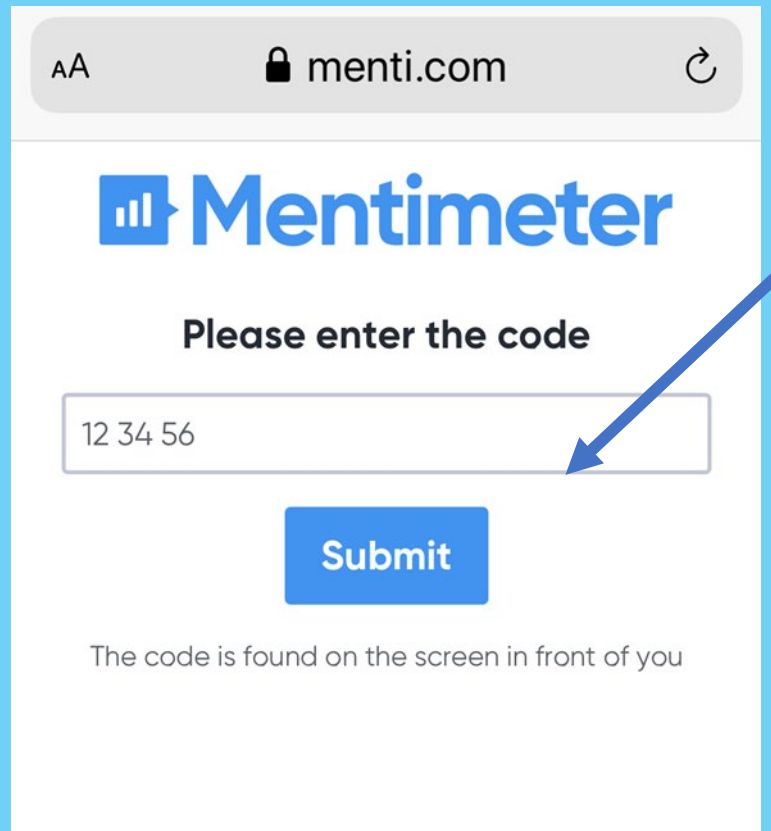

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