Chapter 5C: Update for the Restoration Strategies Science Plan

Edited by Larry Schwartz and Megan Jacoby

SUMMARY

In June 2012, the State of Florida and the United States Environmental Protection Agency (USEPA) reached consensus on new restoration strategies (see Chapter 5A of this volume) for further improving water quality in the Everglades. Following months of technical discussions, these strategies were identified to expand water quality improvement projects developed to achieve ultra-low total phosphorus (TP) water quality standard established for 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, and a water quality based effluent limit (WQBEL) for water discharged into the Everglades Protection Area. The NPDES and EFA watershed permits and associated consent orders also require that the District develop and implement a science plan to enhance the understanding of mechanisms and factors that affect phosphorus (P) treatment performance, particularly, those that are key drivers to performance at low TP concentrations (< 20 micrograms per liter, or µg/L).

The Science Plan for the Everglades Stormwater Treatment Areas (SFWMD 2013), referred to simply as the Science Plan in this chapter, is a strategic document that will be revised and updated as needed. Implementation of the Science Plan is guided by the Five-Year Work Plan, which is comprised of detailed study plans (DSPs). Results from these studies may be used to inform the design and operations of water quality projects, which will ultimately improve capabilities to manage achievement of the WQBEL. Related data and information gathered from these studies will also be incorporated into the development and refinement of the South Florida Water Management District's (District's or SFWMD's) operational guidance tools.

This chapter provides a summary of the Science Plan progress during Water Year 2015 (WY2015) (May 1, 2014–April 30, 2015). As the proposed studies of the Science Plan are further detailed and implemented, future *South Florida Environmental Reports* (SFERs) will integrate and synthesize information to effectively communicate plan findings. The findings will be used to gauge progress toward optimizing P treatment performance (see Chapter 5B of this volume) and achieving the WQBEL for TP (SFWMD 2012a). This information will then be used to identify needed policy and management actions, key areas of uncertainty, and essential information gaps to direct future Science Plan efforts.

INTRODUCTION

In accordance with the Everglades Water Quality Restoration Framework Agreement between the USEPA, Region IV, and Florida Department of Environmental Protection (FDEP), dated June 12, 2012 (FDEP and USEPA 2012) and the Restoration Strategies Regional Water Quality Plan (SFWMD 2012b), the Science Plan has been established to investigate the critical factors that collectively influence the TP reduction and treatment performance in the Everglades Stormwater Treatment Areas (STAs) (SFWMD 2013). It is expected that the results from the Science Plan will be used to enhance the design and operations of projects under the Restoration Strategies Program. The Science Plan is also intended to fulfill the requirements of the consent orders between FDEP and SFWMD (dated August 15, 2012) associated with the NPDES and EFA watershed permits for the Everglades STAs [Office of General Counsel (OGC) Numbers 12-1148 and 12-1149, respectively], issued on September 10, 2012.

Pursuant to the consent orders, the Science Plan was developed by SFWMD in consultation with representatives designated by FDEP and USEPA (referred to as Technical Representatives), on behalf of the state and federal agencies, respectively. Published in June 2013, the complete version of the Science Plan, including the Five-Year Work Plan of the individual studies, is available on the District's website at www.sfwmd.gov/rs_scienceplan. Eight proposed studies outlined in the Five-Year Work Plan were reviewed and received approval to move forward by the District's Restoration Strategies Steering Group. One additional study outlined in the Five-Year Work Plan has yet to be developed. Eight DSPs were developed that lay out the framework for the science and research to be undertaken during the initial phase of Science Plan implementation. The DSPs include background information, study objectives and hypotheses, proposed methodology, and activities and milestones. The complete DSPs, dated September 2014, are available at www.sfwmd.gov/rs_scienceplan. Summary information on the WY2015 progress of the DSPs is provided below. In this update, it should be noted that the study-specific schedules reflect the District's fiscal year (October 1–September 30) to align with the agency's budget.

OVERVIEW OF DETAILED STUDY PLANS

USE OF SOIL AMENDMENTS/MANAGEMENT TO CONTROL PHOSPHORUS FLUX

Michael Chimney

Overall Study Plan Summary

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, adding a limerock cap, or using soil management techniques thereby reducing outflow TP concentrations. This study has three phases. Phase I involves (1) data mining and synthesis of past District-supported research relevant to this study, (2) expansion of an existing literature review on technologies for controlling soil P flux in wetlands or lakes, and (3) to the extent practicable, an assessment of the feasibility of implementing any of these technologies at full-scale in the STAs. Phase II may involve screening candidate technologies identified in Phase I through small-scale laboratory or field tests to assess their ability to sequester P and, if warranted (STOP/GO decision), to select a subset of technologies for further investigation in Phase III.

Phase III will involve conducting large-scale field trials in enclosed portions of treatment cells in one or more of the existing STAs and/or within entire cells of the STA-1 West (STA-1W) expansion area, if warranted (STOP/GO decision). The experimental approach for the field trials will be to compare the ability of treated areas to reduce outflow TP concentrations against the performance of control (untreated) areas. The field trials will be of sufficient size to minimize uncertainty surrounding the scale-up of the technology or technologies in the STAs. The successful outcome of this study will be to identify a technology or set of technologies that, if implemented, will reduce TP concentrations at the STA outflows and achieve the permitted TP WQBEL. These technologies may be applied during construction and operation of an STA to meet the TP discharge limits.

Study Schedule

- Phase I
    - Initiated Fiscal Year 2013-2014
    - Completed Fiscal Year 2014-2015
- Phase II
    - Initiate Fiscal Year 2015-2016, if warranted
    - Complete Fiscal Year 2016-2017
- Phase III
    - Initiate Fiscal Year 2018-2019, if warranted
    - Complete Fiscal Year 2022-2023

Progress to Date (Water Year 2015)

- Initiated Phase I and developed draft report that includes the following:
    - A literature review of existing technologies for controlling soil P flux in wetlands or lakes.
    - Summary of past District findings relevant to controlling soil P flux in wetlands.

    - To the extent practicable, a determination of the feasibility of employing these technologies in the STAs from engineering, treatment efficacy, operations or regulatory, and economic perspectives.
    - Cost estimates for conducting large-scale field trials of different technologies in the STAs and implementing these technologies in the STAs.
    - A list of issues to be addressed to reach STOP/GO decision for Phase II and Phase III of the study.
- A preliminary summary of the Phase I draft report is as follows:
    - The literature review indicates that more than 100 materials that sorb P have been tested as a soil amendment; however, only a few of these products would be suitable for use in the STAs, which discharge water into protected natural marshes. To determine the long-term usefulness and feasibility of application of any of the amendments in a treatment wetland, these products will have to be tested in the field.
    - No published data were found that document the long-term treatment efficacy of soil amendments or soil management techniques to reduce outflow total P concentrations in operating free water surface treatment wetlands.
    - Considering the uncertainties in treatment efficacy, potential impacts to STA operations and the economics associated with implementing any of these technologies at full-scale in the STAs, the Restoration Strategies Science Plan Management Team recommended that (1) the study move forward with planning for a field-trial of soil inversion in the STA-1W Expansion Area, and (2) not to proceed with study Phases II and III for testing soil amendments or any other soil management technique elsewhere in the STAs. The District's management team, the Restoration Strategies Steering Committee, concurred with these STOP/GO recommendations.

Future Activities (Water Year 2016)

- Finalize Phase I report.
- Finalize STOP/GO for Phase II and Phase III.

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

Raul Novoa and Walter Wilcox

Overall Study Plan Summary

The purpose of this study is to develop toolsets and methodologies that support the development of operational guidance and regional operation plans for the flow equalization basins (FEBs)/STAs that best enable the Everglades STAs to consistently achieve the WQBELs for TP. This effort will include hydrologic, hydraulic, and water quality modeling in support of the development of operational guidance for the A-1, L-8, and C-139 Annex FEBs, associated STAs, and the surrounding regional water management infrastructure. The study is expected to support a larger series of efforts spread across the construction, implementation, and monitoring work associated with the Restoration Strategies Program. As project planning and design efforts proceed, information from this study will continually be incorporated into modeling support provided to various Restoration Strategies project components.

Study Schedule

- Task 1: Information gathering
  - Initiated Fiscal Year 2012-2013 Completed Fiscal Year 2013-2014
- Task 2: Field test execution
  - Initiated Fiscal Year 2012-2013 Complete Fiscal Year 2015-2016
- Task 3: Identify model refinements
  - Initiated Fiscal Year 2013-2014 Complete Fiscal Year 2015-2016
- Task 4: Develop operating protocols
  - Initiated Fiscal Year 2013-2014 Complete Fiscal Year 2016-2017

Progress to Date (Water Year 2015)

- An information gathering document, as prescribed in the DSP, will be prepared.
- Completed STA-3/4 Cell 3A field test and developed draft field test report for internal review, The Use of Discharge Perturbations to Characterize In-situ Vegetation Resistance.
- Research article, The Use of Discharge Perturbations to Understand In-situ Vegetation Resistance in Wetlands (Lal et al. 2015), was published in the AGU Publication *Water Resources Research* (accepted March 3, 2015).
- Completed STA-2 Cell 3 field test and developed draft field test report, Vegetation Resistance and Treatment Efficiency.
- Completed operations study field test in STA-3/4 Cell 2A; data analysis is pending.
- Improved functionality of the WaveOp tool to assist in real-time operation support. This tool will monitor the state of the system by connecting to the District’s database and then provide the control room with recommended gate openings needed to achieve target flow rates.
- Utilized systems control and optimization report, Control Concepts for Stormwater Treatment Areas (Jayasuriya Consulting Services 2013), to indicate that it is feasible to view STA facilities as controllable systems where operational algorithms are

capable of inducing desired system response at the temporal and spatial scales necessary to manage stage and water residence times (i.e., STA inflows and outflows can effectively be used to manage stage response). Among other benefits, this effort validates that the planned project activity of developing the iModel optimization tool is warranted.

- As part of the water quality modeling tool enhancement, implemented Dynamic Model for Stormwater Treatment Areas (DMSTA) code changes to allow for expanded sensitivity testing of parameters and enhancement of the Total Variation Diminishing Lax-Friedrich (TVDLF) version of the Regional Simulation Model (RSM) to position this tool for integrated hydraulic and water quality modeling.
- Progressed on developing the iModel operations optimization tool:
    - Completed proof of concept hydrologic model emulator (HME) development and iModel scenario (considering variable outflow gate opening) to provide an initial framework for operating and optimizing STA central flow-path system (STA2, STA2N, STA2S, STA34, and FEB) for achieving water quality targets.
    - Refined HME development and began iModel implementation scenario for system optimization that allows for individual/independent paths within STA-2 (Cell 1, Cell 2, and Cell 3) and STA-3/4 (Cell 1, Cell 2, and Cell 3).

Future Activities (Water Year 2016)

- Continue analysis and reporting of STA-3/4 Cell 2A and STA-1W Cell 2A field experiments.
- Discuss with water managers and STA experts features needed in developing tools to assess real-time conditions and/or intended operations and incorporate means of displaying or considering these features in the tools.
- Finalize the iModel implementation considering individual flow-way on/off operations.
- Further HME development with incorporation of vegetation resistance variation over time and subsequent iModel implementation.
- Develop a suite of decision support tools as a subsequent step to iModel development; the tentative working framework is as follows:
    - Water Year/Seasonal Awareness
        - System state (e.g., schedules)
        - WQBEL considerations
        - Climate outlook
        - Vegetation management activities
    - Water Year/Seasonal Awareness
        - System state (e.g., schedules)
        - WQBEL considerations
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        - Vegetation management activities
    - Water Year/Seasonal Awareness
        - System state (e.g., schedules)
        - WQBEL considerations
        - Climate outlook
        - Vegetation management activities

Graphics exemplifying some of these key tools are shown in **Figures 5C-1** through **5C-3**.

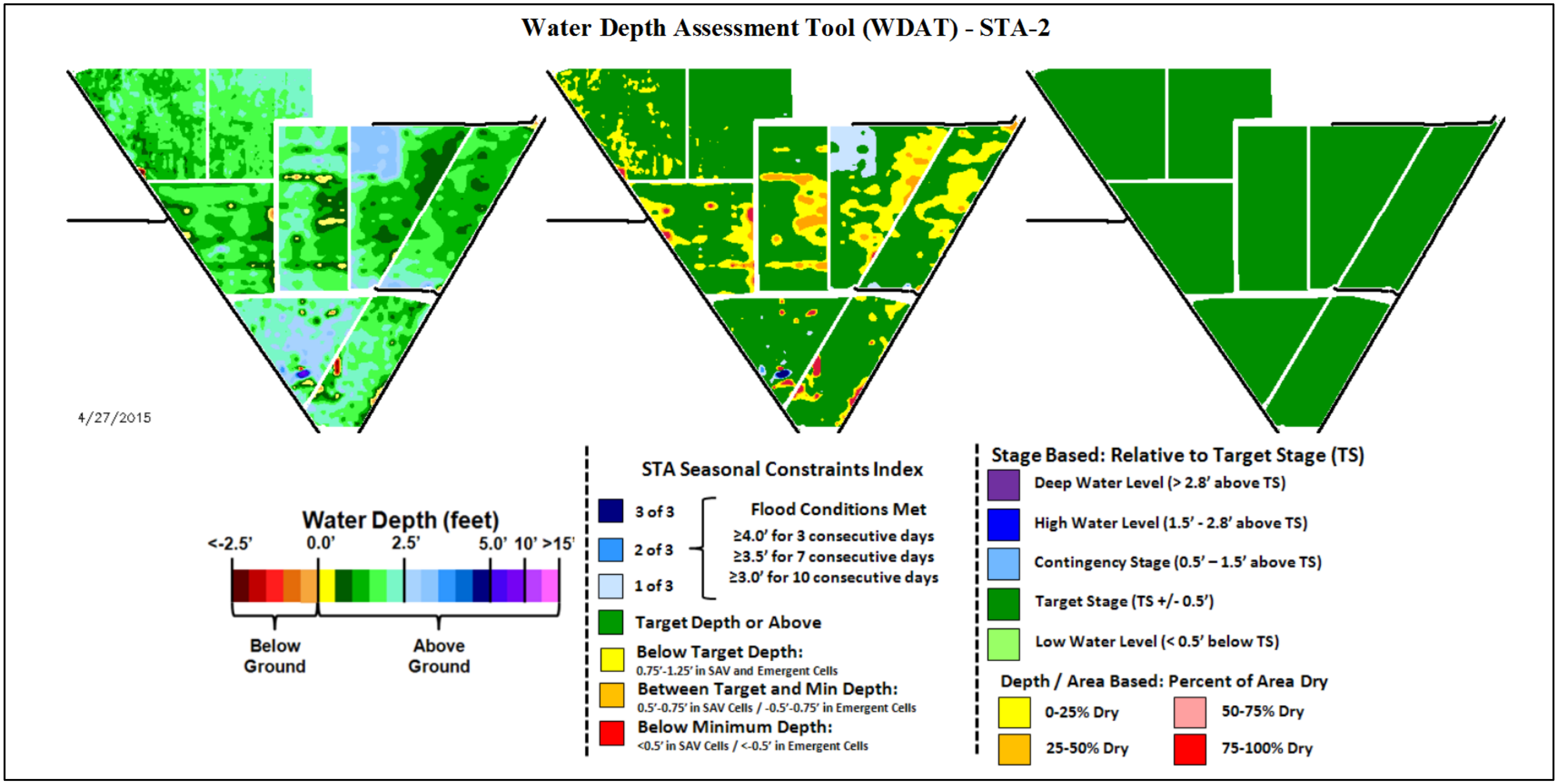

Figure 5C-1. Example of the Water Depth Assessment Tool (WDAT).

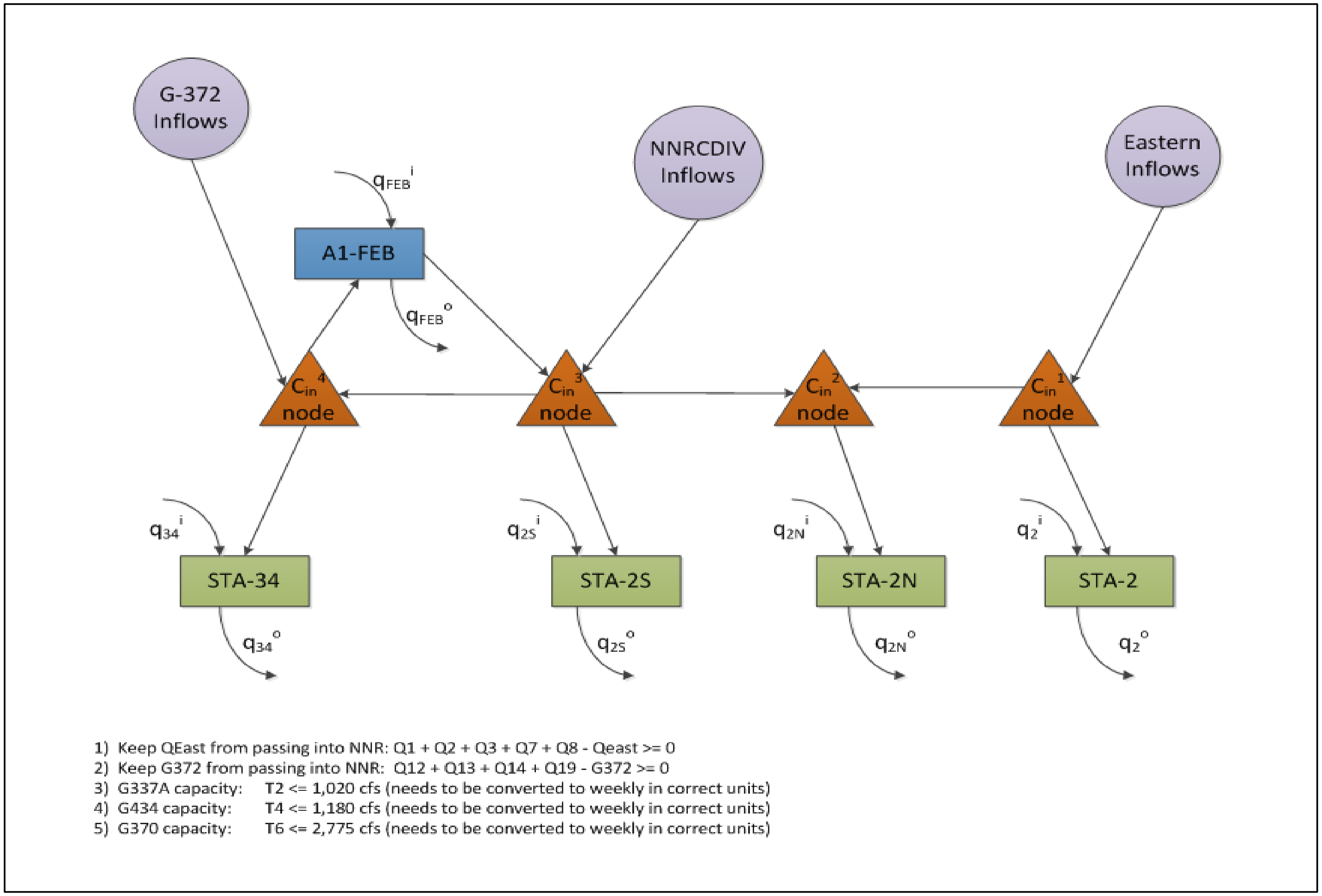

Figure 5C-2. Conceptual iModel for the Restoration Strategies Central Flow Path. [Note: cfs – cubic feet per second.]

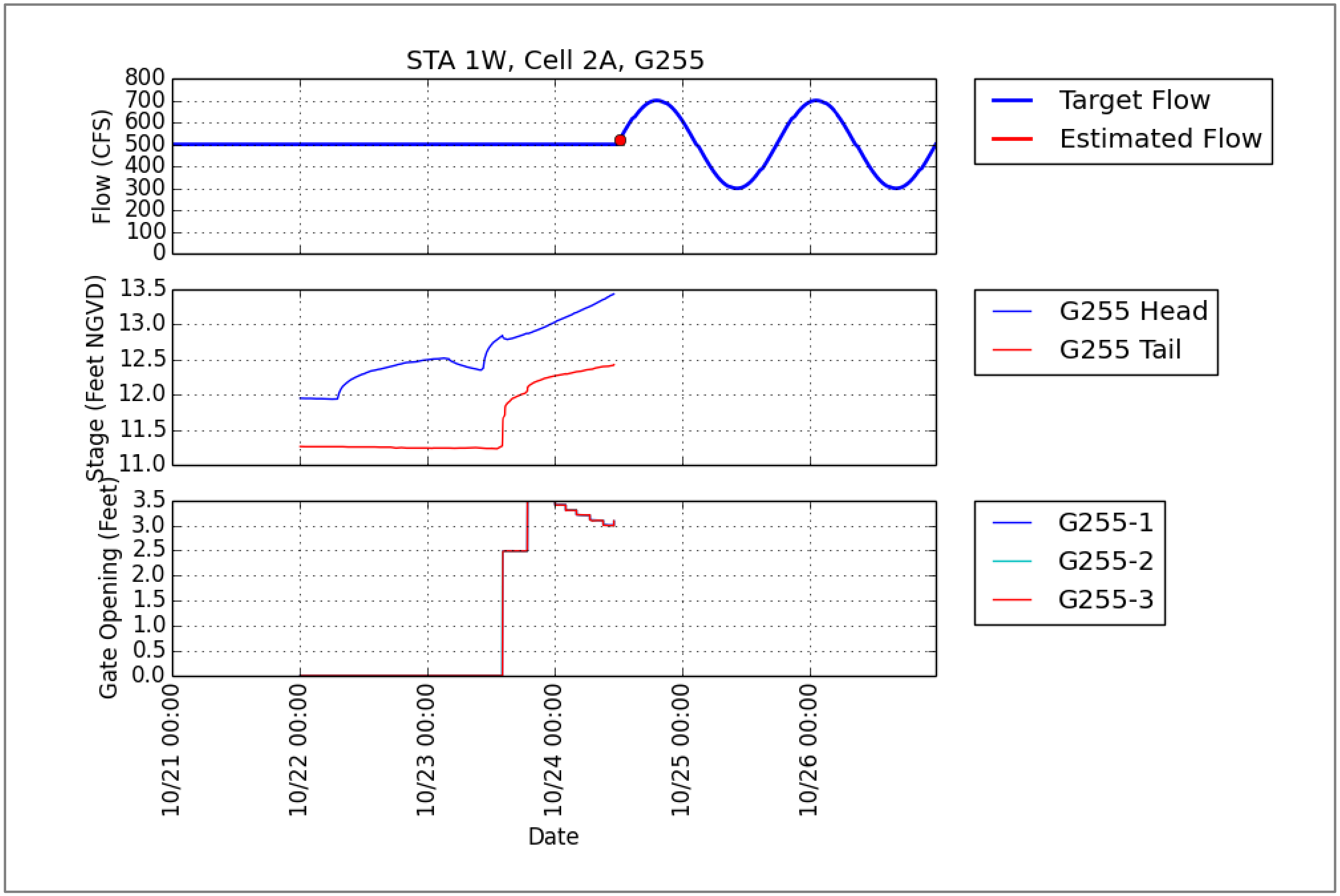

Figure 5C-3. Example of WaveOp Program to assist real-time operations by defining structure gate openings needed to achieve target flows. [Note: feet NGVD – feet National Geodetic Vertical Datum of 1929.]

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

Jill King and Delia Ivanoff

Overall Study Plan Summary

The purpose of this study is to enhance the understanding of mechanisms and factors that affect P treatment performance of STAs, particularly those that are key drivers to performance at the lower reaches of the treatment flow-ways. Understanding the mechanisms and factors that affect the P treatment performance of STAs at low TP concentrations should provide information to develop strategies that will ultimately improve capabilities of the STAs to achieve permit compliance with WQBELs. The study will evaluate P sources, forms, flux, and transformation processes along the STA flow-ways. The key components of this study include (1) data mining, (2) literature review, (3) P speciation, (4) flow-way assessments at different flow conditions, (5) comparison of processes, mechanisms, and factors relevant to uptake in Water Conservation Area (WCA) 2A, (6) particulate transport, (7) soil characterization, (8) measurement of P flux, (9) evaluation of trends and patterns of microbial enzyme activity, (10) vegetation assessments, and (11) quantification of faunal assemblages and excretion.

The individual components of this study are in different stages of implementation. Following the study's launch in January 2014, most components began with the evaluation of the methodologies and techniques and preparation of equipment and materials that will be utilized.

Study Schedule

The study schedule is presented in **Figure 5C-4**.

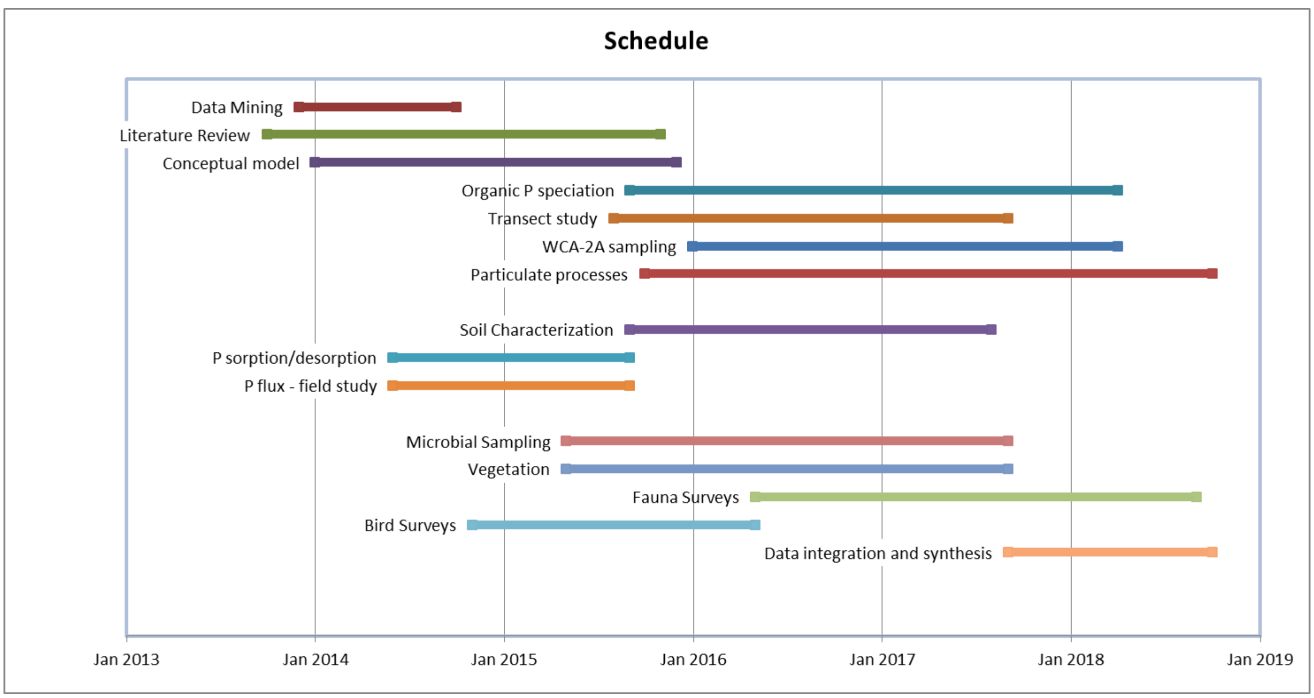

Figure 5C-4. P flux study plan key project components schedule.

Progress to Date (Water Year 2015)

- Data Mining
  - Performed STA-2 and STA-3/4 in-depth data analysis; results were published in *Ecological Engineering* (Pietro and Ivanoff 2015).
  - Conducted data mining and analysis of historical data to examine temporal and spatial trends, determine their usability for the P flux study, and identify data uncertainties to help focus the scope of the study (see highlights below).
- Water Quality Monitoring along the Flow-ways (Transect Study)
  - Identified and prepared the first three locations in each study flow-way in STA-2 Cell 1.
  - Constructed sampling platforms and initiated autosampler sample collection at three locations in STA-2 Cell 1 (Flow-way 1) at 4-hour and 8-hour intervals; selection of the final sampling frequency in under evaluation.
  - Installed a remote phosphorus analyzer (RPA) in STA-2 Cell 3.
- Flux Measurements
  - Identified and initially prepared sites for deployment of P flux chambers, which are composed of heavy duty polyethylene with 5-foot diameter
  - Installed P flux chambers in STA-2 Cell 1 and deployed porewater equilibrators (**Figure 5C-5**) to sample porewater (note that measurements and sampling will be done during the controlled flow conditions)

Figure 5C-5. P flux chamber in STA-2 Cell 1 (left) and porewater equilibrator (right) (photos by SFWMD).

- Microbial Enzyme Activity Study
  - Initiated literature review.
  - Began developing methods for the field collection and laboratory analysis for enzyme assays.
- Vegetation Assessment Study
  - Completed baseline submerged aquatic vegetation (SAV) surveys for STA-2 Cell 3 and STA-3/4 Cell 3B.

    - o Performed emergent aquatic vegetation (EAV) surveys via newly developed low-altitude imagery tool and finalized a standard operating procedure (SOP) for implementation.
    - o Developed SAV survey and biomass/tissue nutrient sampling SOPs.
- Fauna study
    - o Began avian surveys and some preliminary analysis.

Future Activities (Water Year 2016)

- Data Mining
    - o Conduct additional data mining for further geostatistical analysis to retrieve and analyze internal transect, flux, porewater, and other relevant data to explain and quantify P flux, transport, and transformation.
- Internal Water Quality Monitoring (Transect Study)
    - o Install monitoring platforms at three additional locations within STA-2 Cell 1.
    - o Deploy redox probes, YSI sondes, HOBO light meters, and water level loggers at platforms in STA-2 Cell 1.
    - o Construct platforms and initiate autosampler sample collection in STA-2 Cell 3.
    - o Install an RPA at outflow of STA-2 Cell 3.
- Flux Measurements
    - o Conduct first set of field measurements under implemented stagnant, low flow, and high flow events in STA-2 Cell 1. This includes redox measurements, water column sampling within the chamber, and porewater sampling.
    - o Construct and install flux chambers in STA-2 Cell 3.
    - o Conduct porewater sampling in STA-2 Cell 3.
- Microbial Enzyme Activity Study
    - o Finalize SOPs for microbial activity sampling and assays.
    - o Conduct initial microbial test analysis and finalize microbial test methods.
    - o Conduct field sampling and analysis in sync with flow events.
- Vegetation Assessment Study
    - o Conduct quarterly vegetation surveys via newly developed low altitude aerial imagery to determine vegetation (EAV versus SAV) cover, density, and condition.
    - o Conduct quarterly SAV surveys.
    - o Conduct baseline SAV and EAV biomass and tissue nutrient sampling.
- Fauna Study
    - o Continue avian surveys and data analysis.
    - o Finalize and execute fauna study component support statement of work.
- Soil Characterization Study/Phosphorus Sorption and Desorption Characteristics Study
    - o Kickoff contract with the University of Florida’s Wetland Biogeochemistry Team.
    - o Initiate P sorption and desorption study.
    - o Initiate floc and soil litter microbial sampling and analysis.

- Particulate/Sediment Dynamics/Hydraulic Study
    - Finalize statement of work for particulate dynamics study and hydraulic measurements.
- Organic Phosphorus Speciation Study
    - Continue method development to determine the different forms of organic P in water, floc, and soils to determine the labile and non-labile fractions.
- WCA-2A Sampling Study
    - Continue WCA-2A sampling development to examine sites with known variation of P enrichment to which forms of P and internal processes may be limiting the ability of low performing STAs to reduce TP concentrations.

Data Mining Highlights

Examples of the tools used for data mining are principal component analysis, cluster analysis, and subsequent discriminant analysis to determine the presence and nature of multivariate patterns and establish the biogeochemical drivers of these patterns. Results for all flow-ways indicate clusters that were spatially congruent, i.e., there are distinct groups within the multivariate data sets (soil, floc, surface water, and macrophyte characteristics) that are distinctly distributed spatially. This suggests potentially distinct management zones for the STAs. A time series analysis of STA-2 Flow-ways 1, 2, and 3 data indicates significant improvement in performance over time, which is in agreement with findings reported in earlier publications (Chen et. al. 2015, Pietro and Ivanoff 2015). A spectral decomposition of the data using SAS™ PROC SPECTRA analysis indicates 5- to 6-month periodicity at the inflows of Cells 1, 2, and 3. However, this was either non-significant or weakly significant. The outflow data showed 7-month periodicity for the three cells, which were significant.

The general P flux study experimental design was also reviewed during this effort and specific recommendations were made based on the findings from the data mining study. A power analysis was done to determine optimal number of sampling stations and variables to measure. To maintain consistency across the different activities envisioned in the plan, and based on the data considered in this study, it was also recommended that soil and floc nutrients (TP, nitrogen, and carbon) and bulk measurements, surface water nutrients, alkalinity and calcium, macrophyte composition and tissue nutrients, and normalized difference vegetation index be measured consistently within the study flow-ways. This would ensure robustness in any ensuing cross-experimental data analysis. In terms of STA management, an in-depth examination of the inflow to outflow gradient or distinct zones with additional internal data may lead to insights on better management strategies for the individual cells.

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

Manuel Zamorano, Hongying Zhao, Tracey Piccone, Kevin Grace[1] and Tom DeBusk[1]

Overall Study Plan Summary

Implementation of the STA-3/4 Periphyton-based Stormwater Treatment Area (PSTA) Project has been underway since WY2008 [see 2008 through 2013 SFERs –Volume I, Chapter 5 (Pietro et al. 2008, 2009, 2010, Germain and Pietro 2011, Ivanoff et al. 2012, 2013), and 2014 and 2015 SFERs – Volume I, Chapter 5B (Chimney 2014, 2015)]. Beginning in Fiscal Year 2011-2012, additional research and evaluation efforts were initiated for the PSTA Project and these efforts are continuing as part of the Restoration Strategies Science Plan.

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 performance of this technology. Key factors thought to enable the PSTA Cell to achieve ultra-low outflow TP levels will be examined through experiments conducted at a variety of scales, including laboratory bench-scale studies, soil core studies, flow-through mesocosms, and field-scale investigations, with the goal of informing design decisions for successful full-scale replication of this technology. The operational ranges under which the PSTA Cell achieved ultra-low outflow TP levels will be determined, and the management practices required to sustain good performance in the PSTA Cell will be identified.

Performance Data Summary (Water Years 2008–2015)

Data from WY2008 to WY2015 were used to calculate the PSTA Cell's annual hydraulic loading rate (HLR), phosphorus loading rate (PLR), hydraulic retention time (HRT), and TP settling rate (k) (**Table 5C-1**). These calculations accounted for the duration of the PSTA Cell's operational period each year. The operational period was defined as the span of time over which one or both of the PSTA Cell's inflow structures (G-390A and G-390B) were open.

Table 5C-1. Summary of annual hydraulic and treatment performance parameters in the STA-3/4 PSTA Cell during each operational period from WY2008 to WY2015.

Water Year	HLR (cm/d)	HRT (day)	Q_{in} (ac-ft)	Q_{out} (ac-ft)	FWM TP_{in} (µg/L)	FWM TP_{out} (µg/L)	PLR (g/m^2/yr)	Operational Period (day)	k (m/yr)
WY2008	5.5	5.8	2,919	5,201	27	12	0.24	161	14.2
WY2009	6.0	5.9	3,309	6,105	14	8	0.14	168	13.8
WY2010	6.2	6.2	7,022	10,078	20	10	0.42	341	27.4
WY2011	6.1	6.7	3,198	3,933	18	11	0.17	159	7.3
WY2012	8.6	4.4	7,454	9,610	17	12	0.39	262	12.5
WY2013	7.7	5.1	9,326	11,166	16	11	0.45	365	17.8
WY2014	3.3	16.7	4,030	3,794	24	13	0.29	365	10.0
WY2015	5.8	9.4	6,990	7,386	15	11	0.33	365	11.9

Key: µg/L – micrograms per liter; ac-ft – acre-feet; cm/d – centimeters per day; FWM – flow-weighted mean; g/m^2/yr – grams per square meter per year; m/yr – meters per year; Q_{in} – water inflowing; Q_{out} – water outflowing; TP_{in} – total phosphorus concentration in the inflow; and TP_{out} – total phosphorus concentration in the outflow.

[1] DB Environmental Laboratories, Inc., Rockledge, FL

Study Schedule

The current PSTA Study schedule and plan components are shown in **Figure 5C-6**.

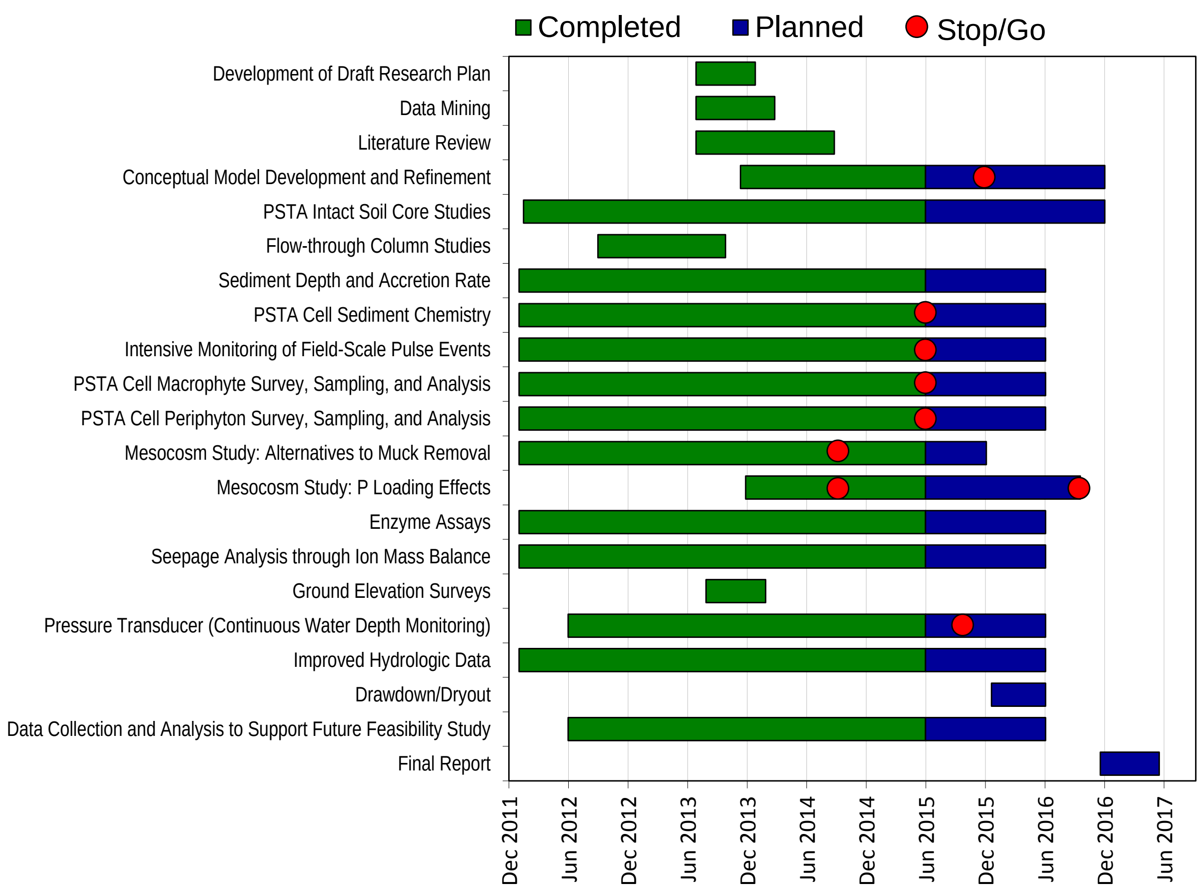

Figure 5C-6. PSTA study plan components and schedule.

Progress to Date (Water Year 2015)

- Implemented third pulse flow event in the PSTA Cell including enhanced monitoring during the pre-pulse, pulse and post-pulse periods. Conducted preliminary analysis of the PSTA Cell's performance during and after pulse events. The results suggest that high flow pulse events had no apparent adverse effects on the PSTA Cell's ability to maintain low outflow TP concentrations during and after pulse events.
- Conducted preliminary analysis of PSTA Cell monitoring well data collected in support of seepage analysis.
- Evaluated RPA data collected at the PSTA Cell inflow and outflow structures to provide insight into potential factors influencing performance of the PSTA Cell. The factors evaluated include flow, two different operational stages, inflow concentration, season, and time of day. Prepared the technical publication, Evaluation of Remote Phosphorus Analyzer Measurements and Hydrologic Conditions of the STA-3/4 Periphyton-based Stormwater Treatment Area (James 2015).

- Developed period of record (POR) annual water and TP budgets for the PSTA Cell using improved flow data and seepage water quantity and quality estimates. Prepared the technical publication, STA-3/4 Periphyton-based Stormwater Treatment Area (PSTA) Cell Water and Total Phosphorus Budget Analyses (Zhao et al. 2015a).
- Initiated work on the PSTA Study Interim Report to compile and evaluate various forms of data that have been collected to date in the PSTA Cell. The report is also intended to help guide the implementation of the remaining portions of the PSTA Study.

Future Activities (Water Year 2016)

- Finalize the PSTA Study Interim Report including recommendations on current and future research efforts for the PSTA Study.
- Continue routine monitoring program and implementation of numerous ongoing study plan components.
- Finalize mesocosm study associated with alternatives to muck removal.

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

Hongying Zhao and Tracey Piccone

Overall Study Plan Summary

The purpose of this study is to determine if TP concentrations or loads change when conveyed through STA inflow or outflow canals, and, if so, what factors influence the changes. For example how much sediment and TP have been accumulated in canals throughout the period of operation, and if remedial field work is needed to address this issue.

The proposed study will be conducted in two phases. In Phase I the goal is to determine if TP concentrations change when conveyed through STA inflow or outflow canals and, if TP concentrations change, what are the factors that may be influencing the change in concentrations. The canals identified for investigation during Phase I are as follows:

- STA-2 Supply/Inflow Canal
- STA-2 Discharge Canal
- STA-3/4 Inflow/Supply Canal
- STA-1E Discharge Canal
- STA-1W Discharge Canal
- STA-1W Inflow Basin Canal between S-5A and G-302

The findings from Phase I will be compiled in a summary report that will include recommendations for Phase II. The canals to be studied under Phase II will be based on the recommendations from Phase I. The discharge canals for STA-3/4 and STA-5/6 are not included in this study because the canal compliance sites and the flow-way outflow structures are identical. If the Phase I results indicate that a canal is behaving as a TP sink or source then Phase II investigations will focus on verifying the Phase I results and determining the causative factors, and providing recommendations for remedial work to address the impacts, if needed, and/or recommendations for future STA and FEB canal designs and/or operations.

Study Schedule

- Phase I
  - Initiated Fiscal Year 2012-2013 Complete Fiscal Year 2016-2017
- Phase II
  - Initiate Fiscal Year 2017-2018 Complete Fiscal Year 2017-2018

Progress to Date (Water Year 2015)

- Prepared the technical publication, Evaluation of the Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow TP Concentrations – Supporting Information for Canal Evaluations (Zhao et al. 2015b) including the following information for all six canals in the study:
  - Literature review
  - As-built drawing review
  - Data query effort (flow and water quality data)

- Prepared the technical publication, Evaluation of the Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow TP Concentrations - STA-1 Inflow Basin Canal Investigation Report (Zhao et al., 2015c). Results suggest that the canal acted as a TP source during the period from May 1, 2000 through April 30, 2013. Conclusions from this Phase I study can be refined and verified by conducting field sediment depth measurement, core sampling, and sediment laboratory testing, as described in the document.
- Initiated analysis of STA-1W Discharge Canal.

Future Activities (Water Year 2016)

- Finalize the STA-1 Inflow Basin Canal Investigation Phase I Report.
- Finalize the supporting information report for all six canals.
- Finalize analysis and summary report for the STA-1W Discharge Canal.
- Initiate analyses of the STA-2 Supply/Inflow Canal and STA-3/4 Inflow/Supply Canal.

EVALUATION OF INUNDATION DEPTH AND DURATION FOR CATTAIL SUSTAINABILITY

Orlando Diaz

Overall Study Plan Summary

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. Field observations and studies have indicated that prolonged moderate and deep inundation is perhaps a cause for cattail density and growth decline in the STA treatment cells, e.g., STA-1E Cell 7 and STA-1W Cell 5A. This study will include three components: (1) the POR hydrologic data, (2) an in-situ study, and (3) the test cell study.

The analysis of POR hydrologic topographic data will help to define the hydrologic characteristics (including inundation depth, duration, and frequency) that occur in EAV cells. The in-situ study will be conducted in STA-1W Cell 2A and STA-3/4 Cell 2A, which historically have differences in soil depth, cattail density, and flow properties. These two studies will help to identify environmental factors such as hydrologic regimes (inundation depth and duration) and soil physic-chemical properties influencing cattail sustainability in the STAs. The results of the POR data analysis and the in-situ study will provide useful information to finalize the experimental design of the test cell study.

In the test cell study, healthy cattail stands will be established in the 15 STA-1W north test cells and will be allowed to mature. Subsequently, the ecophysiology of cattail plants will be assessed at variable inundation depths for certain inundation durations. Cattail survival, growth, biomass, reproduction, mortality, photosynthesis, canopy leaf area index, and tissue nutrient concentration will be examined through field measurements and laboratory analyses. These data will then be used to identify the duration threshold at an inundation depth for cattail sustainability. The ability of the cattail stands to reduce the P concentration in the water column will be also evaluated. The results of this study are intended to provide data that will facilitate the development of effective hydrologic strategies for sustainable vegetation management in the STAs and FEBs.

Study Schedule

- In-situ study
    - Initiated Fiscal Year 2014-2015 Complete Fiscal Year 2015-2016
- Test cell refurbishment
    - Initiated Fiscal Year 2014-2015 Complete Fiscal Year 2014-2015
- Test cell grow-in
    - Initiated Fiscal Year 2014-2015 Complete Fiscal Year 2015-2016
- Test cell study
    - Initiate Fiscal Year 2015-2016 Complete Fiscal Year 2018-2019

Progress to Date (Water Year 2015)

- Continued the POR hydrologic data analysis in support of experimental design.
- In-situ study:
    - Completed set-up of 35 plots in STA-1W Cell 2A and STA-3/4 Cell 2A.
    - Collected initial biomass, floc and soil samples in all plots.
    - Processed plant and soil samples for nutrient analysis.

    - Developed draft SOPs for leaf area index and plant density measurements.
    - Installed five leveloggers in STA-1W Cell 2A to monitor water depths.
- Test cell study:
    - Refurbished 15 STA-1W north test cells (soil replacement and grading).
    - Collected initial soil samples from all test cells.
    - Substantial completion of Gravity Flow Path Project to facilitate higher TP flow to the test cells.

Future Activities (Water Year 2016)

- Complete the POR hydrologic data analysis, including evaluating results from a cattail hydraulic field test in STA-1W Cell 2A. Information from this test will help estimate water surface profiles (using the WDAT utility) in this cell and improve the assessment of vegetation health in response to water depth.
- Finalize literature review.
- In-situ study:
    - Conduct monitoring of proposed parameters in STA-1W Cell 2A and STA-3/4 Cell 2A.
    - Install leveloggers in STA-3/4 Cell 2A as part of the in-situ study to monitor water depths.
- Test cell study:
    - Complete cattail seeding and maintenance of test cell plots and monitor plant germination and development.
    - Install staff gauges in all test cells to monitor water depth.
    - Finalize the experimental design for the test cell study.

STORMWATER TREATMENT AREA WATER AND PHOSPHORUS BUDGET IMPROVEMENTS

Tracey Piccone

Overall Study Plan Summary

The purpose of this study is to produce improved annual STA water and P budgets for STA treatment cells in order to meet the needs of the Science Plan. 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. Recently reported STA treatment cell annual water and P budgets contained high error terms (Ivanoff et al. 2013), thereby bringing into question the usability of the data to characterize and understand treatment performance.

The STA Water and P Budget Improvements Study is being implemented in a phased approach. Phase I included a test case for improving water budgets for individual treatment cells using simplified desktop approaches. During this reporting period, the Phase I summary report was completed (Polatel et al. 2014). Currently used and alternative methods to estimate the components of the water budgets were reviewed for potential improvements. The spatial and temporal variability of rainfall and evapotranspiration (ET) data and the differences in data from various sources were investigated. A comparison of next generation radar (NEXRAD) and rain gauge data found a notable difference in the rainfall estimates by these two methods. It is currently not possible to determine which data set is superior; therefore, it is recommended that STA water budget analyses continue using rain gauges when available with NEXRAD data used to fill gaps. Satellite and lysimeter-based ET methods were compared. No significant difference in the effect of these two methods on the annual water budgets was found. Available methods to estimate seepage were reviewed and applied to STA-3/4 Cells 3A and 3B and an impact analysis to quantify the effect of seepage was conducted. The factors affecting the accuracy of change in storage estimates were identified. Data collection and surface water flow computation protocols and procedures were reviewed. Historical stage and flow data were examined for errors. Corrections were applied to stage data for flow-way inflow (G-380) and mid-levee (G-384) structures. Datum adjustment and sensor calibration corrections were applied to stage data at G-384. Corrections due to a clogged well were applied at G-380. The accuracy of the current flow ratings at the Cells 3A and 3B control structures was reviewed. A computational fluid dynamics-based flow rating equation was developed for G-384A-F culverts.

Low head differentials at internal water control structures were identified as the main source of errors in water budgets for Cells 3A and 3B. Three methods to fix the historical flow rate data, one based on data correction and two on back calculation, were applied. The back calculation method based on redistribution of Flow-way 3 water budget residuals to the cells was chosen to be used in the improved cell-by-cell water budgets for the report. An uncertainty analysis was performed to estimate the expected uncertainties in the water budget residuals. Estimated uncertainties and relative sizes of each water budget components were propagated through the water budget equation. The biggest source of uncertainties in the residuals was identified as the surface water (i.e., structure) flows. Despite constituting a small fraction of water budgets, due to large uncertainties in its estimate, seepage was found to be a major contributor of residual uncertainty.

Phase II began implementing the methodologies investigated during Phase I on an expanded list of treatment cells and will also include developing improved P budgets for selected treatment cells. Phase III, only if determined to be necessary, will include more extensive approaches to further reduce errors in water and P budgets.

Study Schedule

- Phase I Initiated February 2013 Completed September 2013
- Phase II Initiated October 2013
  - STA-2 and STA-3/4 Flow Data Improvements Completed January 2015
  - POR STA-2 and STA-3/4 Water and TP Budgets Complete September 2016
- Phase III To be determined, if needed

Progress to Date (Water Year 2015)

- Finalized report on results of test case to reduce water budget errors (Polatel et al. 2014).
- Initiated improvements to the Water Budget Tool.
- Completed POR flow data and flow rating improvements for STA-2 (Cells 1 through 3) and STA-3/4 structures.
- Completed uploading improved STA-2 (Cells 1 through 3) and STA-3/4 historical flow data in the District's corporate environmental database, DBHYDRO.
- Initiated flow data and flow rating improvements for STA-1E structures, beginning with WY2014.

Future Activities (Water Year 2016)

- Continue flow data and flow rating improvements for STA-1E structures.
- Continue uploading improved historical flow data.
- Continue improvements to Water Budget Tool.

EVALUATION OF SAMPLING METHODS FOR TOTAL PHOSPHORUS

Pete Rawlik

Overall Study Plan Summary

As previously noted, the objective of the Science Plan is to gather scientific information to reduce P discharge concentrations to meet WQBELs established in the NPDES and EFA permits for the STAs. Integral and fundamental to this objective is the proper collection of representative water quality samples from compliance stations and research programs. However, the use of autosamplers in South Florida as the primary method for collecting data for flow-weighted concentrations has been shown in general to produce slightly higher TP results than grab samples, and, on occasion, can produce values that have significantly higher TP results than for grab samples. These unexplainable differences are often not large, but they can be a substantial contribution to TP measurements at low concentrations, adding extraneous and unrepresentative noise to analytical values.

Due to the very low WQBEL discharge TP levels, it is critical that the Science Plan identify factors that may bias results and begin the process of improving sampling regimes in the STAs to reduce the frequency and magnitude of extraneous noise. Findings from this study may also be applied to other non-STA sampling locations. In the Remote Environmental Sampling Test Project, significant amounts of water quality data were collected using a variety of methods under tightly specified conditions to develop a robust database for the study sites, with supplemental information from deployed probes and cameras. Using these methods in concert, issues with each individual method and data stream can be isolated and offending factors identified. The ultimate goal of this project is to make recommendations on how to prevent, mitigate, or minimize for various factors that interfere with representative sampling such that the samples collected for environmental monitoring, compliance and research present the best possible estimate of water column TP in a cost-effective manner. The Remote Environmental Sampling Test Project does not have any preconceived goal of supporting one particular sampling regime over another. Rather, it seeks to produce information to optimize TP sampling across a range of environmental conditions and monitoring locations.

Study Schedule

- Task 1: Sampling equipment installation
  - Initiated Fiscal Year 2012-2013 Completed Fiscal Year 2013-2014
- Task 2: Installation evaluation
  - Initiated Fiscal Year 2013-2014 Completed Fiscal Year 2013-2014
- Task 3: Data collection effort
  - Initiated Fiscal Year 2013-2014 Completed Fiscal Year 2014-2015
- Task 4: Analysis
  - Initiated Fiscal Year 2013-2014 Completed Fiscal Year 2014-2015

Progress to Date (Water Year 2015)

- Installed and evaluated equipment at the following:
  - G310 sampling site (discharge from STA1-W).
  - G390B sampling site (inflow to PSTA at STA-3/4).
- Conducted monitoring and data analysis.

- Initiated preparing draft report:
    - Method description.
    - Field observations including issues with wildlife and vegetation material, and infrastructure issues that impact sampling results.
    - Evaluation of efficacy of sampling methods:
        - Use of temporal as compared to flow-based measures of sampling completeness.
        - Failures of flow-proportional autosamplers due to programming and communication failures, low flow, negative flow, and phantom flow measurements.
        - Data completeness of deployed data sondes and RPA and refine definition of completeness.
        - Issues with flow-proportional autosamplers at structures where flow measurement and direction are suspect.
        - Better define flow-proportionality and to what extent to be achieved.

Future Activities (Water Year 2016)

- Complete study and provide final report with recommendations regarding modifications to sampling practices.
- Complete analysis of G-310 (discharge from STA-1W) alternate sampling regimes.
- Initiate analysis of G-390B (inflow to PSTA at STA-3/4) to show deviations of sampling and possible impact on results.
- Initiate analysis of rainfall events and TP data from RPAs.
- Prepare draft sections on alternate sampling regimes and the potential impacts of sampling deviations and influence of rainfall.
- Integrate draft sections and finalize report.

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