Chapter 5C: Update for the Restoration Strategies Science Plan

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SUMMARY

In 2012, the State of Florida and the United States Environmental Protection Agency (USEPA) reached consensus on new Restoration Strategies for Clean Water for the Everglades (Restoration Strategies). State and federal permits established stringent total phosphorus (TP) limits in the form of a water quality based effluent limit (WQBEL; SFWMD 2012) for water discharged from Everglades Stormwater Treatment Areas (STAs). Consent orders associated with these permits require that the South Florida Water Management District (SFWMD or District) develop and implement a science plan to enhance the understanding of mechanisms and factors that affect phosphorus (P) treatment performance of the STAs. The *Science Plan for the Everglades Stormwater Treatment Areas* (Science Plan; SFWMD 2013b) was submitted to the Florida Department of Environmental Protection (FDEP) in June 2013. Detailed study plans (DSPs) were developed to guide implementation of the Science Plan and the results from the studies may be used to inform the operation or management of facilities that will improve capabilities of the STAs to achieve the WQBEL. The status of each of the nine ongoing Science Plan studies through Water Year 2016 (WY2016) (May 1, 2015–April 30, 2016) is presented in this chapter. A brief summary of the studies are provided in the next paragraphs. Detailed information on four of the Science Plan studies is presented in Appendices 5C-1, 5C-2, 5C-3 and 5C-4.

Use of Soil Amendments/Management to Control P Flux. This study was developed to evaluate whether internal loading of P in the STAs (i.e., the flux of P from the soil to the water column) can be reduced by soil amendments and/or soil management techniques. A comprehensive review of available technologies and amendments indicated that many could lower P concentrations, however there are uncertainties in treatment efficacy and potential impacts to STA operations, along with high estimated costs for implementing these technologies at full-scale in the STAs. At this time, no further evaluation is planned for any soil amendments. A field-scale investigation of the benefits of soil inversion will be performed at STA-1WX1 (Expansion Area #1).

Development of Operational Guidance for Flow Equalization Basin (FEB) and STA Regional Operation Plans. Toolsets and methodologies are being prepared that support the development of operational guidance and plans for the FEBs and STAs to assist in achieving the WQBEL. This includes evaluation of hydraulics, hydrologic and operational model parameters, operating strategies, and application of system optimization tools. Field tests were performed that yielded an improved representation of hydraulics within the STAs. These results can be applied to a variety of STA vegetation types and facility configurations and are used to define operational strategies and protocols. An optimization tool was developed to help inform weekly decision making by approximating potential TP outflow operational flow routing regimes.

Investigation of STA-3/4 Periphyton-based Stormwater Treatment Area (PSTA) Performance, Design, and Operational Factors. The characteristics and design and operational factors of the PSTA Cell in STA-3/4 that contribute to its superior treatment performance are being assessed. The PSTA cell has consistently achieved outflow flow-weighted mean TP concentrations of 13 micrograms per liter (µg/L or 13 parts per billion [ppb]) or lower on an annual basis. Preliminary results indicate that increased hydraulic and TP loading had no adverse effect on treatment performance and, operating at water depths up to 0.55 meters (m), did not affect TP removal performance. Results also indicate lower outflow TP was observed during the wet season and when inflow TP concentrations exceeded 22 µg/L (22 ppb) outflow concentrations generally exceeded 13 µg/L (13 ppb).

Evaluate P Sources, Forms, Flux and Transformation Processes in the STAs. This study is being implemented to enhance the understanding of the mechanisms and factors that affect P treatment performance of the STAs, particularly those that are key drivers of performance at the lower reaches of STA flow-ways. Initial data gathering and controlled flow experimentation have been conducted in two flow-ways in STA-2 (Flow-ways 1 and 3) and baseline sampling has been conducted for water quality, soils, and vegetation in these two flow-ways and in the Western Flow-way of STA-3/4.

Evaluation of the Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow P Concentrations. This study is evaluating if STA inflow or outflow canals are a source or a sink for TP and if so, to identify factors that influence this behavior. Five STA canals are being evaluated. Results to date suggest (1) the STA-1 Inflow Basin Canal behaved as a TP source, however no additional evaluation is recommended as operation of the L-8 FEB is expected to reduce peak flows into this canal; (2) the STA-2 supply/inflow canal source/sink behavior was inconclusive, therefore limited field study will be conducted; (3) the STA-3/4 supply/inflow canal behaved as a TP sink, therefore no additional evaluation is recommended; (4) the STA-1W discharge canal behaved as a sink and it will become part of STA-1WX1 (Expansion Area #1) therefore, no additional evaluation is recommended. Evaluation of the STA-2 discharge canal is under way.

Evaluation of Inundation Depth and Duration for Cattail Sustainability. Identification of the inundation depth and duration threshold to sustain cattail (*Typha domingensis*) communities in the STAs will be evaluated. Inundation that exceeds optimal water depth and duration causes increased stress to cattail causing cattail density and/or growth to decline in STA emergent aquatic vegetation (EAV) treatment cells. The study has two main components, in-situ and test cells. Preliminary evaluation of the in-situ data collected to date does not indicate clear relationships between depth and vegetation condition. In-situ data collection and analysis is continuing. Cattail grow-in for the test cells component will occur in 2016 and 2017.

STA Water and P Budget Improvements. Improved annual STA water and P budgets for STA treatment cells are needed in order to improve the accuracy of estimating STA cell performance and to identify areas of uncertainty in these budgets. A test case was performed in STA-3/4 to improved cell water budgets using simplified desktop approaches. The test case methodologies are being applied to selected treatment cells and will include development of improved water and P budgets.

Evaluation of Sampling Methods for TP. Current sampling and monitoring techniques are being evaluated to determine the accuracy of sampling TP and to determine what factors are influencing the results. The study included collection of surface water samples using flow proportional autosamplers, time proportional autosamplers, grab samples, and remote P analyzers (RPAs). Cameras and probes were also used at the study sites. Results were used to evaluate sampling quality assurance, autosampler design, data interpretation, and impacts from environmental factors.

Investigation of Rooted Floating Aquatic Vegetation (rFAV) in STAs. This study is assessing the ability of rFAV to enhance low-level P removal performance of submerged aquatic vegetation (SAV) communities in downstream portions of STAs. White water lily (*Nymphaea odorata*), American lotus (*Nelumbo lutea*), and spatterdock (*Nuphar advena*)—three rFAV species—occur in P-deficient

environments of the water conservation areas (WCAs) and have formed dense stands in some STAs. Communities with rFAV+SAV will be compared to communities with SAV-only in the STAs to evaluate effects of the rFAV on surface water quality.

INTRODUCTION

In June 2012, the State of Florida and USEPA reached consensus on new Restoration Strategies (see Chapter 5A of this volume) for further improving water quality in the Everglades. A National Pollutant Discharge Elimination System (NPDES) permit, along with a new state-issued Everglades Forever Act (EFA) watershed permit, established stringent TP limits, referred to as a WQBEL, for water discharged from the Everglades STAs to the Everglades Protection Area (EPA). One of the requirements in the NPDES and EFA watershed permits and associated consent orders requires the development and implementation of a science plan to enhance the understanding of mechanisms and factors that affect P treatment performance, particularly, those that are key drivers to performance at low TP concentrations (< 20 µg/L).

Pursuant to the consent orders, the Science Plan (SFWMD 2013b) was developed by the District in consultation with technical representatives designated by FDEP and USEPA (referred to as Technical Representatives), on behalf of the state and federal agencies, respectively. The complete version of the Science Plan is available on the District's website at www.sfwmd.gov/rs_scienceplan. The Science Plan is a strategic document that will be revised and updated as needed. Implementation of the Science Plan is guided by a five-year work plan that is comprised of DSPs. The DSPs include background information, study objectives and hypotheses, proposed methodology, and activities and milestones. The DSPs, dated September 2014, are also available at www.sfwmd.gov/rs_scienceplan. Results from these studies may be used to inform the design and management of the STAs to further improve STA performance. Related data and information gathered from these studies will also be incorporated into the development and refinement of the District's operational guidance tools.

This chapter provides a summary of the Science Plan progress through WY2016. As the current studies and new studies are implemented, future *South Florida Environmental Reports* (SFERs) will integrate and synthesize information to communicate progress. The progress and findings for the different studies are continually evaluated to identify needed policy and management actions, additional areas of uncertainty, and information gaps to direct future Science Plan efforts. The status of each Science Plan Study is presented below. Detailed information on four Science Plan studies is presented in Appendices 5C-1, 5C-2, 5C-3, and 5C-4.

STATUS OF SCIENCE PLAN STUDIES

USE OF SOIL AMENDMENTS/MANAGEMENT TO CONTROL PHOSPHORUS FLUX

Michael Chimney

The purpose of this study is to investigate whether internal loading of P in the STAs (i.e., the flux of soluble P from the soil to the overlying water column) can be reduced by application of soil amendments and/or soil management techniques and, thereby, lower outflow TP concentrations. The study originally was to be conducted in three phases with a STOP/GO decision made at the conclusion of the first two phases. All work on Phase I has been completed and findings are summarized in a District technical publication (Chimney 2015). This report also proposed two options for conducting Phase III large-scale field trials within the STAs. Considering the uncertainties in treatment efficacy, potential impacts to STA operations, the estimated cost of conducting large-scale field trials, and the practicality of implementing any of these technologies at full-scale in the STAs, testing will only be performed on soil inversion at a large scale at STA-1WX1 (Expansion Area #1) and work on Phases II and III for any of the other technologies will not be performed at this time. A summary of progress on this study is presented in **Table 5C-1**, and more detailed information on this study is presented in Appendix 5C-1.

Table 5C-1. Use of Soil Amendments/Management to Control P Flux summary of progress to date.

Task	Status and Comments	Publication or Report
Phase I: Review of existing information Task 1 - Expand an literature review on technologies for controlling soil P flux in wetlands or lakes Task 2 - Synthesize relevant past SFWMD supported projects Task 3 - Assess the feasibility of implementing these technologies at full-scale in the STAs	All tasks completed in October 2015 (WY2016)	Chimney 2015
Phase II: Small-scale experiments to screen a variety of soil amendments/management techniques identified in Phase I for their ability to inhibit soil P flux.	A decision was made not to proceed with Phase II at this time based on the recommendation to only investigate soil inversion in Phase III of this study. Therefore, there is no need to screen soil amendments for future testing	
Phase III: Large-scale field trials to test the most promising soil amendments/ management techniques identified in Phase II testing.	Phase I developed cost estimates and infrastructure requirements to conduct large-scale field trials of soil amendments, soil capping, and soil inversion scenarios to implement these technologies in the STAs. Based on these projected costs and other considerations, a decision was made to only proceed with field-scale testing of soil inversion in the STA-1WX1 at this time.	

DEVELOPMENT OF OPERATIONAL GUIDANCE FOR FLOW EQUALIZATION BASIN AND STORMWATER TREATMENT AREA REGIONAL OPERATION PLANS

Zaki Moustafa and Walter Wilcox

The purpose of this is study is to develop toolsets and methodologies that support the development of operational guidance and regional operation plans for FEBs and STAs that best enable STAs to consistently achieve the WQBEL for TP. The study includes multiple tasks as follows:

- Information gathering on STAs and field tests to evaluate hydraulics and water quality
- Development of hydraulics, hydrologic, and operational model parameters
- Development of local (STAs and FEBs) and regional operating strategies and rules, and application of system optimization tools

To date, a number of field tests have been performed that yielded an improved representation of hydraulic dynamics in the STAs. Results showed that there are two distinctly different depth-based flow regimes in vegetated wetlands. One flow regime shows predominantly laminar flow behavior, while the other exhibits turbulent flow behavior. Both flow regimes have significantly different discharge characteristics (laminar and turbulent) and this means that treatment and discharge behavior can be governed by two separate resistance equations. These results can be applied to a variety of STA vegetation types (e.g., EAV and SAV) and facility configurations allowing for improved estimation of water depths and residence times in real-world application and enhanced representation in physically-based models for project planning or design. Study efforts to provide enhanced operational protocols have also produced useful outcomes. Real-time automation tools have been developed to assist in defining structure gate openings needed to achieve desired flow targets. Additionally, draft operational guidance for the A-1 FEB was developed to approximate depth and discharge regimes planned during the Restoration Strategies project development. Significant progress has been made on the development of an iModel© optimization tool (Jayasuriya and Hajieghrary 2013) to help inform weekly decision making by approximating the potential P outflow ramifications of operational flow routing regimes under consideration. A summary of progress on this study is presented in **Table 5C-2**.

Table 5C-2. Development of Operational Guidance for FEB and STA Regional Operation Plans – summary of progress to date.

Task	Status and Comments	Publication or Report
Information Gathering-Consolidation	Subject matter expert and historical data compilation tasks completed as envisioned in 2013. Literature review, information consolidation ongoing.	SFWMD 2013a
Information Gathering-Field Tests	Field tests were performed across a wide range of STA vegetation types, examining both hydraulic and P dynamics. STA-3/4 Cell 3A completed in 2013. STA-2 Cell 3 completed in 2014. STA-3/4 Cell 2A completed in 2015.	Lal et al. 2013 Lal et al. 2014 Lal 2015a, b Lal et al. 2015 Lal et al. 2016 Mustafa et al. 2014
Development of Hydraulic and Model Parameters	Results from the field tests provided updates to RSM-TVDLF model parameters. RSM source code efforts restructured RSM libraries to allow for increased model portability and ability to incorporate new algorithms. A guidance matrix was provided upon initial startup of the A-1 FEB that provided desirable seasonal FEB depth and discharge ranges for operations consistent with the Restoration Strategy planning work performed with the Dynamic Model for Stormwater Treatment Areas (DMSTA) model.	
Development of Operational Strategies and Operational Support Tools	A series of control-room support tools (Wave-Bot, Wave-Op, etc.) provided recommended gate openings at 15-minute intervals to achieve target flow rates into STA cells. The SFWMD iModel© tool was implemented using modeled DMSTA results and is being updated to utilize real-world flow and P data for the Restoration Strategies Central Flow Path.	Ali 2014
Application of System Optimization Tools	An investigation into the application of control theory to the STAs concluded that the STAs could indeed be conceptualized and modeled as controlled systems.	Jayasuriya and Hajieghrary 2013 Ali and Wilcox 2016

INVESTIGATION OF STA-3/4 PERIPHYTON-BASED STORMWATER TREATMENT AREA PERFORMANCE, DESIGN, AND OPERATIONAL FACTORS

Manuel Zamorano and Tracey Piccone

The purpose of this study is to assess the chemical and biological characteristics and the design and operational factors of the PSTA Cell in STA-3/4 that contribute to the superior treatment performance of this technology. During nine years of operation the outflow flow-weighted mean TP concentrations ranged from 8 to 13 µg/L. The operational ranges under which the PSTA Cell has achieved ultra-low outflow TP levels are being evaluated. A summary of progress on this study is presented in **Table 5C-3**, and more detailed information on this study is presented in Appendix 5C-2.

Table 5C-3. Investigation of STA-3/4 PSTA Performance Design and Operational Factors – summary of progress to date.

Task	Status and Comments	Publications and Reports
Evaluation of the effects of pulse flows on PSTA treatment performance	Task was completed in WY2016. Pulse flow events and associated higher P loads had no adverse effect on the PSTA Cell's P treatment performance.	Zamorano 2015
Evaluation of the effects of constant flows on PSTA treatment performance	Task started in WY2012 and is scheduled to be completed in WY2017.	
Evaluation of the effects of season, time of day, water depth, and inflow concentration on PSTA treatment performance	Task started in WY2012 and will be completed in WY2018. Two different operational water depths—0.40 meter (1.3 feet) and 0.55 meter (1.8 feet)—were evaluated; there was no significant difference in treatment performance between the two depths. Time of day did not affect outflow TP concentration. Lower outflow TP observed during the wet season. When inflow TP concentrations exceeded 22 µg /L, outflow concentrations generally exceeded 13 µg/L.	James 2015 Zamorano 2015
Evaluation of the effects of seepage on PSTA treatment performance	Task started in WY2012 and will be completed in WY2018. Stage differences were the driving force for seepage flow and were used to estimate seepage flow rate and direction. The percent of net seepage to the PSTA Cell varied from 5 to 37 percent depending on the hydrological conditions. Years with a large percent of estimated seepage into the PSTA Cell were a result of the stage differences between the cell and surrounding water bodies. As a result of the 0.15 meter (0.5 foot) increase in the target stage, the head difference between the PSTA Cell and the surrounding water bodies was reduced, thereby reducing seepage into the PSTA Cell. Lateral seepage through the levee between the Lower SAV Cell and the PSTA Cell was the larger contributor of seepage into the PSTA Cell compared to upward movement of deep groundwater into the cell.	Zhao et al. 2015b Zamorano 2016 Polatel and Zamorano 2016

Table 5C-3. Continued.

Task	Status and Comments	Publications and Reports
Evaluation of limerock cap as an alternative to scraping to achieve treatment performance demonstrated by the PSTA Cell	Task started in WY2012 and is scheduled to be completed in WY2018. Limerock-capped mesocosms produced outflow concentrations similar to the muck-scraped PSTA Cell. Muck soil with P content that is low (and chemically stable) can produce ultra-low outflow water P concentrations, with or without a calcareous substrate.	DBE 2015a DBE 2016a
Evaluation of the sustainability of PSTA treatment performance through analysis of sediment accrual and vegetation nutrient contents	Task started in WY2012 and is scheduled for completion in WY2018. There was no difference in sediment accrual depth or sediment P content between inflow and outflow regions of the PSTA Cell. Macrophyte tissues and periphyton showed decreasing P content with distance through the PSTA Cell. STA-3/4 PSTA Cell SAV communities generally had lower tissue P content relative to SAV communities in the outflow region of P-enriched muck-based STA cells.	DBE 2015a DBE 2015b

EVALUATE PHOSPHORUS SOURCES, FORMS, FLUX, AND TRANSFORMATION PROCESSES IN THE STORMWATER TREATMENT AREAS

Odi Villapando, Jill King, and Delia Ivanoff

The purpose of this study is to enhance the understanding of the mechanisms and factors that affect P treatment performance of the STAs, particularly those that are key drivers of performance at the lower reaches of the treatment flow-ways. This study is an evaluation of P sources, forms, flux, and transformation processes along the STA flow-ways and is comprised of several substudies that are in various stages of implementation. These include data mining; literature review; P speciation; flow-way assessments at different flow conditions; comparison of processes, mechanisms, and factors relevant to uptake in WCA-2A; particle transport; soil characterization; measurement of P flux; evaluation of trends and patterns of enzyme activity; vegetation assessments; and quantification of faunal assemblages and excretion. The results will be used to develop strategies that will ultimately improve capabilities of the STAs to reduce P in surface water discharge. The study is being conducted in STA-2 Cell 1, STA-2 Cell 3, and STA-3/4 Western Flow-way under different flow conditions utilizing runoff water as the primary water source. A summary of progress on this study is presented in **Table 5C-4**, and more detailed information on this study is presented in Appendix 5C-3 on four substudies; data mining, flow-way assessments, P flux measurements, and faunal quantification.

Table 5C-4. Evaluate P Sources, Forms, Flux, and Transformation Processes in the STAs – summary of progress to date.

Substudy	Status and Comments	Publications and Reports
Organic P Speciation	Started in 2016 and will be completed in 2017. Developing method to characterize and quantify the different forms of organic P in soil and water.	University of Florida 2016a
Flow-way Assessment	Started in January 2015, to be completed in 2020. Three controlled flow events have been completed in STA-2 • Cell 1 with runoff. Stagnant-no flow/low flow, 100–150 cubic feet per second (cfs)/normal operations. • Cell 1 with primarily Lake Okeechobee water. Stagnant/low flow/stagnant. • Cell 3 with runoff. High flow, 300-350 cfs/stagnant/normal operations. Each flow event transect monitoring consisted of water quality sampling via autosamplers and grab sampling, enzyme activity assays, porewater profile sampling, flux chamber sampling, and in-situ measurements. An RPA was installed at the outflow of STA-2 Cell 3. Additional controlled flow events are planned for the three study flow-ways from 2016 through 2020. More detailed information on this substudy is presented in Appendix 5C-3.	University of Florida 2016b

Table 5C-4. Continued.

Sub-study	Status and Comments	Publications and Reports
P Flux	Started in January 2015, to be completed in 2020. Data mining indicated correlations between soil P, porewater P, and water column P concentrations. A total of 18 chambers (two sets of nine) installed in STA-2 Cells 1 and 3 for measurement of P flux in vegetated versus unvegetated areas at the inflow, middle, and outflow regions of the cells. Measurements in chambers performed in STA-2 Cells 1 and 3 during controlled flow events described above. Completed data mining and analysis of historical data (2005–2010) for surface water, porewater, and soils collected from selected flow-ways. More detailed information on this substudy is presented in Appendix 5C-3.	DBE 2016b
Particle Transport	Started in March 2016, to be completed in October 2017. Initial field work began with collection and analysis of 12 sediment cores from STA-2 Cell 3 and STA-3/4 Cell 3B. Cores analyzed at 1-centimeter intervals to determine critical shear stress thresholds (for erosion) and settling rates versus depth and particle size. Nutrient analysis of these cores will provide information on TP suspension and settling rates. Deployment of continuous monitoring acoustic Doppler velocimeters (ADV) in progress to quantify velocity during pulse and storm events (as opportunities arise).	
Soil Characterization	Started in September 2015, to be completed in May 2018. Baseline spatial soil sampling completed for STA-2 Cells 1 and 3, and STA-3/4 Cell 3A and 3B. Analysis and evaluation of soil physio-chemical data from spatial soil sampling near completion.	
Vegetation Assessment	Started in September 2015, to be completed in early 2018. Analysis of vegetation coverage from 2015 high altitude flight has been completed. This will be performed again in 2016. Vegetation analysis with a low altitude camera referred to as a “Box On Airplane” was tested but due to the complexity of the associated software and data storage requirements an alternate approach with satellite imagery (Worldview 2) will be tested. Ground surveys for SAV in STA-3/4 Cell 3B was conducted in 2015. Additional semi-annual surveys planned for next water year. Initial vegetation sampling was completed in STA-2 Cell 1 (EAV) and Cell 3 (SAV). Samples were analyzed for biomass, TP, total nitrogen, total carbon, total calcium, and ash content.	
Enzyme Activity	Started in January 2015, to be completed in 2020. Completed enzyme assay analyses for surface water, periphyton, floc, and litter for high flow event data analysis is nearly completed.	

Table 5C-4. Continued.

Sub-study	Status and Comments	Publications and Reports
Fauna	Started in October 2015, to be completed in December 2017. Preliminary sampling (40 throw-traps) completed in STA-2 for small-bodied fish and macroinvertebrates. A power analysis was conducted to determine minimum number of throws to obtain estimates of biomass. Additional sampling (124 throw traps) was completed in STA-2 for small-bodied fish and macroinvertebrates. Sites were selected with a stratified random process based on vegetation plots. Preliminary sampling was completed for large-bodied fish (122 electrofishing transects) in STA-1E, STA-1W, and STA-2. The power analysis indicated that the number of samples in the initial effort was adequate. This will be repeated in August 2016. The wet-weight of individuals will be determined for all STA fish and all fish collected for monitoring in the Everglades (non-STA) to compare condition factors. All avian surveys for WY2016 were completed (bi-weekly from October to May). The video data are being analyzed. More detailed information on the avian portion of this substudy is presented in Appendix 5C-3.	

EVALUATION OF THE INFLUENCE OF CANAL CONVEYANCE FEATURES ON STORMWATER TREATMENT AREA AND FLOW EQUALIZATION BASIN INFLOW AND OUTFLOW PHOSPHORUS CONCENTRATIONS

Hongying Zhao and Tracey Piccone

The purpose of this study is to determine if TP concentrations change when conveyed through STA inflow or outflow canals and if so, what factors influence such changes. The study includes estimating how much sediment and TP have accumulated in canals over the analysis period. Canal sediment that appears to be impacting water quality and compliance with the WQBEL is of particular concern. Six STA canals are included in the study, which is organized in two phases. Both phases may not be needed for all STA canals. Phase I includes a literature review, as-built drawing review, and data query of existing relevant data. Phase I also includes detailed analyses of existing water quality and flow data to determine if the canal is a TP source or a TP sink. Concentration-based analyses and a mass balance approach in combination with statistical analysis tools are used to address these objectives. Results of Phase I are intended to be used to guide Phase II field work (if needed). The Phase II field investigations may include sediment thickness probing, sediment core sampling, canal cross-section surveys, and laboratory analysis for sediment chemical and physical parameters. A summary of progress on this study is presented in **Table 5C-5**.

Table 5C-5. Evaluation of the Influence of Canal Conveyance Features in STA and FEB Inflow and Outflow P Concentrations – summary of progress to date.

Task	Status and Comments	Publications and Reports
Literature review, as-built drawing review, and data query of existing relevant data	Completed in July 2015.	Zhao et al. 2015c
STA-1 inflow basin canal evaluation to determine if canal is TP source or sink	Phase I study was completed in July 2015. Results suggested canal behaved as TP source over period analyzed. Phase II field study is not recommended because once L-8 FEB is operational, STA-1 inflow basin canal will have reduced peak flows and less potential for sediment/TP export.	Zhao et al. 2015a
STA-2 supply/inflow canal evaluation to determine if canal is TP source or sink	Phase I study was completed in May 2016. An analysis of available data was not sufficient to make a determination on whether this canal behaved as TP source or sink. Phase II field study is planned to determine if sediment deposition or scour has occurred. This is scheduled to begin mid-2016 and to be completed in 2017.	Ecology and Environment, Inc., and SFWMD 2016a
STA-3/4 supply/inflow canal evaluation to determine if canal is TP source or sink	Phase I was completed in May 2016. Results suggested canal behaved as a TP sink over period analyzed. Phase II field study is not recommended.	Ecology and Environment, Inc., and SFWMD 2016b
STA-1E discharge canal evaluation to determine if canal is TP source or sink	No detailed Phase I or Phase II field study is recommended since cursory review suggests canal behaved as a TP sink due to seepage from Arthur R. Marshall Loxahatchee National Wildlife Refuge.	
STA-1W discharge canal evaluation to determine if canal is TP source or sink	A report on the Phase I analysis is currently in review. Phase II field study is not recommended because in approximately two years the canal will be part of STA-1WX1 (Expansion Area #1).and will no longer be a discharge canal.	Diaz et al. 2016
STA-2 discharge canal evaluation to determine if canal is TP source or sink	Phase I study is scheduled to begin in mid-2016 and to be completed in 2017. The need for Phase II field study will be evaluated after Phase I is complete.	

EVALUATION OF INUNDATION DEPTH AND DURATION FOR CATTAIL SUSTAINABILITY

Orlando Diaz

The purpose of this study is to identify the inundation depth and duration threshold for the sustainability of cattail (*Typha domingensis*) communities in the STAs. Previous field observations and studies have indicated that inundation exceeding certain water depths over long periods causes increased physiological stress to cattail plants, reducing growth and anchorage capacity, causing cattail density and/or growth decline in STA EAV treatment cells. The study has two main components, in-situ and test cell. The in-situ component of this study is being conducted in STA-1W Cell 2A and STA-3/4 Cell 2A, which historically have differences in soil depth, cattail density, and flow properties. Preliminary evaluation of the in-situ data collected to date did not indicate clear relationships between depth and vegetation condition, however, data collection and analysis is continuing. The test cell component will be conducted in the STA-1W northern test cells, where a healthy cattail population will be established and allowed to grow and mature prior to evaluating a range of water depth regimes. Cattail grow-in at the test cells will occur in 2016 and 2017. A summary of progress on this study is presented in **Table 5C-6**.

Table 5C-6. Evaluation of Inundation Depth and Duration for Cattail Sustainability – summary of progress to date.

Task	Status and Comments
In-situ study – STA-1W Cell 2A	Plot set-up completed in August 2014. 2015 wet season cattail monitoring completed in October 2015. Further investigation on this site was discontinued due to widespread presence of floating cattails in the cell.
In-situ study – STA-3/4 Cell 2A	Plot set-up completed in September 2014. 2015 wet season cattail monitoring completed in November 2015. Cattail monitoring will be completed in October 2016. Progress report of 2015 wet season cattail monitoring is scheduled to be completed in September 2016. Preliminary evaluation of the date did not indicate clear relationships between depth and vegetation condition. In-situ data collection and analysis is continuing.
STA-1W northern test cell refurbishment	Phase I test cells refurbishment was completed in May 2015 including excavation of top soil layer, addition of new soil from a nearby area and enhancement of the conveyance channel that will provide gravity flow to the test cells. Phase II test cell refurbishment was determined to be necessary to achieve the optimal soil condition and elevation for the test cell study. Soil will be obtained from the STA-1WX1 (Expansion Area #1) and will be spread in each test cell to the desired elevations. Topographic survey of northern test cells completed in May 2016.
Cattail grow-in	Cattail recruitment either naturally or through seeding will start as soon as all test cells are refurbished. Scheduled for completion in August 2016. Cattail will be allowed to grow and fully mature, prior to the initiation of experimental testing. Implementation of different water depth treatments on cattail sustainability will last approximately 2 to 3 years.

STORMWATER TREATMENT AREA WATER AND PHOSPHORUS BUDGET IMPROVEMENTS

Tracey Piccone

The purpose of this study is to produce improved annual STA water and P budgets for STA treatment cells in order to improve the accuracy of estimating STA cell performance and to identify areas of uncertainty in these calculations. Water budget analysis is an important tool used to understand the treatment performance of STAs, and accurate water budgets are critical to developing accurate P budgets. A more accurate understanding of the P treatment performance of the two main types of STA treatment cells (EAV-dominant and SAV-dominant) is important because it could impact results of long-term STA treatment performance predictions. The study is being implemented in a phased approach. Phase I included a test case (STA-3/4 Cells 3A and 3B) for improving water budgets for individual treatment cells using simplified desktop approaches. Phase II includes implementing the methodologies investigated during Phase I on an expanded list of treatment cells and also includes developing improved P budgets for these treatment cells. A summary of progress on this study is presented in **Table 5C-7**.

Table 5C-7. STA Water and P Budget Improvements – summary of progress to date.

Task	Status and Comments	Publications and Reports
STA-3/4 Cells 3A and 3B water budget improvement test case (Phase I)	Completed in WY2014. Surface water (structure) flows were the largest component of the water budgets and the largest source of uncertainty in the residuals. Low head differentials across mid-levee culverts were the main source of error. Seepage was identified as a significant contributor of residual uncertainty for the test case despite constituting a small fraction of water budgets. Rainfall, evapotranspiration, and change in storage were minor contributors, and current estimation methods for these components were found to be acceptable. Annual water budgets for the test case were greatly improved with revised flow data for the mid-levee culverts; residuals were reduced from as high as 100 percent to 8 percent or less.	Polatel 2014
STA-2 and STA-3/4 period of record flow data and flow rating improvements	Completed in WY2015. Improved flow data for STA-2 (Cells 1, 2 and 3) and STA-3/4 Cells 1A, 1B, 2A, 2B, 3A, and 3B for the entire period of record were entered in DBHYDRO database at www.sfwmd.gov/dbhydro/.	
STA-1E flow data and flow rating improvements	Completed in WY2016. Improved flow data for all STA-1E structures starting with WY2014 were developed and entered in DBHYDRO database.	
Water Budget Tool improvements	Will be completed in 2017. Updates to the Water Budget Tool, including improved seepage estimations, need to be completed before updated STA water and P budgets can be developed.	
Period of record STA-2 and STA-3/4 water and TP budgets	Task will start in 2017 and be completed in 2018. Individual cells included are STA-2: Cells 1, 2, and 3 and STA-3/4: Cells 1A, 1B, 2A, 2B, 3A, and 3B.	
STA-5 flow data and flow rating improvements	Will be completed in WY2017. Improved flow data for select STA-5 structures starting with WY2015 were developed and entered in DBHYDRO database.	

EVALUATION OF SAMPLING METHODS FOR TOTAL PHOSPHORUS

Pete Rawlik

The purpose of this study is to determine if current sampling and monitoring techniques are accurately documenting TP concentrations, and if not, identify the influencing factors. The study includes collection and analysis of surface water samples using flow proportional autosamplers, time proportional autosamplers, traditional grab samples, and grab samples collected using autosampler pumps. Samples were analyzed by the District's laboratory using the same analytical method. Also in place was a remote phosphorus analyzer RPA that collects and analyzes samples for TP in-situ and is an approved variant method that shows high comparability with the laboratory method. Additionally, cameras and remote data collection probes collected data on events at the site and the impact of such events on conductivity, pH, and turbidity. This study not only evaluated the analytical results, but included sampling efficacy, assuring that methods provided the quantity and quality of data expected. Results from this study were used to develop suggestions on improving quality assurance, autosampler design, and data interpretation, and reducing impacts from environmental factors. A summary of progress on this study is presented in **Table 5C-8**, and more detailed information on this study is presented in Appendix 5C-4.

Table 5C-8. Evaluation of Sampling Methods for TP – summary of progress to date.

Task	Status/Comments	Publications
Literature Review	Completed in March 2014.	Rawlik 2016
Installation of equipment	Completed at G390B in December 2013. Completed at G310 in March 2014.	Rawlik 2016
Monitoring	Completed at G390B in October 2014. Sampling continued until December 2014 at G310.	Rawlik 2016
Data Analysis	Analysis of data at G390B uncovered an important autosampler programming flaw that was fixed.	Rawlik 2016

INVESTIGATION OF ROOTED FLOATING AQUATIC VEGETATION IN STORMWATER TREATMENT AREAS

Larry Schwartz and Matt Powers

The purpose of this study is to assess the ability of different rFAV species to enhance low-level P removal performance in SAV communities in the downstream end of STAs and to assess potential adverse effects on water quality by rFAV species that have formed dense stands in some STA cells. During this reporting period, a DSP was developed for the investigation of rFAV including *Nymphaea odorata* (white water lily), *Nelumbo lutea* (American lotus), and *Nuphar lutea* (spatterdock). These species, some of which commonly occur in P-deficient environments of the WCAs, may facilitate the ability of SAV communities in the downstream end of STA communities to achieve ultra-low level P concentrations. As the rFAV occur in SAV dominated areas within the STAs, the paired patches that will be sampled are designated as rFAV+SAV and SAV-only.

The DSP includes field reconnaissance for rFAV+SAV and SAV-only patches within the STAs, and two subsequent study phases. Phase I includes both initial spatial monitoring followed by more long-term temporal monitoring and consists of evaluating P in the water column in the patches to determine if there are differences in these patches. If differences exist in the P in the water column, Phase II of the study will be implemented. Phase II, if warranted, would consist of including an evaluation of P storage in rFAV, SAV, floc, and soil in rFAV+SAV patches and SAV-only patches. Phase II is designed to determine if rooted FAV+SAV patches show advantages in internal transformation and storage of P that provide additional reduction of P in the water column.

Reconnaissance was conducted on January 21, March 1, and April 8, 2016. The study team performed reconnaissance of potential rFAV+SAV and SAV-only sampling sites within STA-1W Cell 5B, STA-2 Cell 3, STA-3/4 Cell 2B, STA-5/6 Cells 2B and 3B, and STA-1E Cell 4S. The sites listed in **Table 5C-9** were selected for Phase I sampling. A summary of progress on this study is presented in **Table 5C-10**.

Table 5C-9. Sites selected for initial monitoring.

Location	rFAV species	Associated SAV species
STA-1W Cell 5B	white water lily	southern naiad (*Najas guadalupensis*) and chara (*Chara* sp.)
STA-5/6 Cell 3B	spatterdock	southern naiad and coontail (*Ceratophyllum demersum*)
STA-1E Cell 4S	American lotus	hydrilla (*Hydrilla* sp.) and southern naiad

Table 5C-10. Investigation of rFAV in STAs – summary of progress to date.

Task	Status and Comments
Development of Work Plan	Completed in 2016.
Initial Spatial Sampling	Completed in June 2016.
Initial Spatial Sampling Data Analysis	Ongoing August 2016.
First Wet Season Temporal Sampling	To be conducted in August 2016.

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