Exhibit B-9
Statement of Work
4600004015-WO09
Sustainable Landscape and Treatment in a Stormwater Treatment Area Study

I. INTRODUCTION

Wave-based field tests were conducted to understand the hydraulics and flow resistance in a Stormwater Treatment Area (STA) study. Two-dimensional maps of hydraulic resistance, types of hydraulic behavior ranging from kinematic to diffusive flow, and parameters of power law equations describing resistance at different discharge rates were produced from these tests (Lal et al. 2013, Lal et al. 2015, Lal 2017). Improved estimation of water depths and residence times could help real-world application and physically based models for project planning or design that optimize phosphorus (P) retention. Results of the field tests revealed macroscale anomalies in flow distribution in STAs. Such features include areas where flow is restricted by microtopographic features, dense vegetation, or accumulated plant litter and other deeper or sparsely vegetated areas where flow is accelerated, and treatment processes may be short-circuited. Such conditions reduce overall wetland treatment capacity.

Using results of previous wave-based field tests and renewed understanding of flow through STAs, hydrodynamic experiments are proposed to provide more precise estimates of flow through wetlands; specifically, on transport, mixing, treatment; and the effect of resistance by vegetation. These experiments will be conducted in test cells to provide more controlled conditions and increase precision of results.

This effort will support the Restoration Strategies Science Plan (RSSP) for the Everglades STAs (SFWMD, 2018) by addressing the following key research questions:

- What operational or design refinements could be implemented at existing STAs and future features, including the STA expansions and FEBs / reservoirs, to improve and sustain STA treatment performance?
- What measures can be taken to enhance vegetation-based treatment in the STAs?
- What are the effects of topography on STA performance?
- What key factors affect and what management strategies could improve system resilience of emergent aquatic vegetation (EAV) communities?

II. PROJECT GOALS AND DESCRIPTION

This study will evaluate transport and dispersion, two processes that affect P removal in the STAs, within a *Typha sp*. community. This will be accomplished in one straight flume and one V shaped flume. The former will evaluate constant flow velocity conditions, the latter varying flow velocities, which allows for evaluation of multiple velocities at once. Salt, a conservative substance, will be added at the inflow of each flume, and its progress will be monitored in time and space to understand transport and dispersion. The amount will be verified thorough a benchmark test. Such a low salt load would dissipate to an undetectable level in less than 100 ft within one hour. The effect of salt on Typha has been studied and known effects do occur at 1,800,000 µSiemens (Hootsmans and Wiegman 1998). The short duration of the salt load should minimize any effects on the plants.

Dispersion in emergent vegetation remains unknown to this date. The mechanics involved in these processes are also not clear, except that they are different from bottom-shear induced mixing. It is very important to quantify dispersion to support model development for P removal within STAs

The Water Quality Based Effluent Limits (WQBEL) require phosphorus (P) outflow from the STAs on an annual flow-weighted mean basis to never exceed 19 µg P L^{-1} in any year and must not exceed 13 µg P L^{-1} in more than 3 out of 5 consecutive years. Because of these stringent limits, STA operations need to take advantage of all management options that can enhance P removal through optimal transport and mixing of P within the STAs, which involves flow rates, dispersion, vegetation resistance to flow, and short circuits. The flume study is aimed at obtaining this information in the most cost-effective method.

1.0 Objectives

The objective of this study is to provide guidance on hydraulic regimes that are consistent with in-situ landscape vegetation, to provide optimal P treatment and reduce vegetation loss. Specifically, the study plans to:

1. Develop a benchmark test under controlled conditions that can be used to predict future modifications to STAs.
2. Develop ranges and relationships of water depth, surface slope, and discharge to provide optimum dispersion of inflowing nutrients, thus resulting in maximum removal of P.
3. Quantify the effects of different flow and plant density conditions on transport and hydraulic mixing including solute diffusion and dispersion.
4. Evaluate the effects of hydraulic parameters, vegetation parameters, and landscape modifications on phosphorus (P) treatment performance.

2.0 Project Description

Transport and mixing within the test flumes can be summarized in four main aspects of wetland hydraulics that will be evaluated in this study:

1. Solute transport - solute moves across the wetland due to transport (discharge/velocity).
2. Dispersion - dispersion allows the solute to mix across the wetland for better treatment and dilutes at higher concentrations using low concentration fluids.
3. Treatment - any biogeochemical process within the wetland that retains P.
4. Particle settling - particulate material in the water column, specifically particulate P, that settles out due to reduced vertical mixing.

Different wetlands can produce different amounts of dispersion, treatment, etc. Optimization of treatment involves carefully balancing various aspects of transport and mixing and even using innovative fill cycles.

A. Flumes

One 80-m × 30-m (263 ft by 98 ft) test cell in STA-1W will be used (Test Cell 13). One tapered V-shaped flume and one straight flume will be constructed inside the test cell. The V-shaped flume will taper outwards downstream, providing 0.2 feet of additional width for each foot of flume length (Figure 1). The unique shape of the tapered channel allows for variable velocity per unit width within the same test cell, which increases experiment efficiency in treatment levels. Treatment will include distinct levels of flows (constant, pulsing), vegetation (uniform, buffer strip, and short-circuit), and conservative solutes (salts). Two flumes (1V and 1S; Figure 1) will be planted with Emergent Aquatic Vegetation (EAV) type Cattails (*Typha sp.*) during Phase I. in Phase II, the Cattail experiments will be allowed to grow in prior to testing (0 - 3 months). Three flow types (e.g., no flow, steady state, and pulsed/wave flow) will be evaluated over the course of a year (3, 6, and 15 months) to capture the effects of increasing density as the Cattail grows in. Salt tracer studies and soluble reactive phosphorus (SRP) addition studies will be done for each steady state experiment. Salt or SRP will be added to the inflow and measured along the transects downstream. Pulse/wave experiments will be measured with a series of pressure transducers to measure wave amplitude, frequency and declination to determine vegetation resistance.

B. Experimental Zones

The experiments will be carried out in several zones (see Figure 1). Assuming weir flow depth is 3.5 in, and inflow volume is $Q = 0.845 m^3/s$,

- Zone A: width between 6 ft and 8 ft, and length 10 ft; $q = 0.0111$ *m/s*.
- Zone B: width between 8 ft and 10 ft, and length 10 ft; $q = 0.0087$ *m/s*.
- Zone C: width between 10 ft and 12 ft, and length 10 ft; $q = 0.0071$ *m/s*.
- Zone D: width between 12 ft and 16 ft, and length 20 ft; $q = 0.0056$ *m/s*.
- Zone E: width between 16 ft and 20 ft, and length 20 ft; $q = 0.00436$ *m/s*.
- Zone F: width over 40 ft, far field.

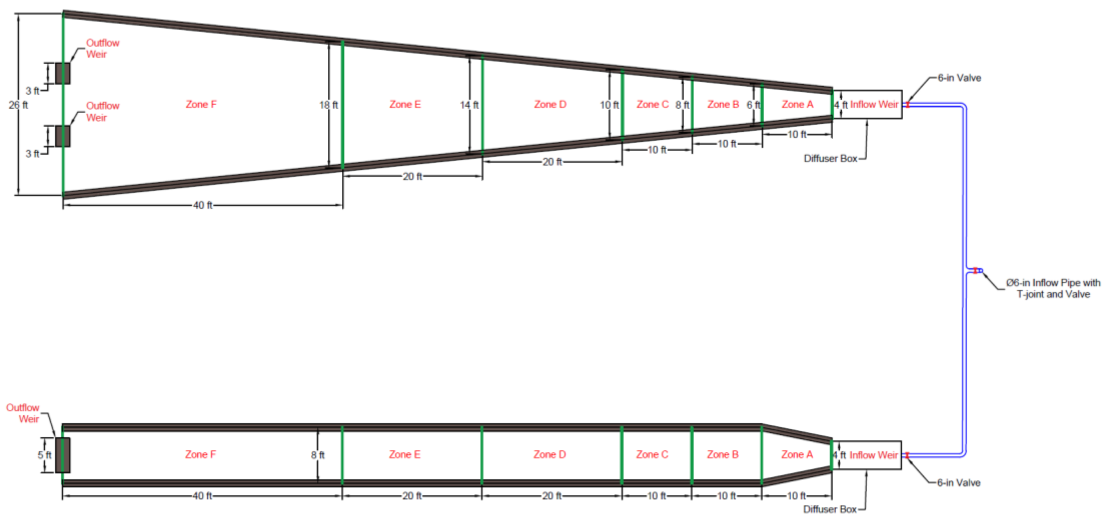

Figure 1. A V-shaped flume (top) and Straight-shaped flume (bottom) located in STA-1W southern Test Cells Complex.

C. Overview of Flow Studies

Flow studies includes a series of no-flow, steady state, and pulsed flow tests that will be conducted over time as EAV and SAV continue to grow and likely to increase vegetation resistance to flow. The following hypothesis will be evaluated during this study.

Hypotheses:

1) There is a range of flow that results in optimal dispersion of nutrient loads
2) Constant flow will lead to incomplete mixing within the test cell
3) Constant flow will produce greater areas of stagnation than pulsed flow
4) Pulsed flows will lead to greater mixing than constant flow
5) Pulsed flow will lead to more short circuiting than constant flow

6) Plant density will affect flow, mixing and optimal dispersions

Three no-flow, steady state flow, and pulsed flow with salt or dye tracer and SRP addition studies will be conducted at least at 3, 6, and 15 months after planting. Flow measurements, sampling etc. may change for each study based on lessons learned from previous event(s) and the data required to accomplish the goals for each flow-type.

1. No Inflow / Outflow Test:

After a given amount of flow volume enters the flumes, the structure outflow and inflow gate will be shut, and water quality will be sampled at given locations throughout the cell for up to 21 days. Total P, particulate P and SRP will be sampled over the course of this period in at least two locations (near inflow and near outflow) to determine when the most P has been removed. This is the equilibration time point where the internal flux of P to the water column is equal to the removal by settling and plant uptake. This equilibration time point is considered the optimal retention period in this flume (Hydraulic Residence Time; HRT) for TP removal.

This test will be conducted at two separate depths: 1.25 feet, the STA target depth and 2.75 feet, which was the maximum depth at which a one-year inundation study Cattail showed minimal signs of stress (Diaz, 2022). These different water depths will be evaluated because depth affects mixing, resistance to flow by plants, hydraulic retention time, and plant conditions.

2. Steady State Flow Tests

Constant steady state flow test will be conducted at high and moderate discharge inflow determined based on STA hydraulic loading rates (HLR). These tests will determine the time for the flume-flow to reach a steady state condition (i.e., $Q_{in} = Q_{out}$) at the selected two water depth variations (e.g., 1.25 and 2.75 -feet).

Tracer studies will be conducted at a low-flow (approximately 10% of the high inflow discharge) to calculate transport of salt and decay of SRP. Salt and soluble reactive phosphorus (SRP) will be added all at once (instantaneous) at separate times. Those flow tests will be conducted at the two water depths (1.25 and 2.75 feet). A separate test will add salt continuously over a 10-minute period to the inflow. Samples and measurements will be taken within the flumes. These measurements will determine the amount of vertical and longitudinal mixing (conductivity measurements) and the effect of this mixing on P removal (phosphorus measurements). Details of this salt and SRP additions will be specified in the work plan (Task 1.2).

Prior to each flow test, sondes will be deployed throughout each flume to measure water depth, waves, temperature, pH, dissolved oxygen, conductivity, turbidity, and velocity at 15-minute intervals. The number and placement of sondes will be specified in the work plan (Task 1.2) and determined in consultation with H&H. The placement of sondes will evaluate vertical and latitudinal mixing as well as short circuiting. The salt tracer study will determine the vertical and longitudinal effect of plants, short circuiting and changing flow on vertical mixing and the resultant P removal.

3. Pulsed / Wave Flow Test

Pulsed/wave flow tests will evaluate the effect of vegetation density on resistance. Vegetation resistance will be calculated as in previous STA experiments (Moustafa and Lal, 2016). Results will be included in a flow-depth-vegetation resistance diagram, to guide STA operation for optimum P removal.

III. WORK BREAKDOWN STRUCTURE

This project will be conducted in two phases. Phase I is the proof of concept to demonstrate that the flumes can adequately hold water and test measurements provide useful information. Once Phase I is completed and data collected are analyzed and documented, a STOP-GO decision will be made. The success of Phase I part of this SOW will be based on the successful installation of the two flumes and completing all proposed Benchmark/Pilot studies (Task 3).

1.0 Task 1: Meetings, Project Coordination / Management, Workplan

1.1 Kick-Off Meeting

A video conference will be held between the Consultant and the District Study Team to discuss the tasks and timelines including support for installing the two flumes. The Consultant will write up meeting notes and any action items to be taken by District staff and Consultant personnel. The District will provide one round of combined comments within the two weeks following receipt of these notes and the Consultant will provide one final revised version.

Deliverable:

- Meeting Notes / Action Items

1.2 Workplan

The Consultant will develop a Draft Project Work Plan in accordance with the project objectives and discussions presented at the Task 1.1 kickoff meeting. The workplan will provide specific criteria for flume installation, planting, water sampling, flow measurements, and flow regimes. This workplan will be developed in consultation with the District Study Team, the Vegetation Management section and Hydrology and Hydrodynamics section of the District. The Consultant will provide oversight of the flume installation and planting, which will be accomplished by sub-contractor(s).

District staff will provide one round of combined comments within two weeks following receipt of this Draft Project Work Plan. The Consultant shall provide the District with a Final Project Work Plan within two weeks of receipt of District comments. The Project Work Plan must include at a minimum:

- Project description and objectives
- Table of deliverables and delivery dates
- Flume installation
    - Reconnaissance meeting
    - Flume final specifications
    - Flume installation process and safety measures
- No-Flow Tests
- Constant Flow Tests
    - Salt and/or dye tracer Tests
    - SRP Tests
- Pulsed Flow Tests
- Sampling

        - Standard Operating Procedures and associated Quality Assurance Quality Control
        - Timing
        - Number of samples and/or sensors
        - Locations of samples and/or sensors
        - Statistics
    - Project Management information detailing the staffing arrangements, roles, and responsibilities and scheduled payment/invoices plan
    - Consultant's contingency plan in case of staff turnover

The District approved Final Project Work Plan shall become the binding document for this Work Order. Any changes to the Statement of Work (SOW) will be incorporated in a work order revision executed by the parties.

Deliverables

- *Draft Work Plan*
- *Final Work Plan*

1.3 Progress / Coordination Meetings

Video and/or tele-conference meetings will be held between the Consultant and the District Study Team at regular monthly intervals or when a need arise to discuss the progress of ongoing tasks, information needed, and project schedule. The Consultant will provide meeting notes that include an assessment of progress against the schedule and action items. The District will provide one round of combined comments on the meeting minutes and the Consultant will provide one final revised version.

Deliverables:

- *Brief monthly virtual meeting*
- *Monthly Meeting Minutes describing past and future project activities / action items, issues / concerns and solutions.*

2.0 Task 2 Flume Installation

2.1 Flume Installation design and specification plan

The Consultant and District Team, including vegetation management staff will have an on-site reconnaissance meeting. The purpose of the onsite meet is to evaluate existing STA-1W South Test Cell 13 conditions and discuss methods to be used for and logistics of flume installation. The Consultant shall submit a draft plan for installation and demobilization of the flume levees. The demobilization will be implemented by a separate work order.

To assure that the integrity of the underlying horizontal seepage barrier will not be compromised the plan will include the following requirements:

- A District employee and SFEC employee will be onsite to supervise the installation
- The Installer will avoid activities that could compromise the liner (digging into soil with a backhoe, moving equipment at high speeds, etc.)
- The installer will use construction mats at a minimum at ingress and egress sites for their equipment.

District staff will provide one round of combined comments within two weeks following receipt of this Draft Installation Plan. The Consultant shall provide the District with a Final Installation Plan within two weeks of receipt of District comments.

Deliverables

- *Draft flume installation design and specification plan*
- *Final flume installation design and specification plan*

2.2 Flume Installation design and specification plan

STA-1W south Test Cell 13 is selected to evaluate the new flume designs and complete Phase I of this study. Prior to flume installation, debris will be removed, the ground must be leveled, and the foundation area for the flumes must be compacted to make sure the flume walls do not tilt or sink.

One V-shaped and one S-shaped flume will be installed in STA-1W south Test Cell 13 (Figure 1). A sub-contractor will install the walls for these two flumes. The walls will be constructed using concrete blocks stacked two-high (Figure 2). The concrete blocks for this flume construction are interlocking, stackable concrete blocks. These blocks feature a 5 ½" V-interlock system to maintain integrity when building storage bins or retaining walls. An embedded rebar lifting hook is included for easy transport and placement. Concrete blocks dimensions are 6'x2'x2′ and weights range between weight: 3,200 lbs. and 3,700 lbs. Two three-foot weirs and one five-foot weir will be installed at the discharge ends of the V-shaped and Straight-flume, respectively.

The Consultant will construct walkways across each flume for sample collections. Locations of those walkways will be built at sampling locations as described in the work plan. These walkways will be used for data collections including, water quality samples, conductivity, stream gauging, water depth, and plant density measurements. The main reason for building those walkways is to avoid any disturbance in inside the flume interiors when collecting the required data.

Deliverables

- *Installed flume*

2.3 Flume Readiness Evaluation

After installation of the flumes, STA-1W Test Cell 13 will be cleared of vegetation before flooding either through direct removal or herbicide. The flumes will be hydrated, and the walls tested for leaks. The plumbing will be tested for operability and leaks. Any problems that could significantly affect planting, grow in or testing will be corrected. The Consultant will prepare a draft memo that reports on the flume installation and readiness for testing. District staff will provide one round of combined comments within two weeks following receipt of this memo. The Consultant shall provide the District with a final memo within two weeks of receipt of District comments.

Deliverables

- *Draft Memo on flume readiness for testing*
- *Final Memo on flume readiness for testing*

Figure 2. Proposed Concrete Blocks for constructing the V- and S-shaped flume walls for Phase I and Phase II of the Landscape Study.

3.0 Task 3: Proof-of-Concept Pilot Studies

3.1 Benchmark Steady State Flow and Salt Tests

This task will determine the required and needed information to set essential parameters for all flow experiments proposed in this study. Hydraulic loading rate (HLR) is a major key parameter that will be calculated based on 100% (high) and 50% (moderate) of the inflow discharge capacity of STAs and applied for the constant flow tests. This comparison will ensure a realistic check of coverage of flows between the more complex environment (e.g., actual STA) and the more controlled condition (i.e., Flume Study). Furthermore, these initial benchmark studies will determine the time needed to run all proposed flow-type runs and the effort needed to complete future tasks successfully.

This task will further test the integrity of the flume (leaks, further enforcement, and adjustment for inflow and outflow weirs, if needed). The initial salt addition tests will provide information on the amount of salt that can be added without exceeding background concentrations observed in STAs at the outflow of the test cell. The salt tests will include one run per each water depth (e.g., 1.25- and 2.75-ft) and one run per flow rate (high and moderate flow rate); a total of four runs. These runs will be used to determine time to steady state flow in the flumes. Steady state will be confirmed when inflow at the pipe and outflow at the weirs is equal ($Q_{in} = Q_{out}$). The total number of runs is eight, four for each flume (Table 1).

Table 1. Number of flume-runs for Benchmark Steady State flows (no vegetation planted yet). Two steady state runs for two water depths (1.25 and 2.75 feet), at two flows (high and moderate discharge) for instantaneous salt additions will be conducted in the two flumes.

Water Depth	High Flow Rate (100%)	Low Flow Rate (50%)	# of Flumes	# of runs
1.25	1	1	2	4
2.75	1	1	2	4
Total tests				**8**

The main parameters to measure are conductivity at pre-selected stations (inflow/outflow weirs, within the flume across transects and at the outflow of Test Cell 13. Flow at inflow and outflow weirs (i.e., measure water depth, above weir crest, and width of flow) will be calculated to determine when steady state has been reached (i.e., $Q_{in} = Q_{out}$).

The consultant will prepare a memo to document the work completed in this task. Associated data collected by the Consultant will be submitted to the District in Excel spreadsheet format.

Deliverables

- *Memo describing benchmark steady state flow and salt tests*
- *Excel Spreadsheet(s) of Data*

3.2 No-flow P removal study

A set volume of water will be discharged into the given flume. The inflow and outflow weir gates will be closed. Total P, particulate P and SRP will be sampled over the course of a 21-day period in at least two locations (near inflow and near outflow, Figure 3) to determine when the most P has been removed. This is the equilibration time point where the internal flux of P to the water column is equal to the removal by settling and plant uptake. This equilibration time point is considered the optimal retention period in this flume (HRT) for TP. The sampling schedule, location and frequency will be determined in the workplan (Task 1.2).

The consultant will prepare a memo to document the work completed in this task. Associated data collected by the Consultant will be submitted to the District in Excel spreadsheet format.

Table 2. Number of Samples and analyses for Benchmark No-Flow P Removal Study (no Vegetation).

Water Depth (ft)	Total # of sampling events (2 per week)	Sampling locations	# of Flumes	# of runs	# of samples	# of Analytes (TP, TDP, SRP)	# of analyses
1.25	6	3	2	2	72	3	216
2.75	6	3	2	2	72	3	216
Total				4	144		432

Deliverables

- *Memo describing benchmark No-flow P removal tests*
- *Excel Spreadsheet(s) of data*

3.3 Wave and Tracer Experiments

Wave and tracer experiments will be conducted for two pulse conditions and two water depths. water slope and flow per unit volume (q_o). Results from these benchmark tests (q_o, slope, and water depth, without vegetation) will be compared to the results obtained from previous full-scale experiments (i.e., STAs experiments) to confirm and validate the flow vs. slope and short circuit diagram.

Generated waves will be applied through pulsed flows to the flumes for a period of a few hours. Tracer studies may also be applied similar to the instantaneous additions of described in Task 3.5. Pressure sensors will be deployed throughout the flume to evaluate wave period and amplitude decay. The wave period and decay will provide estimates of vegetation resistance at low, medium and high depths. Tracer studies may provide information on short circuiting and mixing. Stream gauging will be conducted, if necessary, at several transects to measure velocities during pulsing experiment.

The maximum flow rate and timing of pulse flows will be determined in the workplan (Task 1.2). The minimum flow rate will be 0. At least two (2) wave frequencies will be tested. Wave trials will evaluate the effect vegetation resistance.

Waves will be generated at different frequencies (e.g., 2-, 4-hour cycle). Flow will be calculated and controlled at the inflow valve to reflect/mimic the selected frequency for each pulsing (at two different water depths 1.25 and 2.75-feet, Table 4). Three complete cycles (one complete cycle is the time between two peaks or two troughs) will be generated for each wave frequency (2- and 4-hours frequency). Salt will be added instantaneously at the inflow site. Conductivity sensors (i.e., 1-3 sensors per transect) placed at each transect will document and record the salt transport. Salt tracer studies may provide baseline (no vegetation) information on mixing due to pulsing. Adding SRP instantaneously and collecting grab samples along flow path (centerline and transect) will provide additional information regarding pulsing compared to steady flow condition and may provide insightful information regarding P uptake in wetlands. Modifications may be implemented based on results from the previous tracer study.

A draft report of methods, samples taken, and results for Tasks 3.1, 3.2 and 3.3 including an assessment of use of these flumes to conduct further transport studies. District staff will provide one round of combined comments within two weeks following receipt of this report. The Consultant shall provide the District with a final report within two weeks of receipt of District comments data collected by the Consultant will be submitted to the District in Excel spreadsheet. Samples submitted to the District's lab will be analyzed and results will be provided by the District. Study Lead to the Consultant in Excel spreadsheets.

Table 4. Number of samples for each Pulsing/Wave test and water depth Test

Pulse Test	**Water depth (ft)**	**# of Flumes**	**# of SRP Samples per Flume**	**Total # of SRP Samples**
Three cycles of 4-hour period waves	1.25	2	3	6
Three cycles of 4-hour period waves	2.75	2	3	6
Three cycles of 2-hour period waves	1.25	2	3	6
Three cycles of 2-hour period waves	2.75	2	3	6
Grand total tests and SRP samples		8		24

A draft report of methods, samples taken, and results for Tasks 3.1 and 3.2 including an assessment of use of these flumes to conduct further transport studies. District staff will provide one round of combined comments within two weeks following receipt of this report. The Consultant shall provide the District with a final report within two weeks of receipt of District comments data collected by the Consultant will be submitted to the District in Excel spreadsheet. Samples submitted to the District's lab will be analyzed and results will be provided by the District. Study Lead to the Consultant in Excel spreadsheets.

Deliverables

- *Draft Report of Proof-of-concept studies (Tasks 3.1, 3.2, and 3.3)*
- *Final Report of Proof-of-concept studies (Task 3.1, 3.2 and 3.3)*
- *Excel Spreadsheet(s) of data*

(STOP/GO) The District Study lead and team will review the documentation of Task 3.0 to determine if the study will continue to Phase II, based on the ability of the Consultant to adequately measure flow velocity and flow velocity changes, phosphorus removal, changes in salt concentrations and resultant hydrologic mixing and wave periodicity within the flumes.

4.0 Phase II Full Scale Landscape Study

Phase II will test various flow regimes (steady state, no flow, and pulsing) at the two different water depths after cattail are planted in the flumes and the plants grow in. These tests will be repeated at most three times after planting to evaluate the effects of increasing density of plants as they grow in at approximately 3, 6, and 15 months after planting.

4.1 Cattail Planting and Flume Readiness

Both Flumes will be planted with Cattails (*Typha sp.*) representing Emergent Aquatic Vegetation (EAV). The planting density and placement will be determined in consultation with Vegetation Management Staff (one-foot plants in all four directions). The consultant will write a draft memo describing the planting after completion. District staff will provide one round of combined comments within two weeks following receipt of this memo. The Consultant shall provide the District with a final memo within two weeks of receipt of District comments.

The consultant will provide a second memo at approximately three months to discuss cattail growth and readiness of flumes for testing. District staff will provide one round of combined comments within two weeks following receipt of this memo. The Consultant shall provide the District with a final memo within two weeks of receipt of District comments.

Deliverables

- *Draft memo on cattail planting*
- *Final memo on cattail planting*

4.2 No-flow P Removal Study

This experiment will be conducted, prior to the Tracer and P removal study (Task 4.4) for trial events a 3, 6, and 15 months after cattail planting. It is based on Task 3.2 methods and results. A set volume of water will be discharged into the test cell. The inflow and outflow gates will be closed, and P will be measured at two locations (near inflow and near outflow, Figure 3) over a 14 to 21-day period. (Table 5). The time at which P concentrations reach a minimum is considered the optimal hydraulic retention time in this flume (HRT) for given the age of the Cattail community. The sampling schedule, location and frequency will be determined in the workplan (Task 1.2).

The consultant will prepare a memo of methods, samples taken, and results at the end of each trial event (3, 6, and 15 months after cattail planting). Data collected by the Consultant will be submitted to the District in Excel spreadsheet. Samples submitted to the District's lab will be analyzed and results will be provided by the District Study Lead to the Consultant in Excel spreadsheets.

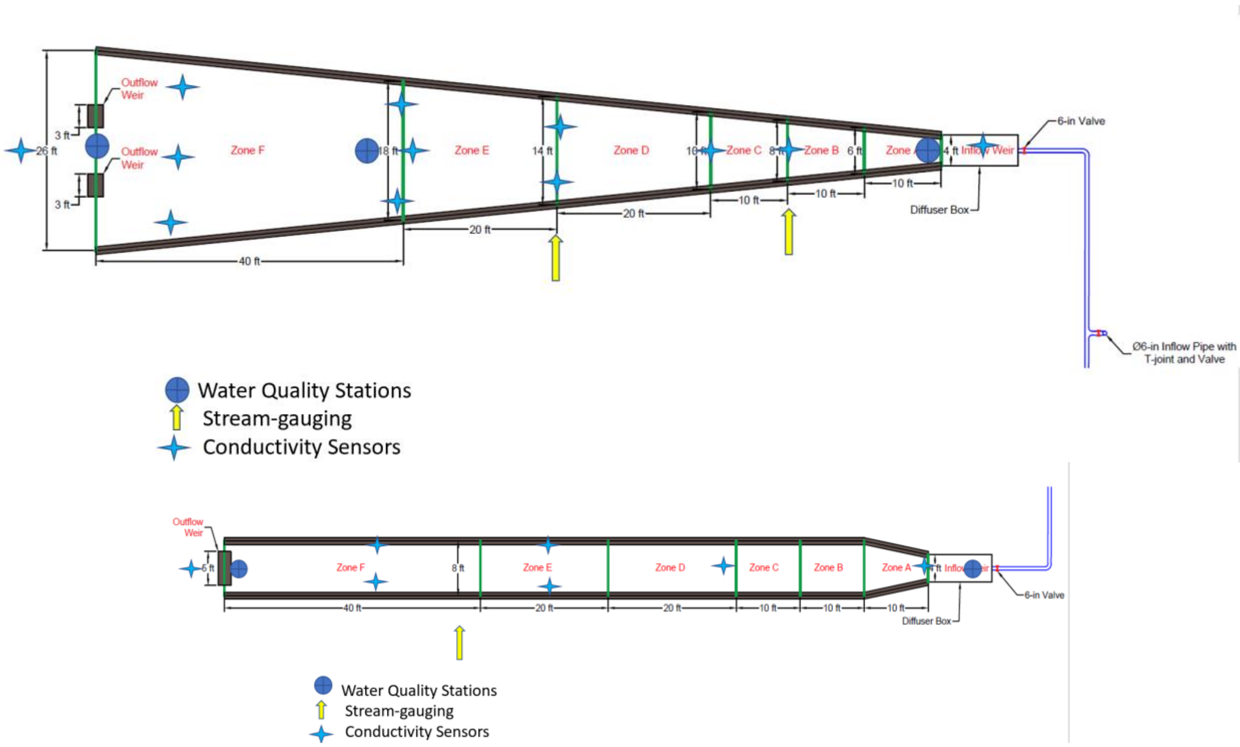

Figure 3. Proposed Sampling Stations Locations for both V- and S-shaped Flumes.

Table 5. Number of runs, samples, and analyses for the No-Flow P removal studies at 3, 6, and 15 months after cattail planting.

Water Depth (ft)	Total # of sampling events (2 per week)	Sample locations	# of Flumes	# of trials (2 per event at 3, 6, 15 months)	# of samples	# of Analytes (TP, TDP, SRP)	# of analyses
1.25	6	3	2	6	216	3	648
2.75	6	3	2	6	216	3	648
Total				12	432		1296

Samples will be taken to measure TP, TDP and SRP concentration at three locations within the flumes (inflow, midflow and outflow, Figure 3), on a twice a week basis during the 21-day experiment. This test will be repeated for up to three events (3, 6, and 15 months after Cattail planting). The optimal HRT will be determined based on the minimum TP, TDP, and or SRP values. This HRT is required to carry out Task 4.3.

Deliverables

- *Memo for Task 4.3 tests (at 3, 6, and 15 months after cattail planting)*
- *Excel Spreadsheet(s) of Data*

4.3 Low flow (≤10% flow rate) Tracer and P Removal Study

These experiments will be conducted/repeated at three events (3, 6, and 15 months after cattail planting, Table 6). Salt and SRP will be added all at once (instantaneous) at separate times. Instantaneous salt addition will measure transport time between inflow and outflow at a low inflow rate (≤ 10% of inflow capacity). Because salt is a conservative substance, it will also provide dispersion and diffusion estimates of transport at the low flow conditions. The difference between P decrease in SRP concentrations between inflow and outflow weirs, and salt concentration is the expected P treatment of EAV.

The amount of salt used will be described and documented from methods and results of pilot studies (Task 3) and will be calculated based on the volume in, and amount of flow to the test cell. The amount of salt dissolved in the water column will be within the background range of existing measurements in the STAs. The work plan (Task 1.2) for the tracer study will determine the number of locations sampled, the duration and timing of samples, in addition to the amount of salt and SRP for addition to the diffuser box.

The consultant will provide memos describing transport and P decay study methods and results through instantaneous addition of salt and SRP (less than one minute) for the two flumes. These memos will be prepared after events conducted at 3, 6, and 15 months after cattail planting.
Data collected by the Consultant will be submitted to the District in Excel spreadsheet. Samples submitted to the District's lab will be analyzed and results will be provided by the District Study Lead to the Consultant in Excel spreadsheets.

Table 6. Number of trials, samples and analysis for Low-Flow (≤ 10% flow rate) conditions to determine transport and P removal at two water depths (1.25 & 2.75 ft).

Water Depth	# of sondes and sonde readings	SRP samples per flume and trial	# of Flumes	# of trials (2 for each event month 3, 6, 15)	# of samples (only 1 analyte)
1.25	10-15 sondes (frequency every 15 minutes)	3	2	6	36
2.75	10-15 sondes (frequency every 15 minutes)	3	2	6	36
Total		6		**12**	**72**

Deliverables

- *Memo(s) of transport and P decay trials conducted at 3-, 5-, and 15-month events.*
- *Excel Spreadsheet(s) of Data*

4.4 Tracer and P Removal Study

These experiments will be conducted at 3, 6 and 15 months after planting (Table 7). Salt is added in two applications (instantaneous & over a 10-minute period), which will increase the conductivity to a point where it could be measured downstream with conductivity sensors with a high degree of accuracy. The amount of salt used is described in the workplan (Task 1.2) and is determined based on the volume in, and amount of flow to the test cell (Task 3). The amount of salt dissolved in the water column will be within the range of measurements of the conductivity meter.

The first application will add salt over a 10-minute period and will support analyses of vertical mixing. The second, a short addition (less than a minute), will support analyses of longitudinal mixing. A separate application of a given amount of SRP is added over one minute to measure the expected removal downstream. The work plan (Task 1.2) for the tracer study will determine the number of locations sampled, the duration and timing of samples, in addition to the amount of salt and SRP for addition to the diffuser box. Stream gauging (3-D velocity measurements) will be conducted at several transects (Figure 3) to measure velocities during those flume runs.

Twelve (12) trials at each water depth and salt additions will be conducted for 3 events (3, 6 and 15 months after cattail planting) (Table 8). Up to two runs per day are possible for the high flow rate (100%) and will be confirmed during Task 3.1.

The Consultant will prepare memos after each event at 3, 6 and 15 months. describing transport and P decay study methods, sampling, and results through instantaneous addition of salt and SRP (less than one minute) and the addition of salt and SRP over a 10-minutes period. Data collected by the Consultant will be submitted to the District in Excel spreadsheets. Samples submitted to the District's lab will be analyzed and results will be provided by the District Study Lead to the Consultant in Excel spreadsheets.

Table 7. Number of trials and SRP samples for each test type, water depth, flow, for 3, 6, and 15- month events to support analyses of vertical and longitudinal mixing.

Test type	**Water Depth**	**High flow Trials**	**Low flow trial**	**# of sondes and sonde readings**	**# of SRP samples (2 samples per flume, 2 flumes, 2 flows, 3 months)**	**# of trials (2 flumes, 2 flows, 3 months)**
Instantaneous Salt and SRP	1.25	1	1	10-15 sondes (15 mins frequency)	24	12
Instantaneous Salt and SRP	2.75	1	1	10-15 sondes (15 mins frequency)	24	12
10-minute SRP and Salt additions	1.25	1	1	10-15 sondes (15 mins frequency)	24	12
10-minute SRP and Salt additions	2.75	1	1	10-15 sondes (15 mins frequency)	24	12
Total					96	**48**

Deliverables

- *Memo(s) describing Tracer and P Removal Experiments for 3 events (3, 6, and 15 months after cattail planting)*
- *Excel Spreadsheet(s) of Data*

4.5 Wave and Tracer Experiments

Wave and tracer experiments will be conducted for 3 events (3, 6, and 15 months after Cattail planting, Table 8). Flows, measurements, sampling etc. may change for each study based on lessons learned from previous event(s). Work also includes measuring water slope and flow per unit volume (q_o) due to short-circuits, caused by existing vegetation growth over time during the duration of the experiment. Results from the test cell (q_o, slope, water depth, and vegetation resistance) will be combined with the results obtained from previous full-scale experiments (i.e., STAs experiments) to confirm and validate the flow vs. slope and short circuit diagram.

Generated waves will be applied through pulsed flows to the flumes for a period of a few hours. Tracer studies may also be applied similar to the instantaneous additions of described in Task 4.5. Pressure sensors will be deployed throughout the flume to evaluate wave period and amplitude decay. The wave period and decay will provide estimates of vegetation resistance at low medium and high depths. Tracer studies may provide information on short circuiting and mixing. Stream gauging will be conducted, if necessary, at several transects to measure velocities during pulsing experiment.

The maximum flow rate and timing of pulse flows will be determined in the workplan (Task 1.2). The minimum flow rate will be 0. At least two (2) wave frequencies will be tested. Wave trials will evaluate the effect vegetation resistance. Tracer studies may be conducted to evaluate the mixing effect pulsing cycles and any short-circuiting effects.

Waves will be generated at different frequencies (e.g., 2-, 4-hour cycle). Flow will be calculated and controlled at the inflow valve to reflect/mimic the selected frequency for each pulsing (at two different water depths 1.25 and 2.75-feet). Three complete cycles (one complete cycle is the time between two peaks or two troughs) will be generated for each wave frequency (2- and 4-hours frequency). Florescent dye tracer and salt will be added instantaneously at the inflow site. Video recording will document the progress of the dye, while conductivity sensors (i.e., 1-3 sensors per transect) placed at each transect will document and record the salt transport. Tracer and florescent dye tracer studies may provide information on short circuiting and mixing due to pulsing. Adding SRP instantaneously and collecting grab samples along flow path (centerline and transect) will provide additional information regarding pulsing compared to steady flow condition and may provide insightful information regarding P uptake in wetlands. Modifications may be implemented based on results from the previous tracer study.

The Consultant will prepare draft report after each event (3, 6 and 15 months after cattail planting)., that include methods, results, and findings from Tasks 4.2, 4.3, 4.4, 4.5 and 4.6 District staff will provide one round of combined comments within two weeks following receipt of each report. The Consultant shall provide the District with a final report within two weeks of receipt of District comments. Data collected by the Consultant will be submitted to the District in Excel spreadsheets and video recordings in electronic format compatible with District video applications (e.g.mp3). Samples submitted to the District's lab will be analyzed and results will be provided by the District Study Lead to the Consultant in Excel spreadsheets.

Table 8. Number of trials and samples, for each Pulsing/Wave test water depth and flume type at 3, 6, and 15 months after cattail planting.

Pulse Test	**Water Depth (feet)**	**Flume type**	**# of SRP Samples**	**Total Trials (2 per month x 3 months)**	**Total Number of SRP Samples**
Three cycles of 4-hour period waves	1.25	V	3	6	18
Three cycles of 4-hour period waves	2.75	V	3	6	18
Three cycles of 4-hour period waves	1.25	S	3	6	18
Three cycles of 4-hour period waves	2.75	S	3	6	18
Three cycles of 2-hour period waves	1.25	V	3	6	18
Three cycles of 2-hour period waves	2.75	V	3	6	18
Three cycles of 2-hour period waves	1.25	S	3	6	18
Three cycles of 2-hour period waves	2.75	S	3	6	18
Grand total of flume trials and WQ samples			24	48	144

Deliverables

- *Draft report(s) describing Task 4.2, 4.3, 4.4, 4.5, and 4.6 at the end of each event (3, 6, and 15 months after cattail planting).*
- *Final Memo(s) describing Task 4.2, 4.3, 4.4, 4.5, and 4.6 at the end of each event (3, 6, and 15 months after cattail planting).*

4.6 Final Report

All hydrology, hydrodynamic, water quality, solids and soils data collected for all Task 4 studies will be compiled, synthesized, and analyzed to determine the effect of different flow regimes, variation, and vegetation on enhancement of sheet flow and P removal. The results of data analysis will form the basis for a final report that will include management recommendations to improve STA performance. The District will provide one round of combined comments on the draft reports and the Consultant will provide one final revised version.

Deliverables

- *Draft final report*
- *Final Report*

IV. HARDWARE-SOFTWARE

The Consultant shall be responsible for providing the hardware and software necessary to complete the above tasks. Software products will be compatible with Microsoft Office 2016 version, Stella Architect 1.8.3, and/or Berkeley Madonna 10.2.8.

V. RESPONSIBILITIES OF REQUESTING DIVISION

The District Project Manager will be responsible for evaluating and accepting all deliverables, coordinating meetings between the Consultant and District personnel, scheduling presentations, coordinating internal reviews, and returning reviewed documents within the agreed upon number of business days for revision, receiving the final report, and approving payment to Consultant.

VI. EVALUATION CRITERIA FOR ACCEPTANCE OF DELIVERABLES

Successful completion of this project will be evidenced by the judgment of District staff that the materials produced by the Consultant are understandable, clear, and performed in a timely and satisfactory manner. In addition, the Consultant's technical evaluation must be thoughtful, scientifically accurate, and satisfy the Project's objectives.

VII. DATA COLLECTION AND REPORTING

All data products shall be made available to the District Project Manager without restriction and be accompanied by comprehensive metadata documentation in the required data format. Quality assurance and data validation is a high priority at the District. All data products and associated metadata created under this Statement of Work shall undergo a strict quality assurance/quality control screen by the Consultant prior to submittal to the District.

Any manuscripts, technical publication, presentation slides or other documents resulting from or related to the work performed under this contract shall be submitted to the District for review prior to publication by the Consultant in any forum or format. This paragraph shall survive the expiration or termination of this contract.

VIII. REFERENCES

DB Environmental, I. 2009. Tracer Study: PSTA Cell, STA-3/4 - Task 3: Final Technical Memorandum. Rockledge, FL.

Diaz, O. 2022. Appendix 5C-1: Evaluation of Inundation Depth and Duration Threshold for *Typha domingensis* (Cattail) Sustainability: Test Cell Study. In 2022 South Florida Environmental Report – Volume I, South Florida Water Management District, West Palm Beach, FL.

Test Cell Study, in South Florida Environmental Report. Volume I. South Florida Water Management District, West Palm Beach, FL

Florida International University, 2019. Setting and Entrainment Properties of STA Particulates/ Work Order #4600003032-WO02 – 9500006758. Submitted to South Florida Water Management District, West Palm Beach, FL.

Hootsmans, M. J. M., and F. Wiegman. 1998. Four helophyte species growing under salt stress: their salt of life? Aquatic Botany 62:81-94

Lal, A. W. 2017. Mapping Vegetation-Resistance Parameters in Wetlands Using Generated Waves. Journal of Hydraulic Engineering 143.

Lal, W. A., M. Z. Moustafa, and W. M. Wilcox. 2013. The Use of Discharge Perturbations to Characterize In-Situ Vegetation Resistance. South Florida Water Management District, West Palm Beach, FL.

Lal, W. A., M. Z. Moustafa, and W. M. Wilcox. 2015. The use of discharge perturbations to understand in situ vegetation resistance in wetlands. Water resources research 51:2477-2497.

Moustafa, M. Z. and W. A. 2016. Vegetation Resistance Field Experiment in Stormwater Treatment Area: A Users' Guide; Prepared for: H & H Staff Training Purposes.

Exhibit C-9
Payment and Deliverable Schedule
4600004015-WO09
Sustainable Landscape and Treatment in a Stormwater Treatment Area Study

Task	Activity Description	Duration (weeks)	Start	End	
	Task 1 - Meetings, Work Plan Project Coordination/Management				
1.1	Kickoff meeting (notes)	0	4/1/2022	4/1/2022	
1.2	Draft Work Plan	2	4/1/2022	4/15/2022	
	Final Work Plan	2	4/15/2022	4/29/2022	
1.3	Progress/Coordination Meetings (notes)	64	4/1/2022	6/23/2023	
	Task 2 - Flume Installation				
2.1	Draft flume Installation design and specification plan	2	4/15/2022	4/29/2022	
	Final flume Installation design and specification plan	2	4/29/2022	5/13/2022	
2.2	Flume installation	2	5/13/2022	5/27/2022	
2.3	Draft flume readiness evaluation memo	2	5/27/2022	6/10/2022	
	Final flume readiness evaluation memo	2	6/10/2022	6/24/2022	
	Task 3 - Proof of concept studies				
3.1	Benchmark Steady State flow and salt tests (memos and data in Excel Spreadsheets)	2	6/24/2022	7/8/2022	
3.2	No-flow P removal study (memo and data in Excel Spreadsheets)	4	7/8/2022	8/5/2022	
3.3	Wave and tracer experiments and Draft final report of Task 3 - including Task 3.3 data in excel spreadsheets	6	8/5/2022	9/16/2022	
	Final report Task 3	2	9/16/2022	9/30/2022	
	Total Phase I				

	Task 4 - Full Scale Landscape study				
4.1	Plant flumes with Cattail (draft and final memo)	2	9/16/2022	9/30/2022	
4.2	No-Flow P removal Study (3, 6, 15 months: memo(s) and Excel Spreadsheets of data)	52	9/30/2022	9/29/2023	
4.3	Low Flow Tracer and P removal study (3, 6, 15 months: memo(s) and Excel Spreadsheets of data)	52	9/30/2022	9/29/2023	
4.4	Tracer and P removal experiments (3, 6, 15 months: memo(s) and Excel Spreadsheets of data)	52	9/30/2022	9/29/2023	

4.5	Pulsed flow wave and tracer experiments (3, 6, 15 months: memo(s) and Excel Spreadsheets of data)	52	9/30/2022	9/29/2023	
4.6	Draft Final Report	4	9/29/2023	10/27/2023	
	Final Report	2	10/27/2023	11/10/2023	
	Total Phase II				
	Work Order Total				