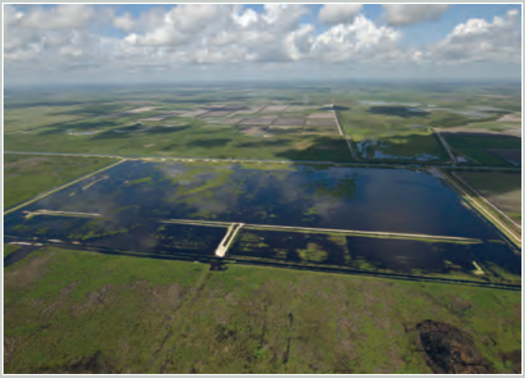
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

RESTORATION STRATEGIES REGIONAL WATER QUALITY PLAN

Science Plan
for the
Everglades Stormwater Treatment Areas

JUNE 2013







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EXECUTIVE SUMMARY

In June 2012, the State of Florida and the U.S. Environmental Protection Agency (USEPA) reached consensus on new restoration strategies for further improving water quality in the Everglades. Based on months of scientific and technical discussions, these strategies will expand water quality improvement projects to achieve an ultra-low total phosphorus (TP) water quality standard established for the Everglades. Under these strategies, the South Florida Water Management District (SFWMD or District) is implementing a technical plan, as documented in the Restoration Strategies Regional Water Quality Plan (SFWMD, 2012a), to complete six water treatment and storage projects in three flow paths between Lake Okeechobee and the greater Everglades—including more than 6,500 acres of new Everglades Stormwater Treatment Areas (STAs). The technical plan also calls for 110,000 acre-feet of additional water storage through construction of Flow Equalization Basins (FEBs) to capture runoff during storm events and provide a more steady flow of water to the STAs, helping to maintain desired water levels needed to achieve optimal water quality performance. Design and construction of the treatment and storage projects is scheduled to be accomplished in three phases over a 12-year timeframe, with completion set for 2025. Collectively, these projects are part of a revised National Pollutant Discharge Elimination System (NPDES) watershed permit issued by the Florida Department of Environmental Protection (FDEP) and approved by the USEPA for operation of the five existing Everglades STAs (STA-1 East, STA-1 West, STA-2, STA-3/4, and STA-5/6) which total approximately 57,000 acres. The NPDES permit along with a new state-issued Everglades Forever Act (EFA) watershed permit establishes stringent TP limits—Water Quality Based Effluent Limit, or WQBEL—for water discharged into the Everglades Protection Area.

The NPDES and EFA watershed permits and associated Consent Orders also require that the District develops and implements a science plan to enhance the understanding of mechanisms and factors that affect phosphorus treatment performance, particularly those that are key drivers to performance at low TP concentrations (<20 micrograms per liter, or µg/L). Issues identified for potential study investigation include the effects of microbial activity, phosphorus flux, inflow volumes and timing, inflow phosphorus loading rate and concentrations on phosphorus outflow, phosphorus removal by specific vegetation, and the stability of accreted phosphorus. The *Science Plan for the Everglades Stormwater Treatment Areas* was structured and developed around six key questions, and related sub-questions, that were identified by the District's Science Plan Team. The effort involved reviewing existing knowledge, determining information gaps, and formulating questions regarding phosphorus removal mechanisms and the factors that influence these mechanisms, including physical, chemical, and biological processes. A list of key questions related to the science, operation, and engineering aspects of STA performance was then developed. Analyses of each individual STA was also performed to determine factors affecting phosphorus removal performance, identify areas for further investigation, and list potential engineering refinements for implementation.

Overall, the Science Plan has been developed collaboratively and in consultation with interagency Technical Representatives and scientific experts from the U.S. Environmental Protection Agency, U.S. Department of Interior, U.S. Army Corps of Engineers and FDEP. This plan is intended to be a strategic, high-level document that will be revised and updated as needed. Specific implementation of science activities and research studies will be guided by the Five-Year Work Plan, which is currently comprised of nine proposed, initial study plans. Results from the Science Plan studies could be used to inform the design and operations of water quality projects, which will ultimately improve capabilities to manage for achievement of the WQBEL. Related data and information gathered from these studies will also be incorporated into the development and refinement of the District's modeling tools. Further information on Restoration Strategies Program including the Science Plan is available at www.sfwmd.gov/restorationstrategies.

1. INTRODUCTION

In accordance with the Everglades Water Quality Restoration Framework Agreement between the U.S. Environmental Protection Agency (USEPA), Region IV, and Florida Department of Environmental Protection (FDEP), dated June 12, 2012 (FDEP and USEPA, 2012) (**Appendix A**) and the Restoration Strategies Regional Water Quality Plan (SFWMD, 2012a), the *Science Plan for the Everglades Stormwater Treatment Areas* (STAs) has been established to investigate the critical factors that collectively influence the total phosphorus (TP) reduction and treatment performance in the STAs. Key topics associated with the scientific investigations covered in this Science Plan include the effects of microbial activity, phosphorus (P) flux, inflow volumes and timing, inflow phosphorus loading rate and concentrations on phosphorus outflow, phosphorus removal by specific vegetation, and stability of accreted phosphorus. It is expected that the results from these studies will be used to enhance the design and operations of projects under the Restoration Strategies (RS) Program, which will ultimately improve capabilities of the STAs to achieve compliance with the state's water quality criteria for TP. This Science Plan is also intended to fulfill the requirements of the Consent Orders between the FDEP and the South Florida Water Management District (SFWMD or District) (dated August 15, 2012) associated with the National Pollutant Discharge Elimination System (NPDES) Watershed Permits and Everglades Forever Act (EFA) Watershed Permits for the Everglades STAs (OGC Nos. 12-1148 and 12-1149, respectively), issued on September 10, 2012 (**Appendix A**). Pursuant to the Consent Orders, this plan has been developed in consultation with representatives designated by the FDEP and USEPA, on behalf of the state and federal agencies, respectively.

1.1 BACKGROUND

As set forth in the 1994 Everglades Forever Act, Section 373.4592, Florida Statutes, and the 1992 Consent Decree entered in the case *United States v. South Florida Water Management District*, Case No. 88-1886-CIV-Moreno (S.D. Fla.), reducing TP levels in the Everglades Protection Area (EPA) would be achieved by a two pronged approach comprised of building STAs and implementing a regulatory agricultural Best Management Practices (BMPs) program in the Everglades Agricultural Area (EAA). With regard to the Everglades STAs, in 1992, the plan contemplated the construction of four STAs comprised of 35,000 acres. In 1995, the plan was expanded by 5,000 acres and reconfigured into six STAs (STA-1W, STA-1E, STA-2, STA-3/4, STA-5, and STA-6). By 2006, however, it became apparent that additional STA acreage was needed and, therefore, STA-2, STA-5, and STA-6 were expanded. As of 2010, approximately 57,000 acres of STAs were built and flow capable. In September 2010, in a related federal court lawsuit between the Miccosukee Tribe and the USEPA and FDEP, the USEPA issued an Amended Determination in which the agency proposed a new Water Quality Based Effluent Limit (WQBEL) for the Everglades STAs—designed to achieve compliance with Florida's phosphorus water quality standard—and an STA expansion of 38,000 acres to achieve this limit. The Amended Determination, however, invited the District to submit a counter proposal.

1.2 RESTORATION STRATEGIES PROGRAM OVERVIEW

In early 2010, the SFWMD, State of Florida, and USEPA began technical discussions to establish a Water Quality Based Effluent Limit (WQBEL) for TP in discharges from the Everglades STAs (SFWMD, 2012b) that would achieve compliance with state's numeric TP criterion in the EPA and to identify a suite of additional water quality projects to work in conjunction with existing STAs to meet the WQBEL. From these discussions, in 2012, the FDEP issued a National Pollutant Discharge Elimination System (NPDES) Watershed Permit and an associated Consent Order (FDEP, 2012a) and an EFA Watershed Permit and associated Consent

Order (FDEP, 2012b) (see **Appendix A**, respectively), establishing the WQBEL and suite of water quality improvement projects to be constructed under the Restoration Strategies Program.

Overall, the planned strategies outlined in the permits and associated Consent Orders are intended to expand water quality improvement projects to achieve the phosphorus water quality standard established for the Everglades. Under these strategies, the SFWMD is implementing a technical plan to complete six projects that will create more than 6,500 acres of new STAs and 110,000 acre-feet (ac-ft) of additional water storage by constructing Flow Equalization Basins (FEBs). The strategies also include additional sub-regional source controls in areas of the eastern EAA where TP levels in stormwater runoff have been historically higher. A robust science plan will ensure continued research and monitoring to improve and optimize the performance of water quality treatment technologies. Design and construction of the treatment and storage projects is scheduled to be accomplished in three phases over a 12-year timeframe, with completion set for 2025. Further information on Restoration Strategies Program is available at www.sfwmd.gov/restorationstrategies.

1.2.1 Water Quality Based Effluent Limit

The WQBEL is a numeric discharge limit applied to all permitted discharges from the Everglades STAs to assure that such discharges do not cause or contribute to exceedances of the 10 micrograms per liter (µg/L) TP criterion within the EPA (expressed as a long-term geometric mean, or LTGM) established under Rule 62-302.540, Florida Administrative Code (F.A.C.) (SFWMD, 2012b). The WQBEL, outlined as a two-part test, was derived from the 10 µg/L LTGM TP criterion and translated into a flow-weighted mean (FWM) TP concentration to be applied individually to the total discharge for each STA. Monitoring for the WQBEL compliance is done at the individual discharge points from each STA. The STAs are in compliance with the WQBEL when the TP concentration representative of the total discharge from each STA does not exceed 13 µg/L as an annual FWM in more than three out of five water years on a rolling basis (Part 1) and 19 µg/L as an annual FWM in any water year (Part 2). The two parts for the WQBEL were developed to allow for expected year-to-year variability in the STA discharge TP concentration, as observed at the marsh reference sites used to develop the TP criterion, while attaining the long-term TP criterion. Therefore, if the discharges from each STA meet the WQBEL, then phosphorus discharges from the STAs into the EPA are not expected to cause or contribute to TP criterion exceedances. As described in the Consent Orders (**Appendix A**), the STAs are not predicted to achieve the WQBEL without additional corrective actions. The proposed corrective actions are expected to be completed by 2025.

1.2.2 Restoration Strategies Regional Water Quality Plan

The Restoration Strategies Regional Water Quality Plan (SFWMD, 2012a) provides a description of the water quality improvement projects to be constructed; conceptual engineering and operational details; and hydrologic and water quality modeling tools, assumptions, and results. The water quality improvement projects are divided into three flow paths—Eastern, Central and Western—which are delineated by the source basins that are tributary to the existing Everglades STAs (see **Appendix B** for detailed STA schematic maps). The identified projects primarily consist of FEBs, STA expansions, and associated infrastructure and conveyance improvements. The primary purpose of the FEBs is to attenuate peak stormwater flows prior to delivery to STAs and provide dry season benefits, while the primary purpose of the STAs is to utilize biological processes to reduce TP concentrations in order to achieve the WQBEL.

Each project component is based on a planning-level estimate of what is required in each flow path to meet the water quality standards for the EPA. The Eastern Flow Path contains STA-1E and STA-1W. The additional water quality projects for this flow path include an FEB in the S-5A Basin with approximately 45,000 ac-ft of storage and an STA expansion of approximately 6,500 acres (5,900 acres of effective treatment area) that will operate in conjunction with STA-1W. The Central Flow Path contains STA-2 (including the recently completed cells of Compartment B) and STA-3/4. The additional project is an FEB with approximately 60,000 ac-ft of storage that will attenuate peak flows to STA-3/4 and STA-2. The Western Flow Path contains STA-5/6 (including the recently completed cells of Compartment C). An FEB with approximately 11,000 ac-ft of storage and roughly 800 acres of effective treatment area (via internal earthwork) within STA-5/6 are being added to the Western Flow Path.

The Restoration Strategies Regional Water Quality Plan also proposes to build upon the success of the existing BMP Regulatory Program by focusing on areas and projects with the greatest potential to further improve water quality. The District's goal is to design projects to increase retention/detention of TP above what is currently required at the basin-ID level in strategic on-site locations or through sub-regional source control projects in conjunction with the onsite BMPs to further reduce TP loads to the STAs.

The S-5A drainage basin within the EAA was selected as a priority area based on the following: inflow concentrations from Lake Okeechobee to the S-5A basin, the water quality of the farms discharging within the S-5A, the potential to affect the inflow to the STAs, and potential positive impacts to the EPA. Conceptual projects within the S-5A basin were considered based on a combination of factors, including water quality of farm discharges, proximity and potential impact to the STA, and having willing participants.

The Consent Orders associated with the EFA and NPDES Watershed permits include a description of the proposed Science Plan aimed at understanding and improving the ability of the STAs to meet the WQBEL (see **Appendix A**). Similar language and direction for the Science Plan is included in the Everglades Water Quality Restoration Framework Agreement between U.S. Environmental Protection Agency – Region IV, and Florida Department of Environmental Protection (Framework Agreement; see **Appendix A**), which governs the roles and responsibilities of the two agencies for the Restoration Strategies Program.

1.2.3 Restoration Strategies Organization

The Restoration Strategies Program has several levels of public and agency oversight guiding implementation of the construction projects and the Science Plan, as summarized below.

- **Restoration Strategies Steering Group.** The main oversight group for the Restoration Strategies Program is the RS Steering Group, which is composed of District bureau chiefs and managers that represent various resource areas within the agency. The RS Steering Group is a forum that tracks the implementation for the RS Program and projects as they are designed and constructed. It is the responsibility of this group to make management decisions and track budget and project schedules, permit acquisition for the new projects and compliance with the existing STA permits and Consent Orders. In addition, this forum makes management decisions on future project development and on proposals for research projects being submitted for consideration as part of the Science Plan.
- **STA Leadership Team.** Oversight of all the existing STAs is the responsibility of the STA Leadership Team which is composed of managers that represent various resource areas within the District. The STA Leadership Team is a forum to update the management team on operations and maintenance projects, current conditions, and the performance status of all STAs and to evaluate operations, construction, performance, budgets, and other relevant issues.

- **Science Plan Team.** To develop the Science Plan, a core team was formed with experts from various disciplines throughout the District, including biology, wetlands ecology, engineering, operations, and hydrologic and hydraulic modeling. The Science Plan Team was tasked with determining information gaps and primary areas of investigation to further optimize STA performance and then developing a work plan based on this information. As the Science Plan Team developed research study concepts and proposals, these proposals were presented to the RS Steering Group for discussion and approval. The research study concepts and proposals were then presented to and discussed by the Technical Representatives.

Additional input to the Restoration Strategies Program is provided through interagency and public forums described below.

- **Technical Representatives.** As described in the Consent Orders and Framework Agreement, Technical Representatives were required to be identified by FDEP and USEPA, on behalf of state and federal agencies. The Technical Representatives have various technical functions but cannot vote or make any consensus recommendations or decisions. Their role is focused primarily on gathering information and fact finding, evaluating results of scientific studies, and assessing the District's progress in achieving Consent Order deadlines. The Technical Representatives are also expected to inform their respective agencies on how results of the Science Plan and interim STA operational performance could be utilized to optimize TP reduction and treatment performance. The District is required to convene regular meetings of the Technical Representatives as often as needed, but no less than every six months.
- **Stakeholder Involvement.** The public and other key stakeholders have the opportunity to provide input on Science Plan development and implementation through the Long-Term Plan quarterly communications meetings. Restoration Strategies is a standing agenda item, including both project updates and a Science Plan update, at these meetings. Further opportunities for public/stakeholder input has been and will continue to be available at key points in the Science Plan development process at the District's Governing Board or Water Resource Advisory Committee meetings. These forums have been used extensively in the past to communicate information and receive input from public stakeholders. Additionally, the Science Plan has been and will continue to be made available for public review and comment.

1.3 RESTORATION STRATEGIES SCIENCE PLAN

During the technical discussions between the State of Florida and USEPA regarding Everglades water quality, it was agreed that a Science Plan would be developed and implemented by the SFWMD. The Science Plan is intended to increase the understanding of mechanisms and factors that affect phosphorus treatment performance, particularly those mechanisms and factors that are key drivers to performance at low TP concentrations (<20 µg/L). Issues identified for potential Science Plan investigation include: effects of microbial activity, phosphorus flux, inflow volumes and timing, inflow phosphorus loading rate and concentrations on phosphorus outflow, phosphorus removal by specific vegetation, and the stability of accreted phosphorus. The Science Plan has been developed collaboratively and in consultation with the Technical Representatives and in coordination with key state and federal agencies and scientific experts. Results from the Science Plan studies could be used to inform the design and operations of water quality projects, which will ultimately improve capabilities to manage for achievement of the WQBEL (FDEP and USEPA, 2012; FDEP, 2012a; FDEP, 2012b).

1.3.1 Purpose, Goals and Objectives

The Science Plan document is intended to provide the overall framework for development and coordination of science activities to identify the critical factors that collectively influence phosphorus reduction and treatment performance in order to meet the WQBEL. As such, this plan only includes science associated with Everglades STA performance, mostly linked to sampling and other supporting information from the STAs. The document does not encompass science related to water quality parameters other than phosphorus or phosphorus source control technologies such as BMPs. This plan is intended to be a strategic, high-level document that will be revised and updated as needed. Specific implementation of science activities and research studies will be guided by the Five-Year Work Plan, as presented in **Appendix C**.

The Framework Agreement states that "…the objective of the Science Plan is to identify the critical factors that collectively govern phosphorus treatment performance; to maximize the understanding that can be gained from existing data, designs and operations; to identify the critical information gaps and research areas that will further treatment objectives in order to meet the WQBEL at each STA" (FDEP and USEPA, 2012). The Consent Orders associated with the EFA and NPDES Watershed permits provide additional details regarding how the Science Plan should be developed and implemented. The Consent Orders state, "after consulting with the [technical] representatives, [SFWMD] shall: (1) identify the critical information gaps and research areas that influence treatment performance; (2) prioritize the science needs; (3) develop and implement the science plan; (4) evaluate the results of ongoing scientific efforts to meet the prioritized science needs; (5) modify the science plan as needed based on results of completed or ongoing scientific studies, and (6) determine how the results of the scientific studies could be implemented to improve phosphorus reductions and treatment performance. Of particular interest is a better understanding of design and operations that sustain outflow concentrations at low phosphorus concentrations (<20 ppb)."

The Consent Orders also identify key areas that likely effect STA performance that should be considered for further scientific studies including (1) phosphorus loading rates; (2) inflow phosphorus concentration; (3) hydraulic loading rates; (4) inflow water volumes, timing, pulsing, peak flows, and water depth; (5) phosphorus speciation at inflows and outflows; (6) effects of microbial activity and enzymes on phosphorus uptake; (7) phosphorus resuspension and flux; (8) stability of accreted phosphorus; (9) phosphorus concentrations and forms in soil and floc; (10) soil flux management measures; (11) influence of water quality constituents such as calcium; (12) emergent and submerged vegetation speciation; (13) vegetation density and cover; (14) weather conditions such as hurricane and drought; and (15) the interrelationships between those factors.

1.3.2 Scope and Schedule

The Consent Orders require that the SFWMD develops a detailed Science Plan, including a work plan and associated schedules within nine months of permit issuance. In accordance with the EFA and NPDES Watershed permits, the Science Plan must be developed by June 10, 2013. The Consent Orders also require that the SFWMD begins to implement studies and research identified in the work plan within 12 months of permit issuance, by September 10, 2013. **Table 1** summarizes the Science Plan development schedule and associated key activities.

1.3.3 Annual Updates and Reports

Updates to the Science Plan will be done as needed, and other associated documents will be prepared to communicate progress throughout implementation of the Science Plan. The primary audiences for these documents include the District's science project managers and management team, Science Plan Team, Technical Representatives, and RS Steering Group. The companion Five-Year Work Plan (**Appendix C**), which guides the specific implementation of science work and lays out the initiatives and activities in the context of an annual budget cycle, will be assessed annually using the adaptive management process outlined in Section 5 of this plan. The Science Plan Team and RS Steering Group will provide input to determine the strategic prioritization for work and projects to be funded in a given year.

Additionally, the Science Plan will include a means to integrate and synthesize information to effectively communicate scientific findings and understanding of the Science Plan results to management and stakeholders. This effort will be published as the *Update for the Restoration Strategies Science Plan*, which will report on progress of the Science Plan implementation and incorporate status and findings of research, monitoring, and modeling efforts outlined in the Five-Year Work Plan. This update will be a comprehensive reporting and analysis of STA science, synthesized to gauge progress toward optimizing phosphorus treatment performance and achieving the WQBEL. The scope of the document will describe the current scientific understanding of the various factors and mechanisms controlling TP removal and analyze the feasibility of implementing potentially viable technologies and approaches. This information will then be used to identify needed policy and management actions, key areas of uncertainty, and essential information gaps, and help direct science plan efforts over the next 10 to 12 years of plan implementation. It is expected that the *Update for the Restoration Strategies Science Plan* will be incorporated into the annual South Florida Environmental Report (SFER) – Volume I and peer reviewed as appropriate using the SFER process.

Table 1. Science Plan activities and schedule (August 2012–June 2013).

Activity	Target/Completion Date
Initiate Science Plan development	August 3, 2012
Identify key questions, information gaps, research areas, modeling, data needs	October 31, 2012
Develop Science Plan outline/table of contents	October 31, 2012
Discuss Science Plan at Technical Representatives Meeting #1 (key questions, science plan outline)	November 6, 2012
Present Draft Science Plan outline & key questions at Long-Term Plan Communications Meeting	November 28, 2012
Discuss Science Plan at Technical Representatives Meeting #2 (key questions, information gaps, research areas, modeling and data needs)	December 5-6, 2012
Discuss Science Plan at Technical Representatives Meeting #3 (research question prioritization approach and criteria; draft list of prioritized research questions)	December 17, 2012
Discuss Science Plan at Technical Representatives Meeting #4 (draft study concept outlines)	January 15-17, 2013
Present Science Plan Development Update at Long-Term Plan Communications Meeting	February 12, 2013
Discuss Draft Science Plan Progress at Technical Representatives Meeting #5	February 13, 2013
Discuss Draft Science Plan Progress at Principals Meeting #1	February 26, 2013
Complete Draft Science Plan for Internal Review	February 27, 2013
Complete Draft Five-Year Work Plan (with conceptual plans for prioritized studies and proposed implementation schedule)	March–May, 2013
Present Science Plan Development Update at Water Resources Advisory Commission Meeting	March 7, 2013
Technical Representatives review of Draft Science Plan with Technical Representatives Meeting #6 (March 20)	March 14-28, 2013
Stakeholder/Public Review of Draft Science Plan Documents	April 11–May 22, 2013
Discuss Draft Science Plan at Long-Term Plan Communications Meeting	May 22, 2013
Discuss Draft Work Plan (with prioritized studies and proposed implementation schedule) at Technical Representatives Meeting #7	May 30, 2013
Finalize Science Plan and Five-Year Work Plan	June 7, 2013

2. STA OVERVIEW

2.1 GENERAL DESCRIPTION

The Everglades Stormwater Treatment Areas, mandated by the EFA (Section 373.4592, Florida Statutes), were constructed south of Lake Okeechobee to reduce TP from runoff waters prior to entering the EPA. STA-1E, STA-1W, STA-2, ST A-3/4, and STA-5/6 are operated, maintained, and managed by the SFWMD. The total area of the STAs including infrastructure components is roughly 68,000 acres, with approximately 57,000 acres of effective treatment area currently permitted to operate including recently completed treatment cells on Compartments B and C (see **Figure 1** and **Appendix B** for overall and detailed STA schematic maps, respectively).

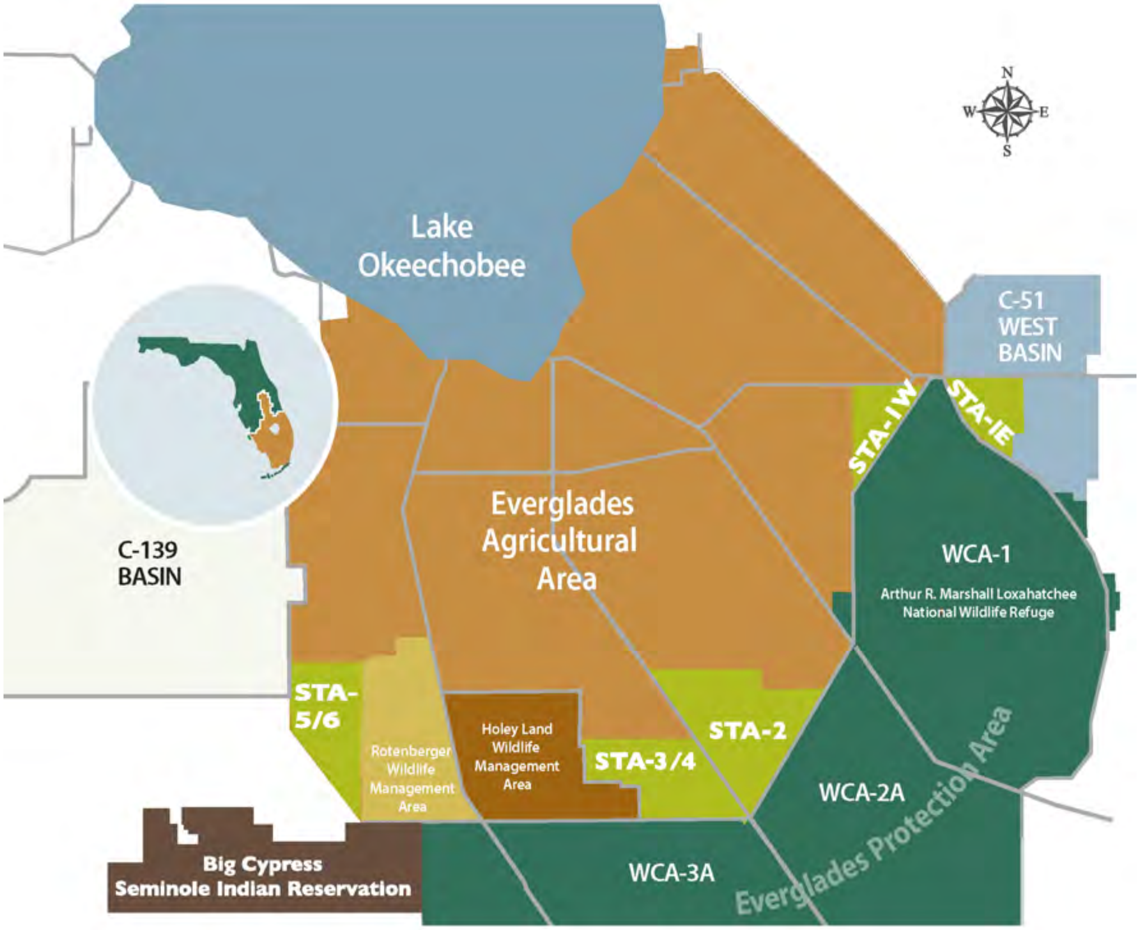

Figure 1. Location of the Everglades Stormwater Treatment Areas (STAs) 1 East (1E), 1 West (1W), 2, 3/4, and 5/6. [Note that STA-5 and STA-6 are currently referred to as STA-5/6, with the completion of construction of Compartment C in mid-2012.]

The STAs retain phosphorus through several mechanisms including plant nutrient uptake and litter decay, settling and sorption, co-precipitation with minerals, sedimentation, and microbial uptake (**Figure 2**). Varying in size, configuration, and period of operation, the STAs are divided into treatment cells by interior levees. Water flows through these systems via water control structures such as pump stations, gates, or culverts. The dominant plant communities in the treatment cells are broadly classified as emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV), and floating aquatic vegetation (FAV). Some cells have mixed vegetation types, including those cells that are presently undergoing vegetation conversion from EAV to SAV. Periphyton communities are interspersed among this vegetation, where conditions are favorable. Treatment performance, which varies temporally and among STAs, depends on numerous factors including antecedent land use, nutrient and hydraulic loading, vegetation condition, soil type, cell topography, cell size and shape, hydropattern (continuously flooded versus periodic dryout), maintenance and enhancement activities, and regional operations. The SFWMD uses an adaptive approach in managing the STAs using weekly data and information, including examination of stage levels, outflow TP concentrations, hydraulic and TP loading, vegetation condition, and any wildlife restriction issues.

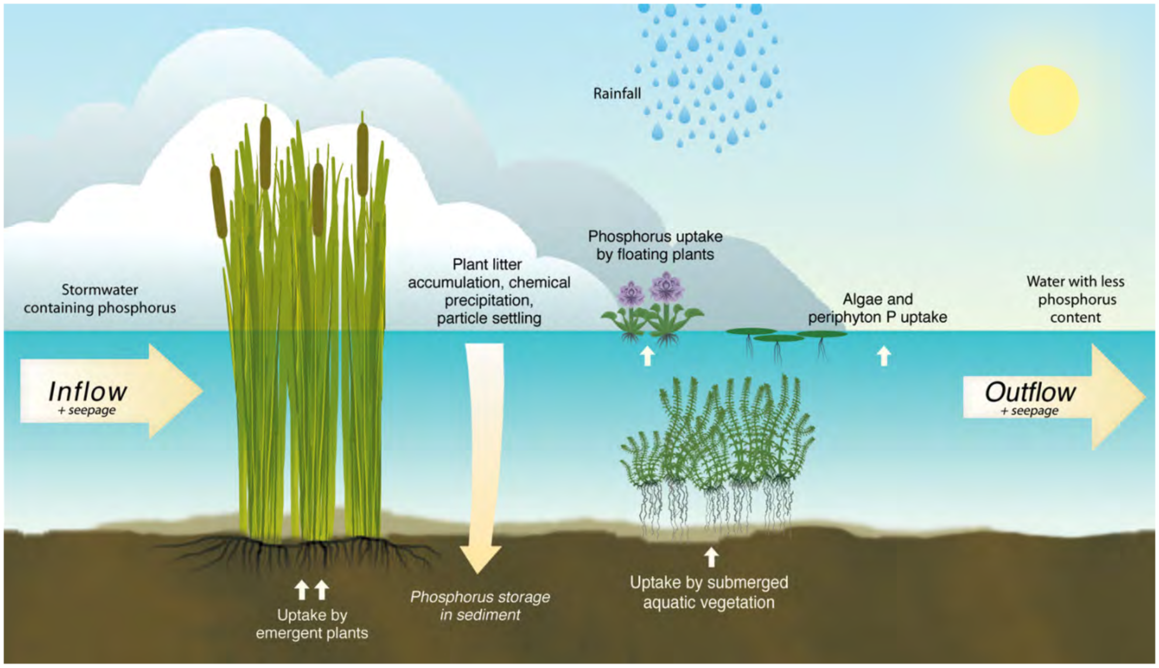

Figure 2. Schematic of phosphorus (P) retention process and mechanisms in the STAs.

2.2 DESCRIPTION OF EACH STA

2.2.1 STA-1E

STA-1E, which began operations in 2004, is approximately 20 miles west of West Palm Beach, located just south of State Road 80 and Canal C-51, adjacent to the northeast boundary of the Refuge and directly east of the STA-1 Inflow and Distribution Works (referred to as the STA-1 Inflow Basin). STA-1E consists of three parallel treatment paths, or flow-ways, with eight treatment cells flowing from north to south. STA-1E provides an effective treatment area of about 5,000 acres within eight treatment cells (see **Figure B-1**). STA-1E receives inflow primarily from the C-51 West basin and the Rustic Ranches subdivision. In WY2008, STA-1E started receiving inflows from a new source (runoff from Wellington Acme Basin B). During dry months, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration of priority cells.

2.2.2 STA-1W

STA-1W, which began operation in 1994 as the Everglades Nutrient Removal (ENR) Project, is located northwest of the Refuge. It is comprised of three flow-ways totaling about 6,500 acres of effective treatment area: Eastern Flow-way (Cell 1A, Cell 1B, and Cell 3), Western Flow-way (Cell 2A, Cell 2B, and Cell 4), and Northern Flow-way (Cell 5A and Cell 5B) (see **Figure B-2**). The Eastern and Western Flow-ways were formerly known as the ENR Project, and the Northern Flow-way was added in 1999. Compartmentalization of former Cells 1 and Cell 2 were completed in 2007, creating Cells 1A, 1B, 2A, and 2B. This STA receives its inflow primarily from the S-5A drainage basin. During dry months, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration of priority cells.

2.2.3 STA-2

STA-2 is located in western Palm Beach County immediately west of Water Conservation Area 2A (WCA-2A). The original STA-2 consisted of three treatment cells (1, 2, and 3) and began operation in 2000. STA-2 was expanded with the construction of Cell 4, which was flow capable by December 2006, but this cell went off-line in WY2010 for Compartment B construction. With the recent completion of Compartment B construction, STA-2 has a total of eight treatment cells and five flow-ways, and a total effective treatment area of approximately 15,500 acres (see **Figure B-3**). STA-2 receives agricultural runoff primarily from the S-6/S-2 Basins and, with the addition of the Compartment B treatment facilities, STA-2 can also receive runoff from the S-7/S-2 Basins. During dry months, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration of priority cells.

2.2.4 STA-3/4

STA-3/4 is located northeast of the Holey Land Wildlife Management Area and north of Water Conservation Area 3A (WCA-3A). It provides a total treatment area of about 16,300 acres to treat stormwater runoff originating within the S-2/S-7, S-3/S-8, S-236, and C-139 basins and releases from Lake Okeechobee (see **Figure B-4**). During dry months, supplemental water is also delivered from Lake Okeechobee, when available, to maintain hydration of priority cells. STA-3/4 is comprised of three flow-ways: Eastern Flow-way (Cells 1A and 1B), Central Flow-way (Cells 2A and 2B), and Western Flow-way (Cells 3A and 3B). A 445-acre section of Cell 2B is the site of the STA-3/4 Periphyton-based Stormwater Treatment Area (PSTA) Project, aimed at testing and evaluating PSTA treatment technology.

2.2.5 STA-5/6

STA-5, which receives inflows primarily from the C-139 Basin, is located in Hendry County and bordered by the L-2/L-3 borrow canal on the west and the Rotenberger Wildlife Management Area on the east. The original STA-5 (Flow-ways 1and 2) began operating in 2000. STA-6, also located in Hendry County, is south of STA-5, east of the L-3 borrow canal, and west of the Rotenberger Wildlife Management Area. The original STA-6, which consisted of Cells 3 and 5, began operation in 1997 and treated agricultural runoff from the United States Sugar Corporation's Southern Division Ranch, Unit 2. After this land was purchased for restoration purposes and farming operations ended, this land became known as Compartment C. In 2006, Section 2 was added to STA-6, and a third flow-way (Flow-way 3) was added to STA-5 on a portion of Compartment C. In 2012, treatment facilities were completed on the remaining portion of Compartment C. The entire STA-5/6 complex consisting of STA-5, Compartment C, and STA-6, has a total effective treatment area of about 13,700 acres (see **Figure B-5**) and is operated as an integrated facility to treat runoff from the C-139 Basin.

2.3 HISTORY OF STA RESEARCH AND MONITORING

2.3.1 Advanced Treatment Technologies

Since the development of the ENR Project (see Chimney et al., 1999), extensive monitoring and research activities have been conducted to gather valuable information in support of refinements to STA performance. Conducted from 1997–2002, the Advanced Treatment Technologies (ATT) Research Program focused on potential technologies that could be used in conjunction with cattail-dominated STAs to meet water quality standards in discharges to the EPA. The technologies investigated included submerged aquatic vegetation treatment system; PSTA; chemical treatments – direct filtration, high rate sedimentation, dissolved air flotation/filtration, and microfiltration/ultrafiltration; low intensity chemical dosing; and managed wetlands. Concurrently, the STA Optimization Research Program included various hydraulic loading rate, water depth, pulsed-flow, and marsh dryout studies that were conducted in the 0.5-acre cattail-dominated test cells located in STA-1W. The findings of the ATT and STA Optimization Research programs are summarized in the 1999–2004 Everglades Consolidated Reports (Chimney et al., 2000, 2004; Jorge et al., 2002; Newman et al., 2003; Goforth, 2003, 2004). The SFWMD incorporated some of the results of ATT research into the planning, design, and optimization of the STAs (e.g., sub-dividing STA-3/4 Cell 3 into two cells, with an upstream EAV cell and the downstream SAV cell).

The results of the ATT Research Program were also utilized in the Basin-Specific Feasibility Studies conducted for 13 tributaries that discharge into the EPA (Brown & Caldwell, 2002; Burns & McDonnell, 2002). The studies considered environmental factors, implementation cost, scheduling, and technical factors in evaluating measures to reduce TP levels entering the EPA. Two key findings from these studies are documented in the Water Quality Standards for Phosphorus within the Everglades Protection Area (Section 62-302.540(2)e, F.A.C.) as follows:

1. At this time, chemical treatment technology is not cost-effective for treating discharges entering the Everglades Protection Area and poses the potential for adverse environmental effects.
2. Optimization of the existing STAs, in combination with BMPs, is currently the most cost-effective and environmentally preferable means to achieve further phosphorus reductions to the Everglades Protection Area, and to restore impacted areas. The effectiveness of such measures should be determined and maximized prior to requiring additional measures. Optimization shall take into consideration viable vegetative technologies, including Periphyton-based STAs (PSTA) that are found to be cost-effective and environmentally acceptable.

2.3.2 Long-Term Plan Process Development and Engineering: Monitoring and Studies

The SFWMD's commitment to continue researching ATTs and modifying the Everglades phosphorus control program was further documented in the 2003 Long-Term Plan (Burns & McDonnell, 2003, and as subsequently amended). The Long-Term Plan identified specific STA enhancement activities (e.g., conversion of treatment cells from EAV to SAV to further reduce outflow concentrations, and construction of interior dividing levees to improve flow distribution). The Long-Term Plan also outlined additional investigations to achieve water quality standards in the EPA as part of the Process Development and Engineering (PDE) activities (as reported in the annual consolidated reports at www.sfwmd.gov/sfer).

As a central element of the overall strategy, the PDE component was developed in recognition that achieving long-term water quality goals involves an adaptive management approach, whereby the best available information is used to develop and expeditiously implement incremental improvement measures in a cost-effective manner. PDE activities included performing enhanced control and monitoring of the STAs, refining STA water quality modeling tools, conducting SAV and PSTA investigations, and improving the reliability of STA inflow forecasts. Over 15,000 acres of STA treatment cells were converted to SAV pursuant to the recommendations in the Long-Term Plan. The PDE component of the Long-Term Plan includes long- and short-term surveys and monitoring to continually assess STA conditions and apply the knowledge in adaptive management of the STAs. This comprises routine and event-driven water quality and spatial soil sampling and analysis, topographic surveys, and vegetation surveys. These data have been utilized in documenting STA conditions, investigating poor-performing cells, and developing or evaluating management strategies for a cell or flow-way.

Water Quality and Flow Monitoring. Routine water quality and flow monitoring sites are divided into two major categories used for characterizing STA performance. Compliance monitoring sites are located at the STA inflow and outflow sites (specifically listed in the permits) that capture the overall treatment performance of the STA. Operational monitoring sites are located at many of the inflows and outflows of individual flow-ways and in some cases individual treatment cells. Together, the data collected at these monitoring sites are used to evaluate STA performance, develop weekly summaries of flow and water quality monitoring data used for operational decision making, and support continued improvement of analytical and forecasting tools. For example, weekly flows and TP data are utilized to assess the performance of individual flow-ways.

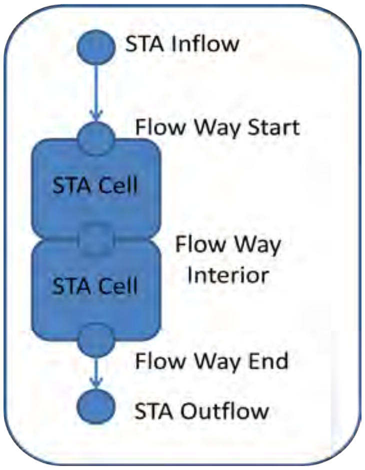

Figure 3. STA simplified schematic.

In 2013, the District began executing a monitoring strategy designed to meet the core requirements for both compliance and operational sites while optimizing sample collection and analysis. This strategy is based upon a set of 10 water quality monitoring guidance statements that can easily be applied to the STAs in a uniform manner. Given the number of monitoring stations involved, such uniformity is necessary to assure that compliance and operational needs are accurately and efficiently met. One of the core concepts of this strategy is the implementation of sampling parameters and frequencies in a manner that is logistically feasible and allows for leveraging of information at both upstream and downstream stations. Such leveraging is possible because most STAs are variations on a very simple design (**Figure 3**), in which water flows from the STA inflow (compliance site) through the flow-way (from start to interior to end), and then through the STA outflow (compliance site). Based on the overall water quality guidance established for the Everglades STAs, the District has implemented a monitoring plan that meets compliance and operational monitoring needs. However, it is acknowledged that research designed to help meet discharge requirements may necessitate that the monitoring plan be modified to act in a support role. It is also understood that the research effort may identify new parameters, frequencies, and locations of interest. Further details on the individual STA water quality monitoring plans are presented in **Appendix D**.

Topographic Surveys. Updated STA topographic survey data is acquired periodically to improve or refine data used in operational decision making and STA performance evaluations (Piccone et al., 2012). For example, updated topographic data is used to refine treatment cell target stages, update the relationship between treatment cell stage and wetted area, and perform various hydraulic analyses such as two-dimensional hydrodynamic modeling. Efforts are made to ensure that each data point is representative of the surrounding marsh, with the intent that no data points are taken on levees, remnant farm roads, or in remnant farm ditches or canals. Updated topographic surveys for the STAs are typically conducted every five years.

Spatial Soil Characterization. Until 2010, baseline soil cores were collected upon completion of construction of new STA cells followed by collection of soil/accrued sediment cores on a three-year cycle on a rotating basis. Samples were analyzed for total phosphorus, total nitrogen, total carbon, bulk density, ash free dry-weight, total sulfur, total calcium, and total iron. Limited but more in-depth investigation of soil accretion and stability of accreted soil P has also been done over the years of STA operations. In-depth examinations of available soil data helped identify gaps in understanding the biogeochemical processes and the factors that influence them. In the 2006-2007 STA-1W rehabilitation, for example, soil information played a major role in deciding the proper management strategy for each affected cell. The resulting vegetation establishment and performance in the three cells attest to the success of the chosen soil management strategy. Going forward, the District is currently evaluating a potential change to a five-year cycle for soil monitoring of all STA cells.

Vegetation Monitoring. Changes in vegetation can occur over time in the STAs, and these changes can affect treatment performance. Vegetation monitoring has aided in focusing vegetation management efforts to improve vegetation conditions, with the ultimate goal of maintaining and sustaining treatment performance. Current vegetation monitoring occurs at various frequencies, including but not limited to annual aerial imagery, annual to semiannual submerged aquatic vegetation ground surveys, ad hoc surveys (include weather-related events or performance investigation events), monthly helicopter over-flights, and periodic field inspections. This monitoring strategy is proposed to continue going forward.

Individual Studies and Analyses. Besides routine water quality sampling at cell inflow and outflow structures, there has been interior water quality and vegetation transect monitoring in recent years. Data gathered from these transects helps identify well-performing and problematic regions along certain flow-ways. Smaller-scale mesocosm and field studies also have been conducted to supplement existing knowledge about the STAs. These studies are summarized in **Table 2** and related information is reported in the 2005–2013 SFERs –Volume I (Goforth et al., 2005; Pietro et al., 2006–2010; Germain and Pietro, 2011; Ivanoff et al., 2012, 2013). For example, studies have been done to help understand the effects of extreme water level condition (dryout and deep water conditions) on cattails (*Typha* spp.) and evaluate effectiveness of SAV versus other vegetation in polishing cells.

Hydrologic studies (tracer studies, vegetation resistance measurements, and two-dimensional modeling) to determine flow pattern and vegetation resistance have also been conducted in certain cells. Comprehensive analyses of period of record STA performance data sets also have been completed (Pietro, 2012). Results of these analyses have identified the important role of hydraulic and phosphorus loading rates as well as inflow TP concentration. However, at very low

Table 2. Summary of applied scientific studies in the Everglades STAs through April 2013.

Study	Description and Objectives	Status (as of April 2013)	Relevance to the Science Plan
STA-3/4 PSTA Project	This project, which began in WY2007, is a field implementation of PSTA technology aimed at further lowering outflow TP concentrations in STA discharges. The primary objective is to have a more accurate assessment of the PSTA performance and the design, operational factors, and biogeochemical mechanisms that help achieve the observed performance. Study includes field sampling/testing, core studies, and microcosm studies.	The STA-3/4 PSTA project structures and operation were modified in WY2012 to improve flow data accuracy. A more in-depth scientific evaluation also began in WY2012. Monitoring for water quality, soil, vegetation, and microbial activities were conducted at different flow scenarios. Water and phosphorus budgets have been updated based on the additional data. Cell target stage was raised by 6 inches and outflow pump operation setting was adjusted in April 2013 to test for effects on the water budget and determine effects on performance. *Status: ongoing.*	Aside from addressing the original project objectives, results from this study will provide inputs to address the following Science Plan sub-questions: (1) What are the treatment efficacy, long-term stability, and potential impact of floc and soil management, (2) What are the sources, forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system, and (3) What are the key physical-chemical factors influencing P cycling at very low concentrations? Results will also be used to update existing or enhance new analytic tool, particularly for low-level P condition performance prediction.
STA-1W Phosphorus Mesocosm	This is a three-year proof-of-concept study to investigate whether several species of native aquatic macrophytes (sawgrass, water lily, spikerush, and water lily + spikerush) can be used to enhance the treatment performance (TP removal) of the STAs. The TP removal capability of these species is being compared to that of cattail and SAV, plant communities that currently dominate the STAs. The study is being conducted at the STA-1W South Research Site.	This is the third year for the mesocosm study. *Status: ongoing; expected completion: November 2013.*	This study address the following Science Plan key questions: (1) What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs, and (2) How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?
STA Vegetation Monitoring: Aerial Imagery	Aerial photographs (using high-contrast infrared film) of the STAs are taken annually during the summer to document vegetation coverage (emergent vegetation versus SAV+open water areas) in accordance with the STA operating permits. Specific areas of interest are also mapped in more detail on an as-needed basis. Aerial photographs, together with ground-truthing data, have been used to evaluate vegetation density on a relative basis in selected areas. Vegetation maps and GIS interpretation efforts are associated with this project.	The 2012 imagery is in process; the 2013 imagery was taken in March 2013 and will also be processed for future analysis and reporting. Further calibration to enable the use of imagery for normalized vegetation density index estimation in the STAs is under way. *Status: recurring, annual.*	Routine annual monitoring to determine emergent vegetation coverage. The information will be used to supplement the cattail inundation study, which addresses the following Science Plan sub-question: How does water depth affect sustainability of dominant vegetation? Results can be utilized for long-term assessment of changes in coverage and density of EAV. The infrequency of image acquisition limits its usability for detecting short-term changes in vegetation coverage and density. The image also is not useful for assessment of SAV actual coverage or species.

Study	Description and Objectives	Status (as of April 2013)	Relevance to the Science Plan
STA Vegetation Monitoring: Ground Surveys	Ground surveys are conducted to assess SAV species coverage and relative abundance. Surveys are also conducted as part of extreme event assessments. Spatial species distributions are mapped and reported annually and as needed for performance-related evaluations.	*Status: recurring, ongoing.*	Routine monitoring to track and assess SAV composition and relative density in SAV cells. Effort partly addresses the following sub-question: What factors determine spatial and temporal variability of SAV community structure (species composition, cover, density)? Data collected will also be used for the following science plan study: Evaluate Phosphorus Sources, Forms, Flux, and Transformation Processes in the STAs.
Spatial Soil Sampling	Spatial soil sampling and testing to estimate P storage in floc and accrued layer, soil accretion, and determine potential effects on performance.	*Status: There was no sampling performed in WY2013. Sampling program is being reviewed to establish a cost-effective and meaningful soil data acquisition.*	Routine soil condition monitoring; previous soil sampling results will be used in some science plan studies.
STA Water Quality Internal Transects Evaluation	Evaluate P removal from the water column along transects of selected flow-ways in STA-1E, STA-1W, STA-2, and STA-5. Data are being used to monitor P cycling within STA flow-ways under various operational and environmental conditions. Over time, these data may provide insight about key processes such as internal P transformations and spatial relationships between vegetation type/health and P retention or sediment P release.	*Status: recurring, ongoing.*	This evaluation assesses the condition of the treatment flow-way, specifically to track the trend of P reduction along the inflow to outflow gradient. The scope and frequency of transect sampling will be expanded for selected flow-ways to help address the following Science Plan sub-questions: (1) What are the treatment efficacy, long-term stability, and potential impact of floc and soil management, (2) What are the sources forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system, and (3) What are the key physical-chemical factors influencing P cycling at very low concentrations?
Investigation of Factors Influencing SAV Performance and Sustainability in STAs	There is a need to better understand the factors that influence SAV species distribution, persistence, and colonization/recovery in STAs. This investigation includes (1) SAV distribution and speciation as a function of water depth; (2) investigation on the potential impacts of bird herbivory on SAV communities; (3) mesocosm study to determine effects of mixed EAV and SAV communities on water quality and stability of sediment P; and (4) large sediment core evaluation study to assess impacts of sediment treatments (dry down, floc removal, etc.) on SAV recruitment and water column turbidity.	*Status: ongoing; herbivory study was discontinued due to difficulty in field assessment.*	Effort partly addresses the following Science Plan sub-question: What factors determine spatial and temporal variability of SAV community structure (species composition, cover, density)?

loading rates, other factors seem to be controlling the STA performance. As these data analyses have been conducted on long-term data collected under non-controlled environment, analyses to date have not conclusively identified the specific influencing factors for the various STAs. PSTA, which continues to be studied by the SFWMD, may provide additional treatment capability at the end of the EAV/SAV treatment train. A PSTA Research Plan with intensive scientific investigations is being developed and implemented to provide more accurate assessment of PSTA technology performance and determine design and operational factors that contribute to that performance and replication options (see **Appendix C**).

2.4 DRIVING FORCES AND ISSUES FACING THE STAS

Because STAs are biological treatment systems, their nutrient removal performance is inherently variable and affected by various external and internal factors. External factors include wet and dry weather cycles, inflow P concentrations and loads, variable water delivery rates that result in changing water depths and flow rates, and wildlife utilization and associated state and federal wildlife protection laws. STA performance is also affected by internal biogeochemical factors including the health of submerged and emergent vegetation communities; algal, periphyton, and bacterial communities; and soil P dynamics and flux. The STAs are not operated in isolation as they are integral components of a complex water management system with multiple objectives, particularly water supply and flood control.

The STAs receive stormwater runoff, resulting in variable inflow volumes and TP loads and concentrations. Because the goal is to treat all the stormwater before it enters into the EPA, high loadings and extended periods of deep water conditions can occur which in turn can negatively impact STA performance. Another challenge related to STA operations occurs during the dry season, particularly during drought periods, when there is not always sufficient water to keep the cells hydrated and some cells dry out. Prolonged dryout conditions have been found to cause elevated outflow TP concentrations upon rehydration as observed historically most often at STA-5/6. Over the years, the SFWMD has implemented a drought contingency strategy to try to minimize drought impacts on STA performance. STA operations are also impacted by wildlife use, in particular species protected under the Migratory Bird Treaty Act, Endangered Species Act, and Bald Eagle Protection Act. STA water depths and flow conditions have been affected at times as a result of the presence of protected species in the STAs.

Effective management of both desirable and undesirable vegetation in the STAs is critical to achieving and sustaining the required treatment performance. The District has determined that the most effective control of non-desirable vegetation is achieved through proactive vegetation management and routinely applies herbicide in the STAs for exotic/nuisance species control. This is particularly critical for floating aquatic vegetation (FAV), which can shade out and impact SAV. To accelerate SAV recruitment in areas that are being converted from EAV to SAV, and in SAV cells undergoing rehabilitation, SAV inoculation has been implemented using equipment on land, in water and in air via helicopter (Pietro et al., 2006; Ivanoff et al., 2012).

The STAs are highly managed systems, the operation of which involves various personnel for routine operation and maintenance of pumps, gates, structures, and vegetation maintenance. Scientists and engineers provide the technical information and evaluation to help ensure proper operation and optimized management, including collecting and analyzing water quality data, soil and vegetation data, flow data, and performance data. Cross-disciplinary teams participate in weekly, biweekly, and monthly communication and coordination meetings. Water depths in each cell are monitored and target stages are set from average ground elevations depending on the dominant vegetation community and condition of the treatment cell. Frequent field visits are made to the STAs by site managers and scientists. Following extreme weather conditions, such as drought or storm events, assessments of the STA plant communities and infrastructure components are conducted. When desired performance is not being achieved, the technical team examines potential causes and implements corrective actions when feasible. Corrective actions can be operational in nature, such as reducing inflow loading to one flow-way by redirecting flows to another flow-way, or reducing target stages to allow vegetation to rejuvenate. Corrective actions can also include structural enhancements such as adding new structures or constructing divide levees to increase compartmentalization, or major rehabilitation activities such as the earthwork that was completed in STA-1W in 2007 and in STA-5 in 2009.

3. SCIENCE PLAN QUESTIONS AND OTHER AREAS OF INVESTIGATION

3.1 SCIENCE PLAN QUESTIONS

The Science Plan was structured and developed around six key questions that were identified by the Science Plan Team. The effort involved reviewing existing knowledge, determining information gaps, and formulating the questions regarding phosphorus removal mechanisms and influencing factors. These include physical, chemical, and biological processes influencing phosphorus reduction in STAs. A list of key questions related to the science, operation, and engineering aspects of STA performance was developed. Detailed analyses of each individual STA was also performed to determine issues affecting phosphorus removal performance, identify areas for further investigation, and list potential engineering refinements for implementation.

In this Science Plan, the six key questions are as follows:

1. *How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management?*
2. *How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?*
3. *What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?*
4. *How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?*
5. *What operational or design refinements could be implemented at existing STAs and future features (i.e., STA expansions, FEBs) to improve and sustain STA treatment performance?*
6. *What is the influence of wildlife and fisheries on the reduction of phosphorus in the STAs?*

Each key question was further evaluated after a preliminary literature review and data analyses. This information indicates what is known and unknown relative to the key questions and identified critical information gaps and research areas. A more comprehensive list of sub-questions relative to the key questions was developed. This list was then organized into a set of sub-questions focused specifically on where informational and knowledge gaps exist, as presented in **Table 3**. Following this table, each key question and their associated sub-questions are presented in Sections 3.1.1–3.1.6. The level of detail presented for the key questions varies in the initial version of this Science Plan, and additional details may be added in subsequent versions. It should also be noted that in the initial version of this Science Plan, all the sub-questions presented in **Table 3** are not covered under the respective key questions, but may be addressed as appropriate in future efforts. In addition, Key Question 6 was not deemed to be the highest priority effort at this time. However, the role of aquatic consumers will continue to be considered by the District as wildlife, fish, and large invertebrates contribute to the phosphorus cycling in the STAs. Investigation into this key question, while not currently scheduled, will likely begin with a literature review to determine if future efforts on this topic could provide useful STA management recommendations. The apparent importance of consumers suggests that even small changes in density and distribution could influence STA outflow TP concentrations.

Table 3. Science Plan key questions and associated sub-questions used to develop proposed study plans (**Appendix C**). [Note that * denotes that proposed study plans have been developed for these sub-questions; planned efforts to implement related study plans for sub-questions without an asterisk have not been established to date, but are expected to be considered further as the Science Plan evolves using the adaptive management process. Sub-questions are listed once under the primary key question but may be associated with one or more key questions.]

Restoration Strategies: Science Plan for the Everglades Stormwater Treatment Areas – Key Questions and Associated Sub-Questions

1. **How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management?**
    - How should storage in the FEBs be managed throughout the year so water can be delivered to the STAs in a manner that allows them to achieve desired low outflow P concentrations?*
    - Would changes in canal management or design improve STA and FEB performance?*
    - What components and operational activities could potentially be incorporated into the FEB designs that would promote settling of sediment and associated PP to prevent transport into the STAs?
    - What water quality treatment technologies should be evaluated along with the FEBs?
    - Should the establishment of FAV be promoted in the L-8 FEB?
    - If FAV is promoted in the L-8 FEB, is mechanical harvesting beneficial or feasible?
    - As EAV will colonize the shallow FEBs (A-1 and C-139), should SAV establishment and management be promoted in these FEBs?
    - If SAV is promoted in the shallow FEBs, what is the optimal EAV/SAV design configuration?
    - Should littoral zones be established in the shallow FEBs to reduce flow impedance?
2. **How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?**
    - What are the sources (internal/external, plants, microbial, wildlife), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system?*
    - What are the key physical-chemical factors influencing P cycling at very low concentrations?*
    - What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P?*
    - What are the treatment efficacy, long-term stability, and potential impacts of floc and soil management?*
3. **What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?**
    - How does water depth affect sustainability of dominant vegetation?*
    - Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: can *Cladium jamaicense, Nymphaea odorata*, and periphyton mats enhance P uptake and removal in SAV cells?*
    - How do water depths and soil characteristics affect sustainability of dominant vegetation: is the formation of floating mats and tussocks determined by water depth and duration regimes and soil characteristics?
    - Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: can fire flag *(Thalia geniculata),* knotweed *(Polygonum densiflorum)* and giant bulrush *(Scirpus acutus)* provide similar P uptake and removal potential as cattail?
    - What factors determine spatial and temporal variability of SAV community structure (species composition, cover, density): will sediment deposition and nutrient loadings lead to a decline in the sustainability and P uptake performance of SAV cells?

Table 3. Continued.

Restoration Strategies: Science Plan for the Everglades Stormwater Treatment Areas – Key Questions and Associated Sub-Questions

3. **Continued.**
    - How do water depths and soil characteristics affect sustainability of dominant vegetation: will lowered stages during the dry season enhance sustainability and associated P uptake performance of hydrilla (and other dominant SAV species)
    - Do dry outs result in changes in the relative cover of musk grass (*Chara* sp.) and southern naiad (*Najas guadalupensis)*?
    - What are the impacts and potential benefits of dry outs and drawdowns on STA performance and sustainability: are the rates of reestablishment of cover and associated P uptake processes of dominant SAV species (Chara spp. and Najas guadalupensis) dependent on the duration and intensity (water table depth) of dry out events?
    - Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: what is the appropriate relative cover of emergent vegetation in the SAV cells?
    - Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: will rotation of emergent vegetation in SAV cells enhance sustainability of these cells?
    - Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: can *Potamogeton illinoensis*, *Vallisneria americana*, and floating leaved species, such as *Nelumbo lutea* and *Nuphar lutea*, survive in deeper portions of SAV cells and complement P uptake by dominant SAV species?
    - Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: what is the effect of the size and distribution of emergent vegetation strips on SAV sustainability?
    - What are the impacts and potential benefits of dry outs and drawdowns on STA performance and sustainability: will P uptake processes in EAV cells be reestablished within one month of reflooding after a controlled drawdown?

4. **How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?**
    - Are there things that can be done in the STAs to enhance settling, filtering and treatment of DOP and PP in the water column?
    - What design or operational changes can be implemented to reduce PP and DOP at the outfall of the STA?

5. **What operational or design refinements could be implemented at existing STAs and future features (i.e., STA expansions, FEBs) to improve and sustain STA treatment performance?**
    - Does pumping at lower STA inflow and outflow rates over 16 or 24 hours in a day, versus 8-hour day shifts, improve STA performance?
    - What is the best period within a 24-hour day to discharge water from an STA in order to achieve the lowest P concentrations?
    - What are the best structural design features for delivering water to and from the STAs and FEBs?
    - How critical is topography in STA treatment performance?
    - What is the cost-benefit of adding more operational flexibility to transfer water between cells and flow-ways or to deliver supplemental water during droughts?
    - Can upward diffusion of P in SAV cells (or portions of cells) be reduced by inducing downward flow?

Table 3. Continued.

Restoration Strategies: Science Plan for the Everglades Stormwater Treatment Areas – Key Questions and Associated Sub-Questions

6. **What is the influence of wildlife and fisheries on the reduction of phosphorus in the STAs?**
   - What are the direct and indirect effects of wildlife communities on P cycling at temporal and spatial scales (e.g., are they net sinks or sources)?
   - What factors determine spatial and temporal variability of SAV community structure (species, composition, cover and density): what are the short and long-term impacts of herbivory by wintering waterfowl on SAV cover, community structure, and sustainability or P uptake of SAV cells?
   - What options are there for mitigating or reducing the impacts of fish and wildlife on STA performance through wildlife management or change in operations?
   - What are the direct and indirect effects on alligators on water column P concentrations in the downstream cells of the STAs?
   - Can the outfall areas of the STAs be designed or operated in a manner to discourage congregations of birds, alligators or other fauna?

DOP – dissolved organic phosphorus
EAA – Everglades Agricultural Area
EAV – emergent aquatic vegetation
FEB – Flow Equalization Basin
P – phosphorus
PP – particulate phosphorus
SAV – submerged aquatic vegetation
SRB – soluble reactive phosphorus

3.1.1 Key Question 1

How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management?

Flow Equalization Basins

The Restoration Strategies Regional Water Quality Plan (SFWMD, 2012a) identifies a suite of additional water quality projects to work in conjunction with the Everglades STAs to meet the WQBEL. These projects primarily consist of FEBs, STA expansions, and associated infrastructure and conveyance improvements. As previously noted, the Restoration Strategies Regional Water Quality Plan also indicates that a Science Plan will be developed and implemented to investigate critical factors that influence TP treatment performance in the STAs, particularly those factors that affect performance at low TP concentrations (<20 µg/L). The FEBs will be evaluated to determine how they will influence performance of the STAs. These investigations could include (1) the effect of hydraulic loading rates (HLR) and timing from the FEBs to the STAs, and (2) the effect of inflow phosphorus loading rates (PLR) and TP concentrations from the FEBs to the STAs on their outflow TP concentrations.

The primary purpose of FEBs is to attenuate peak stormwater flows prior to delivery to STAs and provide dry season benefits, while the primary purpose of STAs is to utilize biological processes to reduce TP concentrations in order to achieve the WQBEL. Kadlec (2011) summarizes the effect of pulsing on wetlands and evaluates potential improvements to wetland treatment performance as flow pulses are reduced. These analyses indicate that storage reservoirs (e.g., FEBs) operated to lessen pulse flows have the potential to significantly improve STA performance. This expectation is based upon several critical processes: optimizing hydropatterns, reducing flow volumes and velocities, and lowering peak loading rates into the STAs. The design and effectiveness of stormwater management systems operate in a manner similar to proposed FEBs. As reducing flow pulses to the Everglades STAs is a key objective of the water quality projects, storage reservoirs (FEBs) are included for all three project flow paths.

Hydrologic and water quality models were utilized to evaluate regional alternatives and identify project features necessary to achieve the WQBEL, including FEBs. Additional modeling will be performed to test assumptions and optimize FEB management to support sustainable STA performance. More specifically, the Dynamic Model for Stormwater Treatment Areas (DMSTA)—developed and calibrated to predict long-term TP removal performance of the Everglades STAs and storage reservoirs—was used in conjunction with the regional hydrologic model (South Florida Water Management Model, or SFWMM), output to evaluate additional project features (STAs and FEBs) necessary to achieve the WQBEL. From the Restoration Strategies Regional Water Quality Plan, key information and assumptions on the FEBs used in the models are as follows:

Flow Path	FEB	Storage Volume (ac-ft)	Vegetated	STA
Eastern	L-8 FEB	45,000	No	STA-1E; STA-1W
Central	A-1 FEB*	54,000	Yes	STA-2 (Comp B); STA-3/4
Western	C-139 FEB	11,000	Yes	STA-5/6 (Comp C)

*The A-1 FEB is currently being designed to provide a storage volume of 60,000 ac-ft.

Although some is expected, no TP removal was assumed for the Eastern Flow Path FEB in the DMSTA modeling. However, to maximize the treatment efficiency of the Eastern Flow Path STAs, enhanced FEB operations and release protocols were integrated. The TP removal performance of the Central Flow Path FEB was assumed to be consistent with EAV, and FEB discharges were simulated with conditions typically encountered in wetland cells or shallow reservoirs. The TP removal performance of the Western Flow Path FEB was assumed to be consistent with EAV for approximately 85 percent of the area and with a reservoir for roughly 15 percent of the area; FEB discharges were also simulated with conditions typically encountered in wetland cells or shallow reservoirs. To maximize the treatment efficiency of the Western Flow Path STAs, enhanced FEB operations and release protocols were also included. The enhanced FEB operations attenuate the impact of peak flows and loads on STAs during wet seasons, attempt to provide optimal inflows to the STAs, and reduce the frequency and severity of dryout conditions in the STAs during dry seasons. While these design and operational protocols may prove reasonable and serve as a starting point, operational results are needed to validate initial assumptions to develop appropriate management strategies.

Flow Equalization Basin Design and Operations

The FEBs serve a key role in meeting the Restoration Strategies Program objectives and their operation and performance are important for long-term, sustainable performance of the STAs. As such, it is important to determine how storage and outflow hydraulics of the basins should be managed, define the optimal and minimum water depths, and identify how discharge rate and timing should be controlled for consistent STA treatment. Additionally, it is necessary to determine how the FEBs should be designed and operated to achieve optimal (mean and range) hydraulic and P loading and concentrations for discharges from these basins to the STAs. At present, design information and operational guidance for the FEBs are not available that define the maximum hydraulic inputs to the STAs to prevent deepwater impacts to vegetation, the minimum hydraulic load to prevent dryout, or the optimal P load and concentration for discharges from the basins to the STAs.

The Restoration Strategies Regional Water Quality Plan modeling includes simulated FEB HLRs, PLRs, and outflow TP concentrations (STA inflow TP concentrations), as well as simulated STA outflow TP concentrations. As previously noted, operational results are needed to validate initial model assumptions to develop appropriate management strategies. Historical data for each STA on the calculated mean and range of HLRs, PLRs, hydraulic retention times (HRTs), and outflow TP concentrations is presented in the 2013 SFER – Volume I, Chapter 5 (Ivanoff et al., 2013). There is some uncertainty regarding relationships among hydraulic and P loading, retention, and concentration in the STAs. Juston and DeBusk (2006) found that in16 occurrences of full-scale STA data of annual flow-weighted mean outflow TP concentrations from 10-20 µg/L, no significant PLR relationships were identified for targeting specific outflow TP concentrations in this range.

A subsequent analysis of period of record (POR) data indicated that at very low outflow concentrations (≤20 µg/L), there is no definitive relationship between outflow TP concentrations and key operational factors, i.e., inflow concentration, PLR, or HRT (Ivanoff et al., 2013). Data show that there were cells that received inflow concentrations of 50-150 µg/L that produced outflow TP concentrations of ≤20 µg/L. Correspondingly, there were cells that received loading rates higher than 1 g/m^2/yr that resulted in outflow concentrations of ≤20 µg/L. This is consistent with previous findings suggesting that other factors may influence an individual treatment cell's ability to produce low outflow TP concentrations (Ivanoff et al., 2012).

FEBs will be managed to the extent possible to maximize STA treatment performance. If continued data analyses warrants, operational hydraulic discharge criteria for FEBs may be established to maximize STA performance. This includes establishment of a maximum HLR to STAs to prevent deepwater impacts to STA vegetation and a minimum HLR to the STAs to prevent their dryout, along with an optimal PLR and TP concentration target range for discharge from the FEBs to the STAs. It is also necessary to consider if water quality inflows to the FEBs should be a component of the Operation Plans. The Science Plan includes analyzing historical TP concentration data by storm magnitude and frequency, generating flows that will reach the FEBs. Such analysis will be helpful in determining if FEBs can be used primarily to treat projected TP concentrations and loads from large storm events or if projected low TP concentration inflows can bypass FEBs.

The design process for the FEBs includes preparing an Operation Plan, which will address various components such as existing and future features, a strategy to meet project objectives, overall plan for peak flow attenuation, instructions to project operators, operations to meet project purposes (e.g., pre-storm and storm operations, water quality, and water supply), and consistency with the adaptive management process. There are also Operation Plans for each STA that address key issues such as inflow, interior, and outflow control structures; operational intent; extreme flow and drought conditions; hydropattern restoration; and performance optimization. Additionally, FEB Operational Decision Support Tools will be developed to help plan and guide real-time operations in terms of hydrologic, hydraulic, and water quality objectives.

Sub-Question Related to Key Question 1

- *How should storage in the FEBs be managed throughout the year so water can be delivered to the STAs in a manner that allows them to achieve the lowest outflow P concentrations?*

Sediment Management

As part of the Science Plan, another key area to be examined is how the different FEBs (shallow and deep) can be designed to optimize settling of suspended material, including particulate phosphorus (PP), to prevent their transport into the receiving STA. Such information will be helpful in determining if the design of FEBs should include a settling basin with maintenance access for sediment (and associated PP) removal. Sediment sumps upstream of discharge structures might allow settling and more efficient dredging. For example, the sediment trap recently completed along the C-51 canal that discharges to the Lake Worth Lagoon has been working well (Palm Beach County, 2010). To minimize erosion and thereby further reduce P transport into the STAs, the design of FEB discharge features (e.g., use of weirs) should also be considered. Another potential source of P may be the conveyance canals that extend from the FEBs to the STAs because of potential deposition and resuspension of phosphorus containing particles. As such, it is pertinent to determine if these conveyance canals, along with the canals entering the FEBs, should be periodically dredged or lined to remove sediment and associated PP.

Preliminary information is available regarding the potential for canal sediment management for P removal. A summary of phosphorus speciation data in canals at 11 structures upstream of the STAs from 1974–2012 indicates that PP was approximately 38 percent of TP. A study on particle size distribution and P fluxes at three structures in the EAA indicates that PP ranged from approximately 10-35 percent (Ivanoff, 1993). Collectively, these data suggest that there may be P settling in canals at these locations. It is also important to note that for peat-based farmlands in South Florida, the majority of runoff PP has been found to originate in the drainage canals as a result of biological growth (Kadlec and Wallace, 2009).

To better understand the factors contributing to relatively high STA-5 inflow TP concentrations compared to the other STAs, the District conducted a canal sediment study in the STA-5 inflow canal in 2007. Based on these results, in 2008 a $1.79 million canal sediment dredging project was implemented in the L-3 canal immediately upstream of the STA-5 inflow structures. Since that time, a positive trend of decreasing inflow TP concentrations has been observed, although other factors could also be contributing to these reductions such as BMP improvements in the C-139 Basin.

Overall, it is important to assess whether the sediments in the canals are an important source of TP to the STAs by characterizing the sediment and TP concentrations in canals flowing to the FEBs and the STAs and determining the factors affecting settling and resuspension in these canal reaches. There is also need to determine if there was a decrease in TP in the surface water in canals where dredging has been conducted (e.g., S12D).

Sub-Questions Related to Key Question 1

- *What components and operational activities could potentially be incorporated into the FEB designs that would promote settling of sediment and associated PP to prevent transport into the STAs?*
- *Would changes in canal management or design improve STA and FEB performance?*

Water Quality Treatment Technologies

Under certain circumstances, selected water quality treatment technologies could be applied in the FEBs. With this in mind, it would need to be determined which candidate technologies should be evaluated in conjunction with the FEBs, and under what conditions would such treatment be implemented (e.g. periodically to capture storm P loads).

To date, many investigations have been performed regarding ATTs that could be used in conjunction with STAs to improve phosphorus removal (Chimney et al., 2004; SFWMD, 2013). A list of these ATTs that could be considered or investigated for use in conjunction with the FEBs would need to be compiled and evaluated in terms of technical, environmental, and economic feasibilities. Considerations are also needed as to what effect each selected technology would have on the water quality discharging from the FEBs to the STAs and how any residuals generated from each selected technology would be addressed. In conjunction, an analysis of TP concentration and load data by storm size would be helpful to determine the feasibility of implementing treatment technologies periodically to capture storm TP loads.

Sub-Question Related to Key Question 1

- *What water quality treatment technologies should be evaluated along with the FEBs?*

Vegetation Management

Vegetation could also potentially play a role in enhancing effectiveness of the FEBs in reducing phosphorus transport to the STAs. EAV, SAV, and FAV all affect P cycling and accretion based on their physical, chemical, and biological interactions. Water stages in STA cells are currently managed based on target depths to maximize vegetation sustainability and treatment performance. The FEBs will attenuate peak stormwater flows prior to delivery to STAs and provide dry season benefits for STAs; therefore, they will be managed to maximize storage. This will result in variable water stages that affect vegetation species composition. Phosphorus treatment in FEBs will be enhanced by vegetation, which will be beneficial to the overall STA performance. However, this raises some key vegetation management issues for FEBs.

The L-8 FEB (Eastern Flow Path) is a deep system with more than 50 feet in potential depth. There is the potential for establishment of FAV in this system as well as the colonization of EAV and SAV on banks exposed during extremely dry periods. The A-1 FEB (Central Flow Path) and the C-139 FEB (Western Flow Path) are shallow systems with approximately four feet in potential depth, and EAV and SAV will colonize these systems. As this will provide treatment, EAV performance was included in planning level treatment estimates in these shallow systems.

Sub-Questions Related to Key Question 1

- *Should the establishment of FAV be promoted in the L-8 FEB?*
- *If FAV is promoted in the L-8 FEB, is mechanical harvesting beneficial or feasible?*
- *As EAV will colonize the shallow FEBs (A-1 and C-139), should SAV establishment and management be promoted in these FEBs?*
- *If SAV is promoted in the shallow FEBs, what is the optimal EAV/SAV design configuration?*
- *Should littoral zones be established in the shallow FEBs to reduce flow impedance?*

3.1.2 Key Question 2

How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?

Forms, Transformations and Movement of Phosphorus within Treatment Wetlands

Phosphorus in wetland and other natural systems are generally categorized into inorganic and organic forms. Depending on its physical state, inorganic P maybe either available [referred to as soluble reactive P (SRP) or dissolved inorganic P (DIP)], adsorbed (e.g., on calcitic surfaces), or attached to particulates (e.g., co-precipitated with metallic ions, or incorporated with detrital materials). Organic P is the form that is associated with organic molecules and can be in the form of diesters (i.e., nucleic acids, phospholipids, and aromatic compounds) or monoesters (i.e., sugar phosphates, mononucleotides, and inositol hexaphosphates). Organic P can also be in dissolved form [dissolved organic P (DOP)] or particulate form (particulate-bound organic P). Breakdown of organic P is mediated by microbial activities. Breakdown of particulate P (PP), which may be comprised of both organic and inorganic P, is mediated by various biogeochemical factors.

Water coming into the STAs contains a mixture of inorganic and organic forms of P. Previous findings indicate that, in general, in well-performing STAs the outflow water contain very little to no SRP, and consist primarily of DOP and PP. Natural and operational factors such as lack of flow, storm events, and dryout can cause changes in the composition and concentration of P in outflow water.

Water quality improvements through the use of treatment wetlands are subject to variability due to both natural and anthropogenic factors. Phosphorus cycling and movement along the treatment flow-ways is a function of various chemical, physical, and biological processes including particulate settling, sorption, flux,, plant uptake, bioturbation, diagenetic processes at the soil surface, and other abiotic and biotic processes in the water column (Reddy and DeLaune, 2008; Bhomia et al., 2001; also, see **Figure 4**). The antecedent land use also affects biogeochemical processes and the ability of the wetland to be a sink for phosphorus. For example, soils that were highly enriched from years of farming have been shown to release P to the overlying water column for extended period of time. In STAs with high levels of labile phosphorus, nutrient flux from the soil to the water column may be as important as external inputs in terms of TP concentration and loading. Release of P from enriched soils to the water column can contribute to the challenge of meeting water quality goals in the STAs.

Flux of P from the soil to the water column occurs through diffusion of dissolved P and resuspension of particulate-bound P. The diffusion of DOP and SRP (or DIP) occurs when the concentration of P in the porewater is higher than the concentration in the overlying water column. Understanding the relative levels of porewater and surface water P concentrations in the different STA flow-ways will help in determining the role of flux in each flow-way and may be useful in developing strategies to minimize flux in the STAs. Where flowing water has low soluble P concentrations, rapid replacement of the water column creates a large concentration gradient and increases diffusive flux of P from soils. However, if surface water has a higher P concentration than levels of soluble P in the soil porewater, then there is a capacity for further P accumulation in the soil. Reddy et al. (1999) also indicated that soluble P may be entrained (i.e., carried in a current) by leaching of dissolved organic and inorganic P from detritus and periphyton or released from surface sediments.

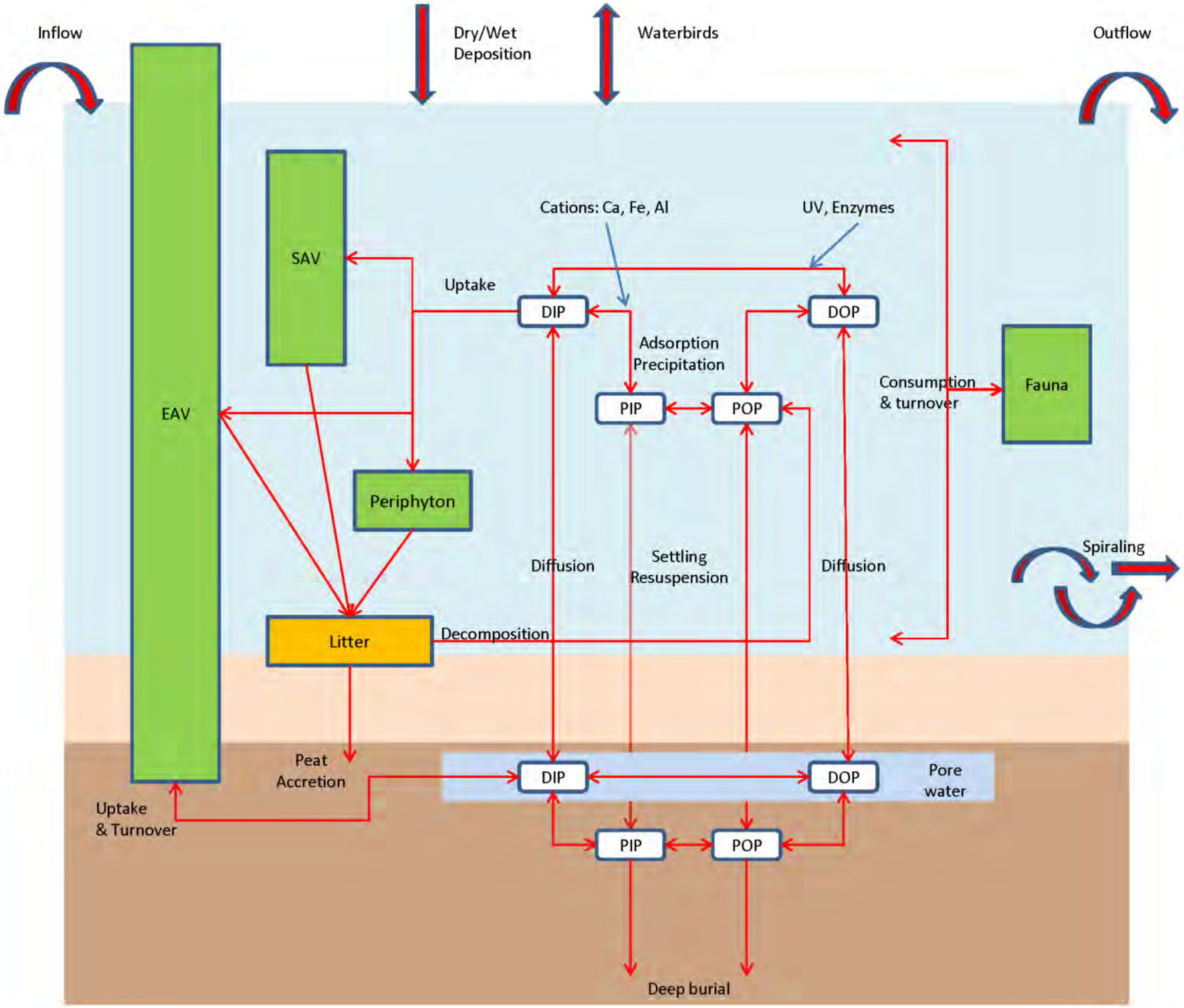

Figure 4. Schematic of chemical, physical, and biological processes that can influence changes in P concentrations between soil and overlying water.

The equilibrium phosphorus concentration (EPC_0) is defined as the P concentration in solution when the nutrient is neither adsorbed nor desorbed by soil (Reddy et al., 1980). Based on recent data, there were higher EPC_0 values and greater labile porewater pools of P at enriched sites (TP concentrations greater than 500 mg/kg) in the remnant Everglades, indicating greater potential for P flux from enriched than unenriched Everglades soils (McCormick et al., 2002; Reddy and DeLaune, 2008; Reddy et al., 2011; Wright et al., 2009).

The role of microorganisms in the transformation of organic P to inorganic P in the water column and soils has long been recognized (Dunn and Reddy, 2005; Reddy et al., 1999). In the water column, the organic forms are generally divided into (1) easily decomposable organic forms and (2) slowly decomposable organic forms, with the most readily available being incorporated into microbial biomass. Reddy et al. (2002a) found that approximately 15-25 percent of the organic P in treatment wetland soils and flocs was microbial. As the life cycle of microbes is short, nutrient turnover is quick and it is likely that most P uptake is returned as labile DOP and PP, leaving only a small fraction as permanently buried in the sediments.

Transfer of PP from or to the soil occurs primarily through deposition or resuspension of particulate matter (Reddy et al., 1999). During resuspension of particulates, some of the P can return to the water column and reduce wetland treatment efficiency (Chimney and Pietro, 2006). The resuspended particulate matter introduces primarily particulate organic P to the water column. High water flow velocity, storm events, and mechanical disturbance (occasional harvesting of nuisance vegetation, structure operation, boat traffic, bioturbation, etc.) can cause increased particulate matter resuspension to the water column.

The influence of metallic cations, such as calcium (Ca), magnesium (Mg), iron (Fe), and aluminum (Al) has also been studied extensively by various scientists. Their role in the STAs, particularly at the very low P regions, requires further investigation. Calcium-related P reduction in an alkaline wetland environment may occur via two main pathways: (1) sorption of P on calcareous soil particles, limestone surfaces, and marl-based detrital material, and (2) co-precipitation with Ca in the water column or porewater (Gumbricht, 1993). Under the right conditions, P will co-precipitate with Ca and Mg in more alkaline systems and with Fe in more acidic systems (Reddy and DeLaune, 2008).The influence of other factors such as redox potential, pH, alkalinity, and sulfate on P cycling under very low P environment also need to be studied.

Photodegradation may also be an important factor in P cycling under a very low P environment. For example, breakdown of dissolved organic matter may be influenced by the ability of light penetration through the water column. Shallow water condition, reduced water turbidity, and open areas may induce higher photodegradataion. Understanding the role of photodegradation in the STAs may provide some useful information in finding ways to further lower outflow P concentrations.

Sub-Questions Related to Key Question 2

- *What are the sources (internal/external, plants, microbial, wildlife), forms and transformation mechanisms controlling the residual P pools within the different STAs and are they the same as observed in the natural system?*
- *What are the key physical-chemical factors influencing P cycling at very low concentrations?*

Role of Vegetation

Along with the microbial processes described above, vegetation is a major biological mechanism used in the STAs to reduce nutrient concentrations. More information on the role and processes associated with various vegetation types is described in Section 3.1.3 (Key Question 3), but it is also important to assess how different vegetation species moderate P flux and availability.

Reddy et al. (1999) indicate that above-ground plant biomass returns P to the water after dieback via leaching and decomposition and deposits refractory residuals on the soil surface, as well as redistributing nutrients to below-ground portions as necessary for storage. However, dead roots and rhizomes decompose underground, thereby adding refractory compounds to the soil and leachates to the porewater. As such, primarily the above-ground portion of the macrophyte cycle returns P to the water, while the below-ground biomass returns P to the soil. Decay and translocation processes release most of the P uptake, with the residual accreting as new soil. DeBusk et al. (2004) indicate that low water velocities and dense stands of submerged and emergent macrophytes facilitate settling of PP. Macrophyte uptake and translocation has been shown to be an important mechanism linking sediments and water column TP concentrations in marsh ecosystems—this process is known as P mining (Noe and Childers, 2007). However, this upward transfer is countered by two opposing processes: the transpiration flux, or downward movement of water and associated P resulting from plant transpiration, and translocation of P from senescing leaves to the rhizomes (Kadlec and Wallace, 2009). Because of the competing processes among plant uptake, detrital decomposition, and the transpiration flux in the root zone, a vertically decreasing concentration of soil TP and porewater P in the soil profile may exist (Kadlec and Wallace, 2009).

SAV decomposition, particularly during low water conditions, may also be responsible for the high flux of PP and SRP. However, this observation has not been strongly demonstrated for effluent DOP. There were no substantial decreases in observed DOP values, underscoring the difficulty in removing DOP in treatment wetlands as plants (and peat soils) were a source of DOP (DeBusk et al., 2004). Additional information is needed on the generation and breakdown of DOP in the STAs, particularly near outflows.

A benthic periphyton community can obtain nutrients directly from the water column as well as via diffusion from the sediment and therefore will influence the net exchange of nutrients across the sediment water interface (Hansson, 1989; Newman et al., 2004). Periphyton reduce P concentrations in the water column through several mechanisms, including direct uptake and storage as cellular organic P, metal-phosphate deposition, co-precipitation with Ca and Mg, and adsorption to inorganic compounds, e.g., calcium carbonate, or $CaCO_3$ (Hagerthey et al., 2011). Periphyton is also closely involved in wetland biogeochemical cycling that allows for long-term sediment storage of nutrients. Periphyton assemblages can play several roles that lead to increased retention of nutrients, including removing nutrients from the water column, slowing water exchange across the sediment/water column boundary thereby decreasing advective transport of P away from sediments, intercepting P diffusing from sediments or senescent macrophytes which cause biochemical conditions that favor P deposition, and trapping particulate material from the water column (Dodds, 2003). Obtaining additional information on periphyton, with the goal of increasing their role in long-term P storage, is important in improving STA performance.

Sub-Question Related to Key Question 2

- *What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P?*

Effects of Marsh Dryout and Rehydration on Phosphorus Flux

Under continuous inundation, P mineralization is slower than under oxidized conditions. In the STAs, particularly in areas where the soil and accrued material is highly organic, P spikes are commonly observed following dryout periods. This is particularly problematic as the newly accreted P in floc and surface soil layer in the STAs is generally highly labile, and a large fraction of stored P can be quickly released back into the water column upon rehydration.

Dryout accelerates mineralization of organic matter in soil and plant litter. The resulting P spike is dependent upon several factors, including the amount of labile organic P in the oxidized soil layer and microbial and SAV P uptake. Microbial communities associated with senescing material will rapidly assimilate some of the released P while excess P can remain in the water column and eventually make its way to the outflow structures. Due to the higher organic content in EAV cell accreted material, the impacts of dryout/oxidation on P flux are generally greater in EAV cells (Ivanoff et al., 2013). However, loss of vegetation when an SAV cell dries out also results in P flux and generally high turbidity upon rehydration. Also after rehydration, the internally generated P can be reabsorbed by the system, through sorption, plant and microbial uptake, Ca and Fe-binding, and settling. However, when water is discharged within a short time from initial rehydration, high P concentrations are observed in the flow-way or STA outflow structures. Soil P flux can be accelerated through repeated cycles of dryout and reflooding.

Since the completion of the Marsh Dry-out Study (White et al., 2004, 2006; Moustafa et al., 2011, 2012), the District has gained considerable experience with the impacts from soil P flux on STA treatment performance during both start-up and upon reflooding following droughts. Findings from these studies along with operational experience in the STAs have led to the establishment of minimum water depth target for the STAs. When water is not available for hydration, maintaining moist soil is another way to minimize P release (Aldous et al., 2005; DeBusk, 2011).

Soil Management to Control Phosphorus Flux

The numerous mechanisms and pathways for internal P flux present a significant challenge to ensuring maximum and sustainable performance of the STAs. Soil management—typically characterized as physical manipulation (soil removal to limestone cap rock, disking, inversion, or capping) or addition of soil amendments—has been utilized in other areas as a means to reduce P flux. In the Everglades STAs, the benefits of soil removal within a 100-acre PSTA cell in STA-3/4 are currently being evaluated. In STA-1W, highly enriched accrued soil layer was removed in two cells (Cells 4 and 1B) and disked in at Cell 2B.

To date, several studies have been performed to test the efficacy of physical soil manipulation. The removal of the accrued sediment layer in STA-1W Cell 1B reduced sediment TP concentrations from 1,300 to <400 milligram per kilogram (mg/kg) (SFWMD, 2007a). Notably, P release [DIP (including SRP), DOP, and PP, which includes PIP and POP) from the plowed/inverted soils in the littoral zone/nearshore area of Lake Okeechobee was orders of magnitude lower than P release from pre-tilled (undisturbed) soils, although there were no significant differences in P release from tilled and scraped (topsoil removed) soils (Water and Soil Solutions, LLC, 2009). Muck removal followed by re-vegetation in the front-end cells of the Orlando Easterly Wetland (OEW) northern flow-train greatly improved the hydraulic performance and P removal effectiveness of the rejuvenated wetland (Wang et al., 2006). Dredging the top 30 cm of sediments in Lake Okeechobee decreased the EPC_0 from 0.03 to 0.01 milligrams per liter (mg/L), indicating that subsurface sediments had greater affinity to retain P. Dredging significantly reduced P flux under oxygenated water column conditions, with P flux in the range of 0.1 to 0.35 mg P m^{-2} d^{-1} (Reddy et al., 2002b).

Drawdown followed by burning can reduce the depth of accumulated sediments. A prescribed burning experiment conducted in Cell 3 of the OEW in 1994 reduced cell biomass by 60 to 70 percent. An increase in water column nutrient concentrations was observed following the gradual rehydration of the cell, but the water was not discharged until concentrations declined to an acceptable level (University of Florida, 2001). If burning is considered for management, detailed chemical and physical modeling will be needed to determine the transport and fate of particulate and aerosol P. Phosphorus pentoxide, generated by oxidation during burning, may redeposit quickly and is highly biologically available after hydration. While the practice of surface burn has been shown to cause temporary spikes in water column P, its long term benefits in controlling P flux may be need further investigation.

In another recent study, physical removal of the accreted organic soil in combination with alum treatments significantly reduced P flux from a municipal wastewater treatment wetland (Malecki-Brown et al, 2009). Because of the difficulties and costs associated with the removal and disposal of soils from a treatment wetland, it was suggested that alum addition alone may be the most cost-effective and efficient means of sequestering P in aging wetlands experiencing reduced P removal rates, but organic soil removal would be a more permanent solution to reducing P flux (Lindstrom and White, 2011).

Many studies have been conducted on the effects of various soil amendments to reduce P flux. The most common soil amendments are various aluminum (Al), iron (Fe), or calcium (Ca) salts that bind P and have been effective in reducing water column TP concentrations in several experiments. Three soil amendments [Al-, Fe- and Ca-based product (polyaluminum chloride, ferric chloride, and hydrated lime, respectively)] were tested for their ability to reduce P flux from a flooded organic soil in a four-month mesocosm study (CH2MHill, 2003). None of the amendments completely controlled P flux, although polyaluminum chloride and ferric chloride were more effective than hydrated lime.

In a field enclosure study involving the application of wastewater treatment residuals consisting of hydrated lime, gypsum, and alum and flooded to a depth of 25 cm, data showed that alum residuals strongly reduced P flux to the overlying water (Hoge et al., 2003). P flux reduction in enclosures with lime and gypsum application was much less. Broadcasting calcium silicate (CaSiO3) slag on top of the soil to create a surface barrier reduced the flux of soil P up to 84 percent compared to an unamended soil control. However, incorporation of the material into the soil was only minimally effective at reducing P release (Chimney et al., 2007).

Overall, additional studies generally confirm the above information (Reddy et al., 1998; Ann et al., 2000). However, ongoing concerns remain about the amount of treatment material necessary to adequately control P flux, length of time that the materials will remain effective, and potential toxicity associated with various soil amendments. Therefore, follow-up studies on the role and applicability of soil management and amendments are needed to ensure that all potential mechanisms to reduce P flux and meet the WQBEL are considered.

Sub-Question Related to Key Question 2

- *What are the treatment efficacy, long-term stability, and potential impacts of soil amendments or management?*

3.1.3 Key Question 3

What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?

Role of Vegetation for Phosphorus Cycling

Macrophyte communities and associated periphyton (and microbes as described previously) are the biological backbone of treatment wetlands. Both emergent and submerged macrophytes, along with macrophytic algae like musk grass (*Chara* sp.), play a central, often dominant, role on P cycling and accretion based on their physical, chemical and biological interactions (Brix, 1997; Kadlec and Wallace, 2009, Chs. 3, 6 & 10). In wetlands designed to treat surface water for nutrient removal, macrophytes stabilize sediments, reduce flow velocity, provide contact surface for microbes and algae, take up and translocate nutrients, and provide biological habitat and energy for the system. As a result of these important roles, the Science Plan will involve investigations of macrophyte ecology and management in the STAs to support the removal of P at low ambient concentrations.

The balance of bidirectional movement and flux of phosphorus across the sediment-water interface determines P retention and outflow concentrations in treatment wetlands. P flux between wetland sediments and the overlying water column is a function of several chemical, physical and biological processes influenced strongly by macrophyte communities. Key processes affecting P flux include diffusion, water movement associated with wetland plants and animals (bioturbation & transpiration), volatilization of gases, and nutrient translocation and release by plants (Kadlec and Wallace, 2009, Chs. 3 & 9; Reddy and DeLaune, 2008). Outflow concentrations reflect a balance between movement into and out of the sediments, and both macrophytes and periphyton directly influence flux at the interface (Kadlec and Wallace, 2009, Ch.6).

Macrophytes, both emergent and submerged, are important to the sediment water flux because they take up, store, and release P in wetlands. Plants take up nutrients primarily from the sediment root zone as well as from the water column and move them into the canopy to support plant growth. While not all macrophytes move P from the sediments through roots, plant-vectored flux between the sediment and water column can be an important internal source of P, particularly in enriched areas (Noe and Childers, 2007). Macrophytes also move P down into the roots and the amount of storage belowground can exceed the amount stored aboveground (Reddy and DeLaune, 2008, Ch. 9). Eventually, plant biomass in the canopy and root zone decomposes and some of the plant nutrients are released into the water column and influence ambient P concentrations. Mineralization of macrophytes can also lead to the creation of residuals and P accretion through burial in sediments. The importance of this mechanism is evident from the fact that macrophyte biomass may turnover as many as five times per year in subtropical settings (Davis, 1994).

Measurement of sediment P flux is highly variable and dependent on the technique used so that its relative importance in the STAs is difficult to determine. Using in situ enclosures, Community Watershed Fund and DB Environmental, Inc. (2009) measured average flux rates from 2005–2008 of 2.08, 2.98, 3.28, and 2.78 mg P m^{-2} d^{-1} at enriched sites in WCA-2A. These values suggest a flux rate of approximately 1 g P m^{-2} yr^{-1}, which is a significant rate for STAs particularly in marsh areas near STA outflows with low TP concentrations. Notably, fluxes as high as 6.5 and 10 mg m^{-2} d^{-1} were recorded at highly enriched sites using cores and in situ benthic chambers, respectively, in WCA-2A (Fisher and Reddy, 2001). Both studies (Community Watershed Fund and DB Environmental Inc., 2009; Fisher and Reddy, 2001) also estimated molecular P diffusion rates calculated using sediment equilibrator data that were consistent with other estimates of diffusion (Kadlec and Wallace, 2009, Ch. 10) and were tenfold to fiftyfold lower than measured flux rates in which water movement was enhanced beyond diffusion levels.

Macrophytes can also influence water column P in treatment wetlands by providing a large contact area for periphyton attachment. Benthic periphyton can obtain nutrients directly from upward movement of P across the sediment-water interface and can influence the exchange of nutrients into the water column (Hansson, 1989; Newman et al., 2004). When macrophytes are dense as in the STAs, the role of benthic algae may be limited by light availability. Importantly, epiphytic periphyton can also take up P efficiently from the water column. Periphyton can reduce P concentrations in the water column through several mechanisms, including direct uptake and storage as cellular organic P, metal-phosphate deposition, co-precipitation with Ca and Mg, and adsorption to inorganic compounds, e.g., $CaCO_3$ (Hagerthey et al., 2011). The role of these uptake mechanisms may be reduced when wetland herbivores harvest the periphyton during seasonal cycles and periods of poor water clarity. Phosphorus can be released from periphyton following cell death, desiccation, and subsequent rehydration.

Beyond their role as attachment surfaces for periphyton and microbes, vegetation communities in wetlands can also lower P concentrations in the water column by pervasive changes they cause in the physical environment. Macrophytes reduce current velocities greatly near the sediment-water interface and thereby stabilize the sediment surface and minimize the movement of superficial sediments and floc. The underwater plant canopy forms a fiber bed that reduces water movement; decreases sediment and floc resuspension and transport; and provides a large surface area for particle impaction, interception, and settling (Kadlec and Wallace, 2009, Ch. 10). These processes promote particle sedimentation and removal from the water column.

New Information to Improve STA Performance through Management of Vegetation Communities

Although the ecological role of macrophytes in wetlands is generally well known as previously noted, there are many opportunities to gather more specific information on their role in nutrient cycling and removal at low P concentrations in the STAs. New information regarding these processes in STAs can support the development of refined vegetation management strategies to promote lower outflow TP concentrations. The overall goal is to improve STA performance by finding better and more integrated ways to manage macrophyte composition, density, and spatial distribution in the Everglades STAs. The following sub-sections highlight the key topics to be addressed by one or more projects in the Science Plan.

Sustaining Dominant Vegetation

As water enters the STA, it flows through dense stands of emergent macrophytes, primarily cattail (*Typha* spp.). The emergent plant community (as well as the microbes) provides the initial treatment of stormwater by creating a relatively calm water column that facilitates the uptake and settling of PP. However, even though cattail are typically very hardy plants with rapid and sustained growth in enriched environments, cattail stands sometimes die back in the STAs thereby reducing the ability of the emergent wetland to remove P from the water column. Also, cattail stands can form large floating mats (tussocks), which can influence both cattail survival and P removal. Although the proximal causes are not very well understood, periods of deep water are sometimes associated with cattail stress and mortality (Chen et al., 2010).

Water stages for different STA cells are currently managed based on target depths of 1.25±0.2 ft. based on prior experience in wetlands and observations in the STAs. However, during peak flows in the wet season and regional storms, water depths can increase and have been observed to impact cattail communities. Results from earlier studies indicated that six weeks of continuous inundation at 3.0 ft and 4.5 ft water depths produced multiple signs of stress in cattails (Chen et al., 2010; Chen et al., 2013). While these results suggest a threshold of harm, they do not give a predictive understanding of a threshold for sustainability in emergent plant communities.

To minimize the impacts of deeper water, depth and duration guidance is applied to STA operations. Although using this practical guidance is sound as an interim approach, the optimum inundation depth and duration needed to develop and sustain healthy cattail communities is unknown, particularly for large scale STA cells. Investigations are needed to gather additional information on the role of depth and water pulses on the sustainability of cattail communities in the STAs. Data will be generated on cattail growing in a range of inundation depths and durations to identify the depth and duration threshold for cattail sustainability in the STAs. This effort should provide specific guidance for better water depth management and should result in better initial treatment and more sustainable cattail stands in the STAs.

Sub-Questions Related to Key Question 3

- *How does water depth affect sustainability of dominant vegetation?*
- *How do water depths, depth duration and local soils affect the sustainability of cattail stands and the formation of floating tussocks?*

Improving Phosphorus Removal with Other Native Macrophyte Species

Different species of aquatic macrophytes can vary in the way nutrients from the water column and sediments are taken up and stored. With this in mind, it may be possible to use individual species to improve STA performance depending upon their physiology and nutrient uptake mechanisms. Certain plant species may be better able to reduce the amount of organic and particulate P near the STA outflows and decrease decomposition rates that result in a high internal loading (Davis, 1991; Kuhn et al., 2002). Investigations will gather information on native vegetation types that are able to grow in low P environments and take up P from the water through enzymes and store it efficiently in their tissues, particularly in belowground components. In addition, P in outflows of well-performing SAV cells is typically comprised of DOP and PP fractions that are not suitable for plant uptake. To better understand organic and particulate P uptake, a study is under way to investigate nutrient removal efficacy and P uptake of native macrophytes found in the pristine Everglades.

Sub-Question Related to Key Question 3

- *Can sawgrass (Cladium jamaicense) and water lily (Nymphaea odorata) along with associated periphyton enhance P removal in SAV cells?*

The nutrient poor, oligotrophic Everglades ecosystem is dominated by sawgrass (*Cladium jamaicense*) ridges and water lily (*Nymphaea odorata*) sloughs. These species thrive in very low nutrient environments by being able to take up available P efficiently, particularly organic P, and having life histories that allow them to accumulate much higher tissue P relative to external habitat and retain this nutrient for long periods by slow turnover and decomposition rates (Brix et al., 2010; Davis, 1991; Lorenzen et al., 2001; Miao, 2004; Miao and Zou, 2012).

Results will be validated at a larger scale and optimum hydraulic regimes (water depth and flow rate) will be maximized for nutrient removal efficacy of the two species. Study results are expected to support management actions using water lily and sawgrass stands near the STA outflows to achieve lower outflow TP concentrations. The study can be expanded to other promising macrophyte species based on new information, particularly new results on how individual species translocate and store P in the rhizophere. The species-specific ecologies of these native vegetation types are expected to provide possible management strategies to improve P removal and enhance STA performance, especially near their discharges.

Sub-Question Related to Key Question 3

- *What is the role of vegetation in modifying P availability in low P environments, including any role in the transformation of refractory forms of P?*

There are many possible species-specific studies besides those involving Everglades oligotrophic species. Fire flag (*Thalia geniculata*) and denseflower knotweed (*Polygonum densiflorum*) can be used to determine their desirability for increasing plant diversity and providing vegetation based treatment in areas where other dominant plant species do not occur or persist, and as species for complementing P uptake and removal in emergent cells. This includes floating-leaved species, such as water lilies (e.g., *N. odorata*, *Nuphar lutea,* and *Lotus* spp.). Field trials can be conducted to determine whether the cover of Illinois pondweed (*Potamogeton illinoensis*) and eelgrass (*Vallisneria* sp.) should be enhanced to complement dominant SAV species and improve performance more specifically if they transform refractory forms of P. The results of the studies on individual species can be used to focus and extend investigations involving the structure of SAV communities.

Sub-Question Related to Key Question 3

- *Can other plant species, such as fire flag (Thalia geniculata), denseflower knotweed (Polygonum densiflorum), and giant bulrush (Scirpus acutus), provide similar P removal as cattail?*

Optimizing STA Performance by Structuring SAV Communities

SAV communities are known to be vital for STA performance and several Science Plan projects are needed to provide better management-relevant information. It is not known what the role of various SAV species is in STA performance, and more information is needed to determine what management actions may be possible to improve and sustain performance of this important aquatic plant community. Moreover, the species composition of SAV communities is not constant over time and a better understanding of seasonal and interannual variability is needed. Dominant species such as southern naiad (*Najas guadalupensis*), musk grass (*Chara* sp.), and *P. illinoensis* have shifted in some cells across the years of STA operation. Herbivory by waterfowl on SAV communities may also play a role in SAV community structure and production. This subject is addressed in Section 3.1.6. These observed temporal changes in community structure may be indicative of declining sustainability and P uptake performance; however, the ecological reasons that drive these temporal changes need to be better understood.

Some SAV species can be influenced by water depth fluctuations and are less tolerant of high nutrient loads than emergent vegetation. The long-term sink for P in STAs is accretion of material (largely microbial and plant biomass) to sediments. However, as SAV cells accumulate deposits of flocculent sediments, the sediment environment becomes less stable for plants. Die back and dislodging of dense beds of *Chara*, hydrilla (*Hydrilla verticillata*), and southern naiad and deposits associated with the beds can occur and may lead to decreased performance in some cells.

More detailed and predictive information is needed on SAV dynamics and its influence on P cycling. Studies may address factors that determine species composition, cover, density, and spatial aspects of SAV canopies. Such spatially based studies may be accompanied by process level investigations of decomposition, P storage, and P translocation. The common thread of these studies is to provide a better understanding of ways to enhance settling, filtering, and treatment of dissolved, particulate, and organic P. The role of SAV in generating and transforming refractory forms P will be considered in cooperation with SAV studies previously noted. Studies will also address the interaction of shallow depths and the health of hydrilla in the SAV cells. Together, these projects will provide information linking submerged plant communities to P cycling, burial, and STA performance.

Sub-Questions Related to Key Question 3

- *What factors determine spatial and temporal dynamics of SAV community structure (species composition, cover, and density), especially the role of sediment deposition and nutrient loading?*
- *Specifically, can shallower depths during the dry season enhance the sustainability and treatment performance of hydrilla and other SAV species?*
- *Do dryouts result in changes in the relative cover of musk grass (Chara sp.) and southern naiad (Najas guadalupensis)?*

Information on SAV composition and dynamics may lead to other innovative and potentially important areas of applied STA research involving plant species (e.g., to assess if emergent vegetation cover enhance P uptake in SAV cells, or to determine what is the optimal mixture and distribution of emergent and submerged plant communities). Overall, as more information becomes available on STA biological interactions, the potential for finding new ways of managing SAV cells increases.

Sub-Questions Related to Key Question 3

- *What is the best mix of emergent vegetation in SAV cells and will rotation of emergent vegetation within SAV cells enhance sustainability of SAV?*
- *Can new species of SAV or floating leaved species survive in deeper areas of SAV cells and complement P uptake by dominant species?*

Vast expanses of SAV beds are highly susceptible to uprooting by wind and high flows. Strips of emergent vegetation installed in many areas to compartmentalize SAV cells to buffer the effects of winds and flow events. For instance, STA-3/4 Cell 3B has a high proportion (40 percent) of EAV cover and has consistently provided relatively high P uptake performance. The potential for introducing other plant species as buffers can be considered, and the relative value of placing vegetation strips in various arrays can be modeled and explored in the field. Specifically, it is important to know the optimal size and distribution of emergent vegetation strips for sustainability of SAV cover. Also, the utility of rotating SAV and EAV to enhance SAV sustainability, stabilize accrued material, and enhance microbial activity needs further study.

Finally, scientific efforts should focus on the role of periphyton in areas dominated by SAV. As floating calcareous mats of periphyton are known to be part of healthy Everglades marshes and are associated with low ambient P levels, it should be evaluated if there are ways to introduce and sustain calcareous periphyton in SAV cells. It is not known why periphyton mats are not more common in the STAs and their value within SAV cells to lower TP concentrations, particularly near outflows, should also be researched further.

Sub-Question Related to Key Question 3

- *What is the optimal size and distribution of emergent vegetation strips on SAV performance?*

3.1.4 Key Question 4

How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?

Meeting the water quality requirements for discharges into the EPA requires managing all aspects of the treatment train to ensure that the lowest possible concentrations of phosphorus are achieved at the STA outflow locations. As described in Section 3.1.2 (Key Question 2), the form of P governs how readily it may be removed or regenerated through the treatment process. Methods to manage the uptake and long-term storage of P along the treatment train are critical to meeting water quality goals. Information provided on Key Question 4 is aimed at the technical basis for studies to improve the quantitative understanding of the generation and turnover of SRP, PP, and DOP. The critical aspect of PP and DOP is knowing for STA outflows whether these P forms are present in the effluent because they are stable (refractory) or because they are regenerated in the vicinity of the outflow or a combination of both processes.

Phosphorus Forms and STA Performance

Inorganic forms of P (e.g., SRP) are known to cycle quickly in aquatic ecosystems. They are readily utilized by STA flora, sorb with calcareous substrates, or co-precipitate with minerals within an STA. Other P forms have longer turnover times, i.e., complex organic and particulate P, and are more resistant to removal or are generated as part of the phosphorus biogeochemical cycle. Generally, DOP in natural waters such as the STAs can range from simple to complex organic molecules. Routine analytical methods to precisely determine the chemical composition of DOP are not completely developed. Instead, DOP is operationally defined as the difference between total dissolved phosphorus (TDP) and SRP. DOP can also be defined by its ability to be broken down by enzymes. PP, which can consist of detritus materials and living organisms (e.g., bacteria, phytoplankton,), is operationally defined as the portion of the total P pool that can be removed by filtration through a 0.45 µm filter. Both DOP and PP are removed in the STAs, and they can also be produced and recycled in the STAs.

In general, during periods when the STAs are performing well, most of the SRP rapidly is reduced to below detection levels, leaving PP and DOP as the predominant P species in the outflow water. However, there are some periods in well-performing STAs (e.g., following stagnant condition or during high-flow storm events) when a significant amount of SRP is detected at the outflow. It is important to determine if this SRP is being produced near the outflow or is being moved through the STA without substantial cycling.

Many biogeochemical and physical mechanisms can reduce PP and DOP concentrations. Particulate P can be reduced through grazing by fauna, incorporation into biological assemblages (e.g., floating periphyton mats), filtering by emergent and submerged aquatic vegetation, decomposition (desorption), and sedimentation or settling. DOP can be taken up by periphyton or microbial organisms, and microbial transformation may make this pool more readily available for uptake by emergent and submerged vegetation, phytoplankton, and bacteria. It can also be reduced through photo-degradation (Sharma et al., 2004), co-precipitation with minerals, and sorption (e.g., excess Fe or Al provides sorption sites).

Key sources at the STA outflows can consist of P from the inflow that has not settled or been sequestered by wetland biogeochemical mechanisms, or P associated with suspended particulates including plankton, bacteria, and detritus generated within the STA. However, knowledge gaps exist regarding the composition and origin of residual P at the STA outflows and on the cycling of P, including PP and DOP as water flows along the STA flow-ways. This information is important to better understand and manage the composition and concentration of P in the outflows from the STAs and distribution canals in order to meet water quality goals.

Sub-Question Related to Key Question 4

- *Are there things can be done in the STAs to enhance settling, filtering, and treatment of DOP and PP in the water column?*

Technologies for Managing Phosphorus Concentrations at STA Outflows

Several chemical agents have been used in various experimental designs in an effort to reduce P concentrations in outflows. Pilot-scale demonstration of the Chemical Treatment–Solids Separation (CTSS) technology, designated to remove TP from post-BMP and post-STA treated stormwater runoff from the EAA, successfully showed that a target outflow TP concentration of 10 µg/L can be achieved. However, capital and operational costs, residuals management, and the potential incompatibility with the downstream Everglades ecosystem were major concerns for full-scale implementation of the technology (SFWMD, 2002).

The efficacy of the Managed Wetland Treatment System (MWTS) in cattail (*Typha* sp.) systems was evaluated using iron(III) chloride ($FeCl_3$) and polyaluminum chloride (PACL). In an MWTS, storm water is mixed with chemicals to initiate flocculation and is then discharged into a treatment wetland dominated by cattails prior to eventual discharge to the EPA. The original concept envisioned chemical treatment occurring upstream of the STA, thereby removing a percentage of TP prior to release into the STA. Test cell studies showed MWTS can reduce outflow TP concentrations better than an emergent wetland system alone. $FeCl_3$ and PACL treatments produced TP concentration reductions of 66 and 76 percent, respectively. However, concerns over increased Al and Fe concentrations at the outflow and floc overflow prompted the District to discontinue research on MWTS (SFWMD, 2002).

The addition of small doses (less than 5 mg/L) of aluminum chloride ($AlCl_3$) directly to EAA runoff prior to its release into the STAs (also known as Low-Intensity Chemical Dosing, or LICD, technology) did not improve TP concentration reductions relative to the performance of a passive cattail marsh. Additionally, SRP and total dissolved P (TDP) concentrations were similar among all systems, indicating that chemical addition had no effect on the relative percentage of P species in the system. Total Al outflow concentrations in dosed wetlands increased relative to inflow concentrations and control wetland outflow concentrations (SFWMD, 2002). Also, alum was effective at P sequestration within the water column of treatment wetland mesocosms. The ability of alum to bind with P as well as organic particles resulted in improved SRP, TDP, TP, total dissolved nitrogen (TDN), total Kjeldahl nitrogen (TKN), and dissolved organic carbon (DOC) wetland treatment efficiency. Alum was most effective at binding SRP, with nearly 40 percent more removal compared to the controls (Malecki-Brown et al., 2009).

Pilot-scale investigations of chemical treatment technologies in the Everglades have produced mixed results. The MWTS technology reduced outflow TP concentrations but was not able to achieve 10 µg/L TP with $FeCl_3$ or PACL. The LICD technology using $AlCl_3$ failed to achieve outflow TP levels lower than a passive cattail marsh wetland, while chemical treatment combined with microfiltration for solids (CTSS technology) was able to consistently produce outflow TP concentrations of 10 µg/L. A key issue with these technologies is whether the outflow from chemically treated systems has an ionic signature compatible with the EPA and is marsh-ready.

Hybrid Wetland Treatment Technology (HWTT) has been applied in the watershed north of Lake Okeechobee. Chemical coagulants are added, either continuously or intermittently, to the front end of the treatment system, which contains one or more deep zones to capture the resulting floc material. A fundamental concept of the HWTT is that the floc resulting from coagulant addition generally remains active and has the capability of additional P sorption. Both passive and active reuse of floc material is practiced in the HWTT. Passive reuse refers to the settling of active flocs on plant roots and stems, where it can contact additional untreated parcels of water. Active reuse refers to the mechanical resuspension of previously settled floc. In addition to passive and active recycling/reuse of chemical flocs, optimization approaches include the sequencing and configuring of the wetland unit processes to provide desirable N and P species transformations. Currently, there are six operational HWTT systems in the Northern Everglades region. Effective performance of the HWTT technology is demonstrated by the reduction in TP concentrations between the inflow and outflow during the entire study period (Watershed Technologies, LLC, 2012). Flow-weighted mean TP concentration reductions of the six active HWTT facilities during the entire study period ranged from 65 to 91 percent.

The Northern Everglades Chemical Treatment Pilot (NECTP) Project Phase I was completed in July 2009 and was conducted to (1) investigate available information on chemical treatment technologies that have been tested within other water bodies to reduce TP loads in stormwater runoff and (2) identify technologies appropriate for use within the Lake Okeechobee Watershed. Results of the study concluded that various chemical treatment technologies are viable and represent effective options for reducing phosphorus loads to the lake (Bottcher et al. 2009).

Overall, additional investigations are needed into potential design features, operational changes, or physical or chemical barriers to the transport of DOP and PP from the STAs into the EPA.

Sub-Question Related to Key Question 4

- *What design or operational changes can be implemented to reduce PP and DOP at the outfall of the STA?*

3.1.5 Key Question 5

What operational or design refinements could be implemented at existing STAs and future features (i.e., STA expansions, FEBs) to improve and sustain STA treatment performance?

STA Operations

The primary purpose of the Everglades STAs is to utilize biological processes to reduce TP concentrations in order to achieve the WQBEL, but there are also operational or design refinements that could potentially influence phosphorus treatment performance in existing and future STAs that need to be explored further. FEBs can capture and provide storage for high flows to be delivered later at low inflow rates to help achieve low outflow TP concentrations from the STAs. Therefore, there is a need to determine optimal, real-time STA inflow rates. While high flow rates may increase entrainment and transport of sediment and floc and increase outflow TP concentrations, extending the time period that inflow occurs may help achieve lower outflow levels (note that inflow pumping typically occurs during eight-hour, daytime shifts). Also, some of the major pump stations have large diesel pumps with only high pump rates. Lowering STA inflow rates can minimize impacts to STA vegetation that typically occur due to deepwater conditions in the inflow cells, particularly as their sustainability can affect treatment performance. Extending outflow time periods may also help achieve lower outflow TP levels. As photosynthesis rates peak during the day and phytoplankton and microfauna have diel movement patterns, such factors can also affect outflow TP concentrations. Preliminary data from the STA-3/4 PSTA Project suggests that outflow TP values are lower at night than in the day, but further data collection and evaluation is needed.

Sub-Questions Related to Key Question 5

- *Does pumping at lower STA inflow and outflow rates over 16 or 24 hours in a day versus 8-hour day shifts, improve STA performance?*
- *What is the best period within a 24 hour day to discharge water from an STA to achieve the lowest phosphorus concentration?*

Sediment Management

Changes in TP concentrations have been observed in inflow canals in STA-2 and STA-3/4. TP levels have been observed increasing and decreasing from the STA inflow pump stations to the inflow structures at the upstream side of the STA flow-ways. There is also some evidence that these concentrations may increase as water moves from the treatment cell flow-ways to permit compliance discharge structures in some STAs. Particulates originating in storm water are present in STA inflow and outflow canals. During times when velocities are high, sediment resuspension could result in elevated TP in STA inflow water or STA outflow collection canals. During severe droughts, water levels in some canals are significantly lowered to the extent that portions of the canal sediments are exposed for periods of time. When re-wetted, the effects of sediment P flux to the overlying water column or release of P from wetting/drying cycles of portions of canal sediment could also influence the water TP concentrations observed at the STA inflow and outflow structure sampling locations. Water seepage into or out of STA canals to or from adjacent water bodies or groundwater might also be a contributing factor in changes in TP concentrations. Other influences may be also considered. These conditions will equally apply to conveyance of water to and from FEBs, especially from the FEBs to STAs.

Sub-Question Related to Key Question 5

- *Would sediment management in inflow and outflow canals improve STA performance?*

Minimizing Short-circuiting and Improving Flow Distribution

Short-circuiting of flows reduces contact with the treatment system and HRT and can reduce treatment performance. Short-circuiting exists in STAs for various reasons but sometimes is caused by erosive velocities associated with inflow structures. Wider and deeper STA inflow distribution canals and energy dissipaters may minimize flow velocity and in turn short-circuiting. Reduced short-circuiting could also help reduce deepwater impacts to vegetation. Wider and deeper STA outflow distribution canals may also reduce outflow velocities.

Bulrush (*Scirpus acutus*) plantings have been successful in reducing open water in SAV cells and increasing the percent cover of vegetation in these cells. Quantifying improvements in TP removal efficiency as a result of these plantings is difficult; however, in relation to reducing short-circuiting, this is a relatively inexpensive and simple remedy compared to earthwork or structural features. Also, other structural measures could improve flow distribution, reduce short-circuiting, and enhance treatment performance. For example stilling basins immediately downstream of STA inflow culverts might reduce flow velocities and short-circuiting. Box culverts, spreader canals, or broad-crested weirs might widen the inflow distribution zone and thereby reduce deep water impacts and short-circuiting. Overflow weirs (as opposed to gated spillways and gated culverts) might also reduce transport of floc and sediment. The structural issues regarding short-circuiting and flow distribution apply to existing and future STAs.

Sub-Question Related to Key Question 5

- *What are the best structural design features for delivering water to and from the STAs and FEBs?*

Topography

In STA cells where farm ditches and borrow canals perpendicular to flow are filled, variations in topography across cells may still exist that affect hydraulics and the ability to maintain target stages to sustain vegetation. Topographic variability occurring in several existing STA cells are thought to contribute to their poor performance, as discussed in the *STA Performance* sections of the 2008–2012 SFERs –Volume I, Chapter 5 (Pietro et al., 2008–2010; Ivanoff et al., 2011–2013). With this in mind, future STA design may benefit from analysis to define the optimal degree of topographic accuracy for the treatment cells.

Sub-Question Related to Key Question 5

- *How critical is topography in STA treatment performance?*

Operational Flexibility

Operational activities are necessary to maintain optimal conditions for vegetation in the STAs as sustainability of the vegetation can affect treatment performance. Occasionally, individual cells need to be drawn down (or dried out in some instances) to allow for construction access, planting, or to rejuvenate vegetation. SAV cells need to remain hydrated even during drought periods. The FEBs are expected to reduce the frequency of dryout but it still may occur. As a result, this may require greater flexibility to transfer water between STA cells and flow-ways by increasing the number of permanent or mobile pumps, or through structural changes. Supplemental water supply pumps have been effective in sustaining SAV cells in STA-5/6. Additional pumps and structures increase flexibility but also increase operations and maintenance costs. Aquifer storage and recovery (ASR) wells might also be evaluated to provide a source of water to prevent dryout.

Sub-Question Related to Key Question 5

- *What is the cost benefit of adding more flexibility to transfer water between cells and flow-ways or to deliver supplemental water during droughts?*

Inducing Downward Flow in STAs

The exchange of phosphorus between the soil and the water column occurs due to a combination of physical, chemical, and biological processes including macrophyte mining, plant transpiration induced flux, chemical diffusion, and hydraulic gradients that induce upward or downward movements of water in wetland soils. The physical processes are typically dominated by advective flux. The physical processes also include effects such as turbulence, which could result in deposition/resuspension of sediments at the soil-water interface. The magnitude of the exchange of water (and the associated dissolved or particulate phosphorus) between the soil and water column depends on the hydraulic conductivity, surface area, and gradient between the aquifer and surface water. The gradient and resultant upward or downward movement of water through the soils can be manipulated to effect a change in flow between the soil and water column. The gradient is a function of the potentiometric surface (head to which water in the aquifer will rise) and water level in the STA. When water level in a STA is altered, a gradient is created and flow is either induced into the soil or from the soil to the water column to achieve static equilibrium. Within the STAs where the rate and frequency of water level changes may be controlled, there may be an opportunity to use this principle to achieve operational goals. Where soil pore water TP concentrations are high relative to water column concentrations—which is the case in most SAV cells—alternating or persistent soil to water column (upward) flow may be less desirable than persistent water column to soil (downward) flow for achieving the lowest possible TP concentration in the water column. A key assumption is that the aquifer beneath the water body is fully saturated and the potentiometric surface is in contact with the water column. Based on current data, there is solid performance in STA cells where the average water table is relatively high compared to surrounding water tables (STA-1E Cell1, STA-2 Cell 1, and STA-3/4 Cell 3B), suggesting that upward diffusion of phosphorus may be reduced by inducing downward advection flow.

Sub-Question Related to Key Question 5

- *Can upward diffusion of phosphorus in SAV cells (or portions of cells) be reduced by inducing downward flow?*

3.1.6 Key Question 6

What is the influence of wildlife and fisheries on the reduction of phosphorus in the STAs?

Influence of Fish and Wildlife on Phosphorus Removal

A wealth of ecological literature confirms the central role of consumer populations in material cycling in most ecosystems, including productive wetlands such as the Everglades STAs. Kitchell et al. (1979) summarize the influences of consumers on ecosystem processes and nutrient cycling. They emphasize that animal consumers translocate nutrients across components of the ecosystem and are particularly active in moving nutrients and other materials across the sediment-water interface (bioturbation). Animal consumers also transform biomass and nutrients through selective feeding, digestion, and assimilation. Together, the multiple processes associated with animal consumers fundamentally alter the nature of biological materials and rates of nutrient cycling. As strong evidence for the importance of consumers, Hanson et al. (2005) have documented the critical role of fish in shaping biological communities including macrophytes, phytoplankton, and benthic invertebrates in prairie wetlands. Using radiotracers in field mesocosms, Noe et al. (2003) demonstrated that consumers in oligotrophic Everglades wetlands were a major driving force in P cycling, although consumers proportion of ambient biomass was relatively low. With much higher biomass levels in STAs, the role of consumers in nutrient cycling is expected to be pivotal. The bottom line is that materials being produced and stored in ecosystems have been highly modified by the food web activities of animal consumers; P-bearing peat being accreted in sediments of the STAs is not an exception to this generalization. The interaction of consumers with P cycling and peat accretion provides a direct linkage between faunal activities and STA performance.

In a review of wetland nutrient enrichment and abatement, Sanchez-Carillo et al. (2011) summarize evidence on sources of internal nutrient loading and conclude that changes in biological communities with wetland eutrophication are closely tied to nutrient cycling and sustainability. They join Angeler et al. (2003) in calling for manipulation of food webs (biomanipulation) as a management approach with great potential to alter the structure and function of freshwater wetlands and to modify water quality in the process. Lacoul and Freedman (2006) summarize cases where herbivory was a major factor in the dynamics of aquatic plant assemblages. From the perspective of treatment wetlands in general, Kadlec and Wallace (2009, Ch. 10) emphasize that birds and other grazing animals can be important by processing P via feeding and excretion, and transporting P through daily and seasonal movements. They apply fecal production rates of birds to illustrate that flocks of birds in treatment wetlands “may influence the ability of treatment wetlands to achieve ultra-low phosphorus concentrations, but will not affect treatment at the secondary or primary level.” Frederick and Powell (1994) estimate that even the reduced numbers of birds present today in the Everglades can produce significant P loading in colony locations and that these loads are many times greater than P inputs from the atmosphere. They qualify these high numbers, like Kadlec and Wallace (2009), by noting that birds are not important agents of P loading at the scale of the entire Everglades.

Overall, these examples are actually conservative when viewed in the context of biologically productive STAs as they only considered bird effects on P cycling. There is also a substantial body of information on other animals that also process P in organic matter and play a role in internal cycling in wetlands, as summarized in the following sub-sections. As reviewed thoroughly by Vanni (2002; see **Figure 5**), birds, fish, and macro-crustaceans (crayfish and grass shrimp) can alter several pathways leading either to higher or lower TP concentrations in the water column of aquatic ecosystems. Therefore, observations applicable specifically to the STAs should be considered to decide how important birds and other consumers are to internal P cycling, transport, transformation, and STA performance.

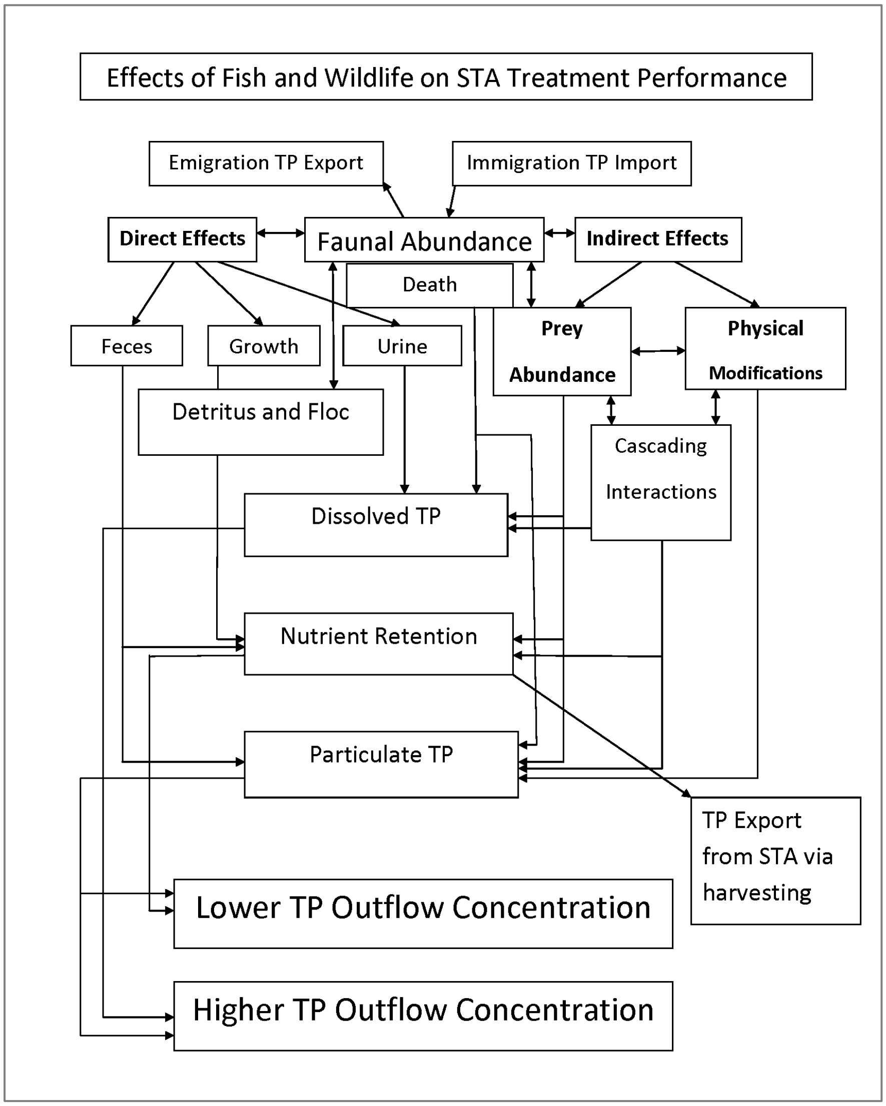

Figure 5. Interactions between fauna and STA outflow concentrations and performance (modified from Vanni, 2002).

The STAs are species rich and highly productive constructed wetlands. As such, these wetlands are host to many animal consumers, most conspicuously avifauna and alligators. In cells near outflows, biological effects could be a major factor in outflow TP levels when concentrations are very low. STAs are known to attract many species of migratory birds which arrive in large numbers and stay for months at a time during the fall and winter seasons (Gawlik and Beck, 2010). At the scale of entire STAs, it is unknown whether fish and wildlife interactions will affect outflow TP concentration significantly even though they are influencing water column P dynamics locally. Gawlik and Beck (2010) place these observations in perspective. They found bird densities in the STAs to be 35 times the density of birds found in marshes of WCA-3A averaged over the entire year, but 50 to 120 times greater during the fall and winter. Wetland fishes are also expected to contribute substantial internal P loading and support high algal growth rates through strong bottom-up influences (Zimmer et al., 2006). Fish can also initiate cascading trophic interactions across wetlands like the STAs. For example, Evelsizer and Turner (2006) found that excluding fish caused large differences in macrophyte abundance after one growing season in a prairie marsh. Also in prairie wetlands, Zimmer et al. (2001) documented system-wide changes in water quality and invertebrate abundance due colonization by flathead minnows. Both direct and indirect effects (**Figure 5**) associated with faunal predation, grazing, and physical modification of the environment are most likely to be worthy of further study as they cascade through the marsh near STA outflows and have the greatest potential to alter outflow TP concentrations.

Faunal consumers can cause both top-down (i.e., predation, herbivory) and bottom-up (i.e., excretion) interactions. Disentangling the consequences of community level interactions occurring simultaneously in an STA will not be done easily and simply, but studies from the literature support working in that direction. For example, Wetzel et al. (2005) document the unique role of tree islands in Everglades nutrient redistribution at a landscape scale. They illustrate the dominant nutrient cycling and distribution mechanisms associated with biological communities and stress the role of these processes in the development of Everglades tree islands.

The overall challenge is to review available literature and information on the STAs to decide what ecological interactions may be important and conduct the studies necessary to make decisions on potential management and operational means to lower outflow concentrations through cascading biological interactions. Indirect effects may be worthy of quantification but are not easily estimated with existing information (e.g., crayfish grazing down periphyton biomass, ducks consuming SAV, alligator disturbance to sediments). Direct effects are supported by a substantial literature and can be estimated more easily. For example, using the rate of 0.2 g TP per bird per day and 1,000 birds per 62,500 m^2 (0.25 km^2) (Manny et al., 1994), the areal internal TP loading could easily equal that from external stormwater inputs to an STA of $1g/m^2/yr$. When birds like terns, black skimmer, or white pelicans gather in specific areas, they may generate nutrient hotspots. After such impacts near outflows, TP concentrations could potentially be changed substantially, at least for part of the water year (e.g., waterfowl grazing and defecation plus reduction of SAV surface area for periphyton). The central information need is to get quantitative estimates of faunal densities and interactions and then to ascertain whether these linkages are positive or negative to performance and whether fauna are sources or sinks of TP for the STAs. It is also important to note that solid information on fish and wildlife is also valuable for monitoring ecosystem performance as well as encouraging public understanding and support for the STAs and Everglades management as a whole (Gawlik, 2005).

Influence of Birds

Very few wildlife surveys have been conducted within the STAs to date, although there has been some direct attention to birds (Gawlik and Beck, 2010; Chimney and Gawlik, 2007). Additionally, the Audubon Society has routinely conducted citizen science surveys in STA-1E and STA-5 in recent years. While limited in scope and duration, these surveys show that the STAs support a relatively diverse and abundant community of birds. Over 200 species have been identified in STA-5 alone (eBird, 2012). Moreover, the STAs support more than twice the density of birds of the EAA and, as mentioned earlier, the STAs provide habitat for over 30 times that of the natural marsh when averaged across all seasons (Gawlik and Beck, 2010). Recent Audubon Christmas bird counts confirm densities of this range. Managing the STAs to minimize dryout may encourage bird use during dry periods. The most numerous species include the American coot (*Fulica americana*; resident and wintering), common gallinule (*Gallinula galeata*; resident), and blue-winged teal (*Anas discors*; wintering). Coots and many dabbling duck species forage on SAV, including hydrilla, and most individuals (approximately 90 percent) within the STAs are found in the SAV cells. By the time the spring migration of blue-winged teal occurs, the biomass of SAV is often greatly reduced; however, the extent to which this loss is due to herbivory by ducks or other animals (e.g., large fishes) is not known.

Fish-eating birds, especially wading birds (e.g., herons, egrets, and storks), are also common in the STAs. Wading birds play an important role in the redistribution of nutrients in wetlands by transferring TP from aquatic habitats to terrestrial breeding colonies and roost sites, largely through the process of feeding their offspring aquatic prey animals and via defecation. This might suggest that breeding wading birds are, or have the potential to be, a net exporter of TP from the STAs. TP content both of duck (Fleming and Fraser, 2001) and wading bird (Susan Newman, unpublished data) feces is high relative to other animals, although P content is variable (1 to 9 percent). The export, import, and recycling of their feces may play an important role in STA P dynamics and outflow concentrations. Following the example used by Kadlec and Wallace (2009) with 10 g dry weight produced per bird per day, 2 percent P in dry weight (Scherer et al., 1995 also estimated 1.9 percent), and 35 birds per hectare average for the STAs (Gawlik and Beck, 2010), birds are cycling 7 g P per hectare per day. The importance of this cycling is evident when comparing bird release to ambient P levels in an STA; at 25 µg P/L and a wetland depth of 0.4 m, there is 100 g P per hectare in the water and birds are recycling this amount every 15 days. Together, these observations and additional examples from the literature (e.g., Post et al., 1998; Sekercioglu, 2006) provide strong justification to gather more definitive information on avifauna influences on STA performance and determine TP export or import by birds.

Birds protected by the Migratory Bird Treaty Act or the Endangered Species Act establish a direct linkage between avian presence in the STAs and direct operational limitations that can influence STA performance, a legislatively driven interaction not usually considered by ecologists like Vanni (2002). Black-necked stilts (*Himantopus mexicanus*) are a migratory bird species that overwinter in the STAs and are known to nest on the ground within drying portions of STA cells. As this species is protected by the Migratory Bird Treaty Act, operational steps have been taken to minimize the flooding of nests and these operations have the potential to affect the overall functionality of these treatment wetlands. Another protected avian species that has the potential to impact STA operations is the Everglade snail kite (*Rostrhamus sociabilis plumbeus*). Consequently, quantitative information is needed on the influence of operational modifications implemented in compliance with the Migratory Bird Treaty Act or the Endangered Species Act on STA performance and treatment capacity. Any effort in this subject would build upon surveys, such as those for black necked silts, conducted annually in the STAs.

Influence of Fish

In addition to more conspicuous avian species, Chimney and Jordan (2008) documented 28 species of fish within the ENR Project (with expansion, currently known as STA-1W). Study results found high densities of small omnivorous and herbivorous fishes averaging 77 fish/m^2. Other studies have reported similar or higher densities in productive North American wetlands (e.g., Zimmer 2006), while Tomlinson et al. (2010) noted much lower densities in the United

Kingdom's Broads wetland system despite the presence of high nutrient levels. Species composition found in the ENRP was more similar to nearby natural wetlands in South Florida, but the constructed wetland had much higher fish densities. Larger species like bowfin (*Amia calva*), Florida gar (*Lepisosteus platyrhincus*), and blue tilapia (*Oreochromis aureus*) represented about one-half the biomass but less than 1 percent of the fish density. Larger species like bowfin (*Amia calva*), Florida gar (*Lepisosteus platyrhincus*), and blue tilapia (*Oreochromis aureus*) represented about one-half the biomass but less than 1 percent of the fish density. While more information is needed on fish in the STAs, observations in enriched Everglades marshes suggest that STA fish could be larger and have higher P body content that fish in unenriched marshes.

The role of direct grazing and predation of fish in the STAs remains largely uncertain, but several examples from the literature suggest that fish are major players in plant growth and composition and in nutrient cycling. STAs can be expected to have dense fish populations with their high nutrient levels and relatively stable water depths. In prairie wetlands, Zimmer et al. (2001) found fish colonization led to higher turbidity, TP, and chlorophyll *a* in the water column and lower densities of crustaceans and aquatic insects. Zimmer et al. (2006) showed that fish were a major agent of P transport from the sediments into the wetland water column; similarly, Vanni et al. (2006) found that shad were important in the transport of P from sediments back into the water column of reservoirs. Also, Evelsizer and Turner (2006) reported that macrophyte abundance and composition changed greatly in the presence of fish. Like the previous example for birds, fish excretion of TP is estimated to be a significant source of internal TP loading. At 77 fish per m^2 (Chimney and Jordan, 2008) and an excretion rate of 200 µg P per fish per day (Zimmer et al., 2006), fish excretion releases as much TP as contained in the wetland water column in less than one day at 25 µg TP/L and depth of 0.4 m. While more information is needed to confirm this TP release rate and fate of the various forms of excreted TP, there is strong evidence that fish serve an important role in TP cycling in the STAs and may cause sizeable changes in TP concentrations of real significance near STA outflows. An updated fish population survey in all STAs is clearly needed as a starting point, along with a thorough literature review of fish nutrient cycling rates.

Influence of Macro-crustaceans, Mollusks and Alligators

While it is known that other submerged aquatic wildlife species (e.g., crayfish, grass shrimp, apple snails, and other aquatic macroinvertebrates) utilize the STAs for foraging, breeding, and refugia, the species richness and densities of these fauna are unknown. It is expected that the STAs as eutrophic to mesotrophic wetlands will provide ample food and habitat to potentially support relatively high densities of shrimp and crayfish (10-20 per m^2) and other benthic invertebrates. When densities are high, it will ensure that macro-crustaceans and other invertebrates could have significant interactions as consumers and recyclers of P. Snails, particularly apple snails, can effect plant communities and also be important food for fish and birds like the endangered snail kite. Importantly, crayfish are heavily preyed upon by fish and their densities can be highly variable as a result. Although their densities are much lower than fish, crayfish have a much greater average biomass and could easily excrete P at levels approaching that for the fish community. The role of all invertebrates in P cycling in the STAs needs quantitative study. At a minimum, basic population numbers and spatial distribution are needed to begin assessing the role of large crustaceans in STA performance.

Alligators are abundant in the STAs and yet there have been no quantitative studies of their abundance or impacts on the functionality of the STAs. While it can be argued reasonably that for the STA area as a whole, it is not likely that crocodilians have a major impact on water column phosphorus levels. However, alligators are not uniformly distributed and may concentrate in deeper areas and peripheral canals, particularly during low water periods. Obviously, their body mass is huge relative to other organisms (around 50 kg). Even at a density of five alligators per hectare, their biomass is far lower than fish, probably about 25 percent of fish biomass and their P release rate is expected to be lower as well. Still, when concentrated near outflows, alligators could be significant in P recycling and their role in physical disturbance of the sediments could influence water column P concentrations strongly. As a result, when working toward very low P outflow concentrations, additional information on direct and indirect effects of alligators on water column P concentrations would be valuable, particularly near outflows. Also, the role of alligators in P mass balance in the STAs would help guide future studies and management strategies.

New Information to Improve STA Performance through Management of Fish and Wildlife Communities

Although the ecological role of fauna in wetlands is known generally as previously noted, there are many opportunities to gather more specific information on the role of larger aquatic organisms P cycling and removal at low P concentrations near the effluents of the STAs. Quantitative information regarding the processes associated avifauna, fish communities, and other faunal components in STAs can support the development of novel management strategies to promote lower outflow TP concentrations. From the outset, it is clear that most management approaches to fish and wildlife will involve indirect actions to modify animal distributions and abundances, i.e., modifying plant habitats, conducting selective removal, attracting individuals away from the STA, managing seasonal depths, or physically modifying the STA. The overall goal is to improve STA performance by finding better and more integrated ways to manage fish and wildlife composition, density, and spatial distribution in the STAs. The following sub-sections introduce topics to be addressed by one or more projects in the Science Plan.

Quantifying the Role of Fish and Wildlife in Phosphorus Cycling and Mass Balance

Updated Population Data

To better understand how fish and wildlife may influence nutrient reduction in STAs, species densities over the year must be determined as a first step. While there is a fairly good understanding of the avian species that use the STAs, more data on density and spatial distribution is needed on avifauna. Aerial surveys for waterfowl, wading birds, and other avifauna would be helpful. Subsurface sampling is essential for fish and macro-crustacean population levels and locations. Various types of submerged aquatic surveys (e.g., fyke nets, gill nets, throw traps) should be considered. While the potential role of consumers on STA performance may be concentrated near STA outflows, some initial studies should focus on areas across nutrient, vegetation, and food resource gradients in the STA. Eventual studies of management strategies may focus more on areas within about one kilometer of STA outflows.

Better Information on Diet, Feeding Rates and Phosphorus Release

From the literature, applicable rates of feeding and nutrient release will be summarized for use in South Florida wetlands. For very abundant species, the review will attempt to obtain data for the actual species. For less abundant taxa, rates will be derived at a pooled taxonomic level, such as guilds. If information is not available for key species, new data on diet and feeding may be gathered. The literature will also be screened for information on the forms and availability of P being released by aquatic consumers. However, this subject may require new sampling and analysis for P forms and availability in the STAs. Once there is sufficient information on how many of each species utilize STAs and their associated feeding and P release rates, then questions regarding how these species potentially affect STA functionality can be addressed at least at the level of deciding on relative importance.

A modeling effort would be an excellent way to integrate information on the role of consumers of fish and wildlife in the cycling, transport, and fate of P in the STAs, most importantly in the vicinity of outflows. Initially, modeling could use existing data from the STAs and other wetlands to bracket the influence of larger consumers. As more quantitative information becomes available, models could grow in completeness and complexity. Any model development for fauna should be coordinated with or integrated into other STA P dynamics modeling.

Some initial questions using population and species level data may include:

- Do fish and wildlife affect P import, export, or nutrient cycling within the system enough to alter outflow TP concentrations?
- What are the primary diets of waterfowl and submerged aquatic wildlife in the STAs?
- What P content is associated with various dietary components and how does P content vary P cycling by consumers?
- What rates of TP cycling can be expected in the STAs from wildlife, fish and macro-crustaceans? How significant is faunal recycling to ambient P turnover?
- What is the form and availability of excreted TP for the dominant faunal components?
- How does the grazing of SAV (e.g., hydrilla) affect STA functionality? What are the affects of herbivory in terms of SAV growth, health, biomass, and TP uptake?
- How do changes associated with herbivory tradeoff against TP recycling derived from bird excretion?
- Are cascading trophic interactions associated with fish predation capable of altering STA outflow concentrations?

Investigating Possible Management Actions for Fish and Wildlife

Finding Options for STA Fish and Wildlife Management

The consideration of potential management actions will be the final phase of the study. Information from the literature should provide some management options. However, novel fish and wildlife management activities themselves may require additional field observations and pilot studies. Tomlinson et al. (2010) provide a good example of such an information-gathering process, in which they conducted a thorough literature review, summarized field data, interpreted ecological information, and then provided management recommendations to improve and sustain fish populations within the Broads wetland system near Norwich, England.

As part of possible management options, landscape-level approaches both within and outside of the STAs could be considered. There is active literature on the intersection of population, community, and ecosystem science involving landscape dynamics, natural or man-made, and ecosystem responses. Concepts from these studies can be pursued in the STAs. For example, selective clearing in the STA could change species distributions and abundance to favor lower TP concentrations. Reshaping internal canals and surgically creating transecting channels may allow modification of fish predation patterns and cascading interactions with P recycling and retention. Altering landscapes outside the STAs may attract waterfowl or wading birds away from the STA daily or seasonally and thereby alter the P mass balance. Particular attention will be paid to any potential wildlife interference with P measurements in the STA discharges.

Sub-Question Related to Key Question 6

- *What options are there for mitigating or reducing the impacts of fish and wildlife on STA performance through wildlife management or change in operations?*
- *Can the outfall areas of the STAs be designed or operated in a manner to discourage congregations of birds, alligators or other fauna?*

Evaluating the Role of Alligators

Importantly, alligators also should be factored into STA performance. As part of the surveys for avifauna, the population density and distribution of alligators must be determined for various size groupings. The surveys will need to accommodate seasonal changes in population density and migratory patterns. Alligators probably do not directly cycle much P relative to other biotic components like fishes or waterfowl, but they are capable of disturbing and resuspending sediments and causing marsh short-circuiting. Their role in TP concentrations in the vicinity of outflows should be examined quantitatively.

Sub-Question Related to Key Question 6

- *What are the direct and indirect effects on alligators on water column phosphorus concentrations in the downstream cells of the STAs?*

3.2 SCIENCE PLAN SUB-QUESTIONS TO GUIDE STUDY PLAN DEVELOPMENT

Although many potential areas of investigation were identified during the generation of sub-questions, implementing all of these for hypothesis testing at the same time is not feasible. Consequently, this information was further evaluated with the goal of determining a proposed initial suite of studies or research to be included in the Five-Year Work Plan. Specifically, the Science Plan Team evaluated the areas of investigation and sub-questions considering testability, feasibility, timeliness, and importance in reaching the WQBEL based on the following criteria:

- **Testability**. Can a study be realistically designed and conducted around the question to get reliable results? What is the uncertainty factor?
- **Feasibility**. Can information learned from the study be realistically implemented? Would study results be transferable and applied at the scale needed?
- **Timeliness**. Is it short-term, quick win versus long-term? Can the study be completed in time to support decisions, and is it in the critical path of other studies, etc.?
- **Importance**. Does it have the potential of reaching the WQBEL objective, and will it be sustainable and resilient over the long-term?

In collaboration and consultation with the Technical Representatives, eight sub-questions were selected as the basis for developing the proposed study plans. The selection process was semi-quantitative and utilized best professional judgment of the Science Plan Team, Technical Representatives, and federal agency experts and consultants during multiple meetings and workshops. In addition, several opportunities for public and stakeholder participation and review of the sub-question evaluation process and the selected sub-questions were provided at Long-Term Plan Communications Meetings, Water Resources Advisory Commission Meetings, and during the Draft Science Plan public review period (see **Table 1** for details). As presented in **Appendix C**, the initial Five-Year Work Plan includes seven study plans (derived from the sub-questions listed below) as well as study plans for two other areas of investigation discussed in Section 3.4. As shown in **Table 3**, the eight selected sub-questions are as follows:

1. How should storage in the FEBs be managed throughout the year so water can be delivered to the STAs in a manner that allows them to achieve the lowest outflow P concentrations?
2. Would changes in canal management or design improve STA and FEB performance?
3. What are the treatment efficacy, long-term stability, and potential impacts of floc and soil management?
4. What are the sources (internal/external, plants, microbial, wildlife), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system?
5. What are the key physical-chemical factors influencing P cycling at very low concentrations?
6. What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P?
7. How does water depth affect sustainability of dominant vegetation?
8. Can *Cladium jamaicense, Nymphaea odorata,* and periphyton mats enhance P uptake and removal in SAV cells?

The remaining sub-questions or any new ones generated as the plan is implemented will continue to be evaluated and prioritized annually through an adaptive management process outlined in Section 5. From this process, new studies not currently on the schedule will be identified, prioritized, designed, and added as the Science Plan progresses.

3.3 RESEARCH AND STUDY PLAN DEVELOPMENT

The next step in the process outlined conceptual plans for the studies that would address the eight sub-questions highlighted (with asterisk) in **Table 3**. These proposed plans lay out the framework for the science and research to be undertaken during the initial phase of science plan implementation and comprise the five-year work plan in **Appendix C**. The conceptual study plans are organized into a consistent format and include the following components: study name, principal investigator, key question the study addresses, sub-question(s) the study addresses, along with descriptions of:

- **Background.** This provides information on each sub-question being investigated, which includes review and analysis of existing data and literature done initially to document what is known/unknown and assist in identifying the sub-questions to be addressed in this Science Plan. It is expected that additional data and literature review also will be conducted to aid in developing hypotheses for the individual study plans.
- **Study Hypotheses and Objectives.** Hypotheses development is important to clearly lay out the individual study plan rationale and, more specifically, what will be tested in those plans. It is also critical to guiding the experimental design and associated statistical analyses. The individual study plans may include testing several hypotheses. The objectives of the study plan will be stated in order to link study results to potential management actions and operational activities and, to some extent, where practicable, the approach to the FEB and STA design. This includes the rationale on how the results will be scaled up. Linking the results of the individual study plans to management actions will also help with hypotheses development.
- **Proposed Methodology.** This presents a description of location, general scope, and duration of the study and whether the study will be carried out in phases or sub-studies (sequentially or concurrently). Data review and analysis are important components of the study plans. Extensive sampling and analyses have been performed over the years in conjunction with STA operations. Although these data have been analyzed, further evaluation is necessary to identify important data gaps and help design the field methods and data collection aspects of the study. The District currently performs or oversees research on STAs and other wetland ecosystems, as documented in the annual SFER (see Table 5-13 of the 2013 SFER – Volume I, Chapter 5). Where applicable, current research or research already under way will be integrated into the study plan. Field methods and the approach to data collection will be described. Some studies may require more focused monitoring beyond the monitoring program that is currently in place to fill information gaps and test hypotheses. The design of this sampling effort (e.g., matrix, parameters, frequency, and location) is also covered in this section. Where applicable, a description of management/modeling tools to be developed and used to meet individual study plan objectives is included (see Section 4 for the role of modeling).
- **Activities and Milestones.** A list of the major activities and milestones with anticipated completion dates for each individual study plan.

The current conceptual plans are continuing to evolve into full scale research plans with more robust technical designs. Each of the principal investigators will hold several workshops over the coming months to further develop their respective study plans into more comprehensive experimental designs, with input from the Technical Representatives and other technical experts. Further details including the specific resources and budget required to carry out the work (e.g., in-house staff versus contractual support) are also being determined.

3.4 OTHER AREAS OF INVESTIGATION

3.4.1 STA Water and Phosphorus Budget Improvements

An accurate water budget for an STA (or individual cell) is necessary for developing a phosphorus budget and ultimately for understanding phosphorus treatment performance of each STA. STA water budgets are comprised of several components including structure flows (inflows and outflows), rainfall, evapotranspiration (ET), seepage, change in storage, and residual (error). Recently, the STA Water Budget Application has been used to compute water budgets for entire STAs and individual STA cells. Using this automated tool, water budgets can be computed on a daily, monthly, seasonal, annual, or multiyear basis. For STA water budget calculations, inflow, outflow, ET, rainfall, and stage data are obtained from the District's hydrometeorologic database (DBHYDRO) and seepage through levees is estimated with seepage coefficients and stage differences. Water control structure flows are the largest component of STA water budgets, accounting, on an average year, for about 70-80 percent of the annual water budget, while rainfall and ET are roughly 10-12 percent (Abtew e al., 2013a). In dry years, especially during drought when inflow and outflow structures are mostly closed, seepage, ET, and rainfall account for larger percentages. Water budgets for entire STAs are developed using the inflow and outflow structures referenced in the operating permits, known as the compliance monitoring sites. Flow estimates for the compliance monitoring sites are maintained in Preferred (PREF) DBKEYs, which are presently subject to the highest level of quality assurance that can be provided by SFWMD data management staff. While most STA inflow and outflow structures have PREF DBKEYs, this is not the case for most of the internal structures.

Annual water budgets for each STA typically have less than 10 percent error, whereas individual cell water budget errors can be much larger, i.e., 40-50 percent (Abtew et al., 2013b). The primary source of such error is often attributed to estimates of structure inflows and outflows and seepage. Flow-way or cell water budgets can have large error terms because flow-way inflow and outflow structures and cell-to-cell structures are typically culverts, which are difficult to estimate for flow, particularly when operating under low head difference conditions that are prevalent in the STAs. When the head differential among upstream and downstream sections of a water control structure is very small (typically less than 0.05 ft), the discharge estimate is highly sensitive to errors in headwater and tailwater elevations. In such cases, small errors in headwater and tailwater elevations result in large errors in estimated discharges. Unfortunately, by design the STA culverts, especially internal structures, typically operate under a low difference regime much of the time (greater than 50 percent in many cases). Generally, these head differences are less than the headwater and tailwater stage sensors resolution, which is typically about 0.03 ft.

In some cases, further improvements in cell water budgets may require structural retrofits, operational changes, enhanced monitoring, equipment installation, field investigation (e.g., surveying), as well as development and maintenance of additional DBKEYs as needed and as resources permit. To improve STA water budgets, errors in all water budget components should be reduced to the maximum extent practicable. Agency efforts are under way to evaluate sources of error in the STA water budgets and develop recommendations for reducing such errors and improving water and phosphorus budget accuracy, for both entire STAs and individual cells.

Seepage is often the largest unquantifiable term in the water budget. While it can be estimated, it is frequently co-mingled with the error term. Modeling tools exist for estimating seepage flows (e.g., SEEP2D seepage analysis program) associated with STA cells. For STA cells with large error terms in the water budget, in addition to making all possible improvements in the other water budget terms, the seepage estimates should be evaluated for potential improvement using appropriate methods and tools. In some cases, it may be necessary to collect field data to more accurately characterize the seepage component of some STA cells. Because installation of seepage monitoring facilities (e.g., wells and monitoring equipment) and labor can be expensive and time-consuming, such efforts need to be further evaluated in relation to the Science Plan.

The rainfall component of STA water budgets is currently estimated from rain gauges in the STA or the nearest gauge in the surrounding area. As part of the STA water budget evaluation, a review of the rain gauge network used for each STA may be helpful. The evaluation may result in the addition or relocation of gauges to measure rainfall in the STAs. Raindar (Nexrad rainfall) is an areal radar-based rainfall estimate that is adjusted with the point-based gauge observations. Raindar data can be used for filling gaps or replacing irregular observations, or possibly to develop better areal estimates of rainfall. Rain gauge data (point measurements) can also be used to estimate the average rainfall over an entire STA, a flow-way, or a specific cell (Huebner et al., 2007). For example, a simple average of applicable rain gauges or a more scientific approach in combining these data can be used to get an areal estimate (e.g., Thiessen Polygon method). Overall, the impact of these different approaches in developing rainfall estimates used for the STA water budgets needs to be further investigated to establish the specific recommendations for the Science Plan.

Defined as evaporation/evapotranspiration from wetlands and water bodies, ET is one of the better quantified components in the STA water budgets. DBHYDRO has PREF data for potential ET. The model for ET computation was developed from lysimeter experiments associated with the ENR Project. This model has been published in many peer-reviewed journals and books and is applied in several countries (Abtew and Melesse, 2003). Any additional effort to estimate ET for the STA water budgets might not significantly change their accuracy. The STA ET data is derived from a model that uses input data from the closest weather station.

The STA Water and Phosphorus Budget Improvements Team has begun evaluating STA-3/4 Cells 3A and 3B as a test case for improving STA water budgets. Once complete, these results can be applied to other STA water budgets. Once the water budget improvements are made, revised phosphorus budgets can also be developed using the improved water budgets. For STA water and phosphorus budget improvements, a study plan has been developed and included in the Five-Year Work Plan (**Attachment C**).

3.4.2 STA Water Quality Monitoring

STA performance and compliance calculations are comprised of both structure flows and TP concentrations. In accordance with the issued permits, the calculation of the WQBEL requires TP concentrations measured at representative outflows. Water quality measurements are generally collected using (1) grab samples, which are singular collections of water from specified location, depth, and time, and (2) flow-proportional composite samples, in which a programmable pump collects a series of samples from the same specified location and depth, but with multiple events over time that have been initiated by defined and measured flow volumes. A third measurement of TP, time-proportional composite samples, is a variation on the composite when flow data are not available. With this monitoring, a programmable pump collects a series of samples from the same specified location and depth, but with multiple events over time that have been initiated by a defined periodicity. Using these data, in combination with structure flows allows for the calculation of TP flow-weighted mean concentrations for WQBEL compliance.

In general, quality control of samples is monitored through a comprehensive program that tracks equipment cleaning, maintenance and the ability to replicate results in the field and laboratory and ensure that monitoring data are of high quality (SFWMD, 2011a; SFWMD 2012d). While sampling failures are rare (i.e., usually less than 1 percent of samples collected), a troubling issue for end users of water quality data has been the frequent occurrence of data sets in which grab and composite estimates are significantly different—in other words, clarification is required as to which sampling approach is more accurate. Often, composite data show higher TP concentrations than grab samples for the same sampling period (MSA, 2008). Such differences have been attributed to actual differences in source waters over time or to unexplained variability in the auto-samplers. While composite samples can vary from grab samples because they represent a longer time period, it would be expected that the sampling data converge over long periods of repeated sampling. To explain why composites trend higher than grabs, it may be assumed that TP concentrations are greater during the period between grab samples. Short-term changes in concentration might explain differences in selected sampling intervals with small data sets, but given the long duration of sampling and the amount of data showing consistent differences, such short-term changes are not a likely explanation. It has been suggested that because the flow composites are specifically responding to flow events, this may be the factor that influences the composites to be higher. Again, this presumes that grabs have not been capturing flow events, and this is not likely given the robustness of existing data sets.

However, additional study on this subject offers another possibility. A comparison of grab samples with samples collected as time-composited samples—composited daily rather than weekly—suggested that grab samples are comparable to several daily composited samples but not to a smaller subset of composites, which deviate from the others. Some these composite samples were also associated with strong flow events. This information, along with equipment maintenance records, suggests that equipment used in collecting composite samples may intermittently be collecting floating and submerged debris. Such accumulations might be short-term and temporary but not observed by staff during composite sample collection. In contrast, staff that collects grab samples and follows standard operating procedures typically avoids debris accumulations, which are not considered representative of the water body as a whole. Consequently, the observed differences between grab and composite samples may be well explained by such brief, localized events that affect the composite results.

With this possibility in mind, the District has recently deployed remote analyzers that can both sample and analyze TP in the field at specified time intervals (Struve et al., 2005). These experimental data are relatively similar to the associated grab samples, thereby validating both these methods but raising further question about flow composite sampling. Remote analyzer data reveal several short-term events in which trends in TP levels were briefly interrupted by spikes of elevated concentrations. It is presumed that these spikes were ephemeral events where debris impacted the sample collection equipment and briefly influenced the measured concentrations. In one case, the event measured by the remote analyzer can be tied to a sample collected by the flow composite equipment. While TP levels from grabs and the remote analyzer were relatively low, the value from the flow composite was significantly higher as it was comprised only of sample waters collected during the short-lived spike. As such, composite samples may be greatly impacted by debris as well as perhaps by organisms that can accumulate on sampling equipment.

Given the implementation of the WQBEL and sensitivity of compliance calculations to relatively small changes in concentrations, focused research that uses various methods to examine the impacts of sampling method, trigger method, frequency, and data analysis and calculations would aid in better understanding this issue. Efforts should include samples collected using grabs, flow composites, time composites, and the remote analyzer, along with newly available breakpoint flow data, as well as in situ conductivity and turbidity to detect ephemeral events. It would also be helpful to collect samples to evaluate surface biological growth on the deployed equipment over time. To minimize logistical issues of implementing this research, a pilot program could be carried out at G-310—one of the discharge structures for STA-1W—to leverage existing research and compliance monitoring at the site. Based on these results, other key structures throughout the STAs might need to be evaluated and applicability to other District projects should also be considered. For STA water quality monitoring, a study plan has been developed and included in the Five-Year Work Plan (**Attachment C**).

4. INTEGRAL ROLE OF MODELING

The use of numerical modeling tools will be an integral part of effectively implementing the Science Plan. Models will be applied to evaluate and analyze existing data for information or knowledge, test hypotheses as an inexpensive way to scale the scope of experiments, isolate processes and explore scenarios that cannot be cost-effectively tested in field experiments, support development of study designs including determining monitoring /measurement needs, and facilitate rapid assessment of alternatives and optimize treatment performance.

To date, established models have played a key role in the Restoration Strategies Program. Hydraulic and hydrologic models have been applied to quantify flows and system responses to varying climate, operations, and management options. Water quality models have been used to predict STA performance (TP reduction) resulting from the various hydrologic regimes and management options. For the purpose of the Science Plan, the existing suite of tools as well as other tools necessary to achieve specific defined modeling objectives will be employed as described in each individual study design (see **Appendix C**).

4.1 STRATEGY FOR SCIENCE PLAN IMPLEMENTATION

As with much of the Science Plan, the strategy for application of models is expected to evolve over time as needs change. Currently, the proposed strategy initially deemphasizes modeling and instead focuses on question definition and study identification. The appropriate tools or modeling strategy to address each question or study is then introduced as part of the study design. The exception is the development of a model or decision support tool for operation of the FEB/STA treatment train within the larger regional system and existing or proposed water management infrastructure. This FEB/STA operations study has a modeling basis and is designed, and will be developed with modeling needs and requirements at its core.

For each proposed study, the selection of modeling or analyses tools, design of monitoring to acquire data and information for building and implementing (including parameterization, calibration, and validation/verification) models, and determination of evaluation and performance measures will follow problem identification. It is expected that each study plan will include a modeling and analyses section, or integrate the modeling and analysis in the description of the study design. Each study in the Science Plan will continue to be assessed for its analysis needs, related collected data, and opportunities to leverage the study configuration and data collection for modeling all or parts of the chemical/physical processes in the FEB/STA complex.

The outcome of this approach is the possible development of a suite of tools that address specific issues instead of a single, integrated tool that attempts to address all questions. The proposed strategy will leverage available tools as well as develop, implement, and apply new tools as necessary and appropriate based on the specific objective of the individual study. Opportunities to consolidate tools and knowledge gained from each implementation in a system-wide analyses and prediction tool will also be explored as part of the FEB/STA operations study.

It is anticipated that this modeling strategy will be revisited during each plan cycle and may evolve with time and as new information is generated. It is expected that the tools applied in the Science Plan will range from simple analytical models to very complex, physically based numerical models covering multiple disciplines including hydraulics and hydrology, water quality, and ecology. Overall, the objective is to properly match the choice of tool and complexity to the analysis necessary to address the issue or question identified.

4.2 STANDARDS AND BEST PRACTICES

In all cases, the SFWMD requires that the modeling work implemented by staff, consultants, or others as part of the Science Plan follow industry best practices appropriate for the scale and complexity of the model. It is anticipated that where, and as appropriate, modeling implemented under the Science Plan will formally incorporate stages of the modeling life cycle including, but not limited to, conceptualization and design, scoping and tool selection, implementation, documentation, peer review, and archiving. The Methodology for Model Implementation and Application (SFWMD, 2010) describes the District's recommended modeling best practices and provides guidelines for consideration. ASTM International, formerly known as the American Society for Testing and Materials (ASTM), also publishes modeling standards and best practices.

5. ADAPTIVE MANAGEMENT TO REDUCE UNCERTAINTY

The District's Science Plan Team has endorsed an adaptive management approach to allow the Restoration Strategies and associated efforts to move forward even with uncertainty by ensuring that actions are evaluated against goals and objectives and altered to optimize outcomes as necessary.

5.1 CONSTRAINT OF UNCERTAINTY

Despite the extensive scientific endeavors mentioned previously, the understanding of the effects of water management actions on STA performance is incomplete. In some cases, there is sufficient scientific information to move forward with recommendations that will help meet the goals and objectives of Restoration Strategies (e.g., need to keep the STAs hydrated to avoid dryout and subsequent P flux upon their rewetting.). In other cases, the information is known but is not well linked or appropriately analyzed to inform policy makers and water managers. Other issues have simply not been well studied. Some decisions can proceed despite relatively high scientific uncertainty, while others may require additional scientific understanding before decisions can be made. Where success is constrained by uncertainty, a robust, strategic science program for the STAs will help reduce uncertainty and enhance the ability to succeed.

5.2 DEFINING ADAPTIVE MANAGEMENT

Adaptive management is a cycle of exploration, action, evaluation, and adjustment that links science and policy. It allows for robust iterative decision-making in the face of uncertainty that involves taking action, evaluating results, and adjusting actions on the basis of what has been learned with the objective to reduce uncertainty over time. Adaptive management is a tool which can be used not only to change a system but also to learn about the system (Holling, 1978). Because adaptive management is based on a learning process, it improves long-term management outcomes. The challenge in using the adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short term outcome based on current knowledge (Allan and Stankey, 2009).

The purpose of adaptive management is to raise key questions for management regarding the optimum approach for achieving water quality goals, design ways to reduce uncertainty and address major issues, and incorporate new data and other relevant information into decision making to improve project design and execution. Elements or key features of adaptive management include the following: (1) explore alternative actions to achieve objectives and embrace risk and uncertainty to build understanding, (2) implement one or more of these actions, recognized as somewhat experimental and designed with evaluation in mind, (3) characterize system uncertainty through multi-model inference and predict outcomes explicitly (e.g., with process-based models), (4) measure and evaluate outcomes objectively with monitoring (feedback to decision making), and (5) adjust the actions after comparing measured outcomes to predicted outcomes.

Adaptive management can proceed as either passive adaptive management or active adaptive management, depending on how learning proceeds. Passive adaptive management values learning only insofar as it improves decision outcomes (i.e., passively), as measured by the specified parameter of interest. In contrast, active adaptive management explicitly incorporates learning as part of the objective function, and hence, decisions which improve learning are valued over those which do not (Holling, 1978; Walters, 2002). In both cases, as new knowledge is gained, the models are updated and optimal management strategies are derived accordingly.

5.3 APPLYING ADAPTIVE MANAGEMENT TO SCIENCE PLAN

Adaptive management will be a key aspect of performance management and is intended to be used by the District's Science Plan Team during science/research project planning, design, and implementation to identify uncertainties early in the planning process to facilitate progress and communicate to management to obtain buy-in on the approach to addressing those uncertainties and documenting management decisions. The Science Plan requires an adaptive management process to address uncertainties by incorporating robustness and flexibility into program/project planning and implementation, and by testing hypotheses, linking science to decision making and adjusting implementation, as necessary, to improve the probability of achieving the objectives of the Science Plan.

Adaptive management will provide a credible means by which scientists can inform policy makers and policy makers can demonstrate accountability to the public for results. The adaptive management process ensures that actions are evaluated against the objectives of the program and altered to optimize outcomes. As described in Williams et al. (2007), the scientific basis for adaptive management is "…a comparison of hypothesis-based predictions against evidence." The application of adaptive management in the Restoration Strategies Science Plan is one of active adaptive management through the testing of specific hypotheses regarding improvements to water quality. Information gained from the various research projects will be incorporated in the design, construction and operations of the water quality features specified by permit. Implementation of adaptive management in the Science Plan will involve the integration of project/program design, management, and monitoring to systematically test assumptions in order to adapt and learn.

5.4 ASSESSING PERFORMANCE

Implementation of adaptive management is an iterative process (**Figure 6**). As the proposed study plans are refined and executed, it is anticipated that review of results along with regular evaluation of progress and data will be conducted with input from the Technical Representatives. Workshops will be held with the Technical Representatives and federal agency experts and consultants to improve the study plans, refine experimental design, and specify data analysis procedures. These workshops will allow for more rapid dissemination of information and prompt assessment of the potential need for specific steps to take if mid-course corrections are necessary. Such a continuing feedback loop will ensure that the most relevant and promising studies move forward in the process. In a parallel effort, technical staff will also coordinate closely with the Restoration Strategies Steering Group and construction and engineering teams to ensure that relevant information from the study plans are considered and incorporated into the design-build-operate activities associated with the Restoration Strategies capital projects as appropriate.

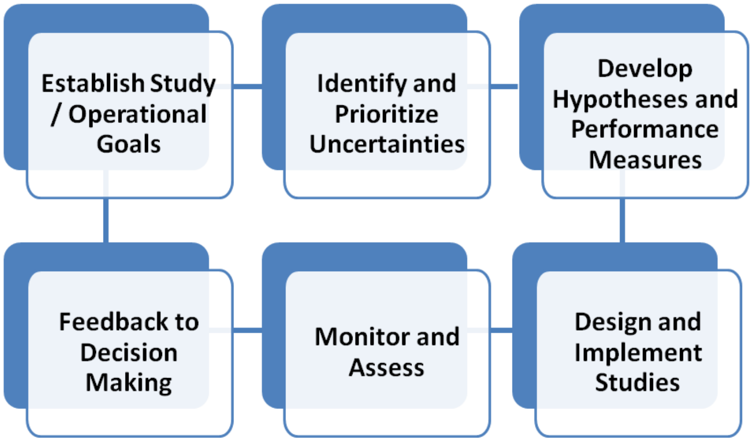

Figure 6. Key elements of the step-wise adaptive management process.

6. PEER REVIEW

6.1 REVIEW PROCESSES FOR SCIENCE PLAN AND PROJECTS

The use of the peer review will be an integral part of the Restoration Strategies Science Plan and its resulting projects and products. All forms of review, however, must be applied efficiently in order to be effective. The advantages of peer (independent) and advisory (invested) review are well established for quality assurance and design improvement in applied science. On the other hand, review can be a time-consuming and arduous process that must be well-focused and designed specifically for useful input. Technical review has been used extensively by the District, FDEP, and other agencies in the region over the past two decades. It allows a diverse group of experts and stakeholders to discuss scientific ideas, assist with project formulation, improve data analysis, and facilitate publication of relevant and timely information.

6.2 LEVELS OF REVIEW DURING SCIENCE PLAN DEVELOPMENT

Meaningful input, both internal and external, is being sought throughout the process of developing and implementing the Restoration Strategies Science Plan. Prior to public presentation, the Science Plan will be vetted internally through technical teams participating in the process. Interested parties and technical experts from external organizations will have multiple opportunities to provide comments on the Science Plan, as summarized below:

- **Science Plan Team.** All plan documents will be presented to the Science Plan Team for review prior to incorporation into the Science Plan and public presentation. The Science Plan Team is a multidisciplinary group with many years of experience and considerable expertise. The internal RS Steering Group will also provide input in the plan development process.
- **Technical Representatives Meetings.** Representatives and selected technical experts will be given an opportunity to review and provide input to the Plan. In particular cases, as needed, input will also be provided by the Principals.
- **Long-Term Plan Quarterly Communication Meetings.** The Long-Term Plan meetings provide an important venue for technical review and public discussion on the Science Plan and its products. There will continue to be a standing Science Plan Update agenda item at each meeting. These meetings and the associated Long-Term Plan process have a proven track record of soliciting input and incorporating information into that plan on an ongoing basis. This component of the adaptive management process will be continued under Restoration Strategies.
- **Water Resources Advisory Commission/District Governing Board Meetings.** Both of these regular meetings will provide additional opportunities for public comments on the Science Plan and its projects.
- **South Florida Environmental Report (SFER).** As projects and products are forthcoming from the Science Plan, the annual SFER will provide a vehicle for expert review and publication as needed.
- **Peer Review by Independent Experts.** When needed for vital projects and products, external reviewers will provide constructive criticism and expert advice. This formal review process will be used as needed to resolve critical questions and get highly specialized guidance on pivotal issues.

7. QUALITY ASSURANCE

The District's missions provide the impetus for creating a quality system that works under the philosophy of total quality management and continuous process improvement. This means that quality assurance and quality control are incorporated into every aspect of data collection, data processing, data management, and reporting. It also underscores that these processes are repeatedly reviewed and adapted for changing conditions in support of legal mandates and mission-driven efforts of the agency.

The District's quality system is outlined in the Quality Management Plan (SFWMD, 2012c), and supported by the Field Sampling Quality Manual (SFWMD, 2011a), Chemistry Laboratory Quality Manual (SFWMD, 2012d), and SFWMD Enterprise Scientific Data Management Policies and Procedures (SFWMD, 2007b; 2009). Collectively, the policies, objectives, principles, organizational authority, responsibilities, accountability, implementation plan and process-specific standard operating procedures (SOPs) are defined for ensuring quality in environmental monitoring and ecological studies. This provides a structured and documented management system for planning, implementing, assessing and sustaining the quality work performed by or for the SFWMD throughout all projects including those related to the Science Plan.

7.1 QUALITY MANAGEMENT PLAN AND QUALITY MANUALS

All data collection activities for the environmental monitoring programs and scientific research studies outlined in the Science Plan must be scientifically valid and defensible, with data quality objectives clearly defined and data quality assessment performed annually for each project. This quality policy statement is implemented by ensuring that adequate quality assurance procedures are employed from study design to data reporting, and data management. All monitoring data must be of acceptable completeness, representativeness, and comparability, and of known and documented quality. The reported data must include required reporting attributes, and, where applicable, documented quality control (precision and accuracy) data and appropriate data qualifiers in accordance with the FDEP Quality Assurance Rule (Chapter 62-160, F.A.C.; FDEP, 2008). All research data also will be of the highest quality possible and in accordance with methods and techniques described in the scientific literature to allow results to be published in peer-reviewed publications.

The Field Sampling Quality Manual defines the minimum field sample collection and measurement protocols needed to meet the requirements of Chapter 62-160, F.A.C. These protocols apply to the collection of surface water, groundwater, atmospheric deposition, soil, sediment, and biological samples collected by the District when conducting environmental monitoring and scientific research projects, including the STA Science Plan project. The Chemistry Laboratory Quality Manual defines the quality assurance program for the District‘s analytical chemistry laboratory that will be used for the Science Plan. It is prepared to comply with Section 5 of the National Environmental Laboratory Accreditation Conference requirements (NELAC, 2003) and to define quality assurance requirements, and minimum standards of compliance for laboratory quality control procedures that applies to the analyses of surface water, groundwater, estuarine water, rain water, and biological tissue samples. Overall project organization and responsibilities for quality assurance are detailed in the District's Quality Management Plan.

7.2 QUALITY ASSURANCE OVERSIGHT

The District's Cross-Functional Quality Assurance Team has been established to achieve organizational quality assurance objectives. This team consists of standing representatives from each facet of the data flow process, including quality systems, scientific data management, ecological research, water quality monitoring, laboratory analysis, data validation and stewardship, and compliance assessment and reporting. The team focuses on quality assurance issues that arise from data collection, validation, assessment, reporting, and other data use processes. It regularly meet to assess research and monitoring data in DBHYDRO and other District databases, review root causes, discuss improvement alternatives, report findings and recommend corrective actions to management, and help implement and monitor changes in District monitoring procedures.

7.3 ESTABLISHED STANDARD OPERATING PROCEDURES

Ten quality system Standard Operating Procedures (SOPs) (e.g., SFWMD, 2012 f, g, i) have been developed by the District’s Cross-Functional Quality Assurance Team to provide the necessary information for routine procedures that affect the quality and consistency of products or services provided by the District and contractors that provide the information necessary to perform a job properly, facilitate consistency in the integrity, reproducibility and quality of data, and conduct employee training. A suite of 16 SOPs have also been developed to guide the management of ecological data sets (e.g., SFWMD, 2012h). Detailed procedures that are not routine or that are unique to a project are required for each of the project level monitoring or research plans.

7.4 QUALITY SYSTEM AND PERFORMANCE ASSESSMENT REPORTS

The District’s Cross-Functional Quality Assurance Team produces an annual quality assessment report that provides management with an overview of activities conducted during the water year and an assessment of the quality of data and services (SFWMD, 2011b; 2012e). Data sets from the District’s databases are downloaded and queried to examine the number and type of samples analyzed, percentage of qualified data, and the nature of the qualifications. Field and laboratory audit reports, findings, and corrective actions are noted, as are the results of field quality control samples. Metrics are used whenever possible to evaluate performance, such as project completeness percentages, results of laboratory performance testing for continuing certification, participation in the Cross-Functional Quality Assurance Team meetings and associated QA/QC training and workshops, and the results of customer surveys. A key part of this annual report is summaries of accomplishments and improvements made by each section and recommendations for future actions.

8. DATA MANAGEMENT

The District's Data Management and Governance Council guides the governance and stewardship of District data to ensure its proper documentation, organization, preservation, archiving, accessibility, and discovery. Specifically, the District Scientific Data Management Policy (SFWMD, 2007b) applies to all data under this Science Plan. The policy elements are supported by a suite of enterprise-wide procedures and data subject area Standard Operating Procedures (SOPs). Data management SOPs define roles and responsibilities for project staff and guide the complete data lifecycle from the establishment of any study or project through its data distribution. The SFWMD network of data stewards is engaged early in the lifecycle to establish study-level metadata and the system of record for any proposed data set. Early data steward engagement helps ensure data conventions and delivered data formats facilitate data acquisition and better enable the synthesis and assessment that occur later in the lifecycle.

Standardized metadata is key to enabling these objectives and provides support for data structure heterogeneity that is characteristic of the ecological sciences. Water quality monitoring metadata follows requirements defined by the FDEP. Hydrologic monitoring metadata is based on practices of the U.S. Geological Survey. Ecological monitoring and research metadata follows the Ecological Metadata Language standard based on prior work done by the Ecological Society of America and others, including the Knowledge Network for Biocomplexity.

The District maintains a scientific data management system consisting of three databases: DBHYDRO, Metacat, and ERDP. DBHYDRO is primarily for water quality and hydrologic monitoring data (publicly accessed at http://www.sfwmd.gov/dbhydro), whereas Metacat and ERDP are primarily for metadata and ecological monitoring and research data. Ecological Monitoring and Research data are available upon request to the District's Applied Science Bureau. As applied to this Science Plan, data are managed as follows:

Data Subject Area	**Process and Database**
Water Quality Monitoring	Coordinate with data stewards in the District's Water Quality Bureau to validate data and archive data in DBHYDRO
Hydrologic Monitoring	Coordinate with data stewards in Infrastructure Management Bureau to validate data and to archive data in DBHYDRO
Ecological Research	Coordinate with data stewards in the District's Applied Sciences Bureau to validate data and archive data in and retrieve data from Metacat and ERDP

To the extent practical, the data management system will play a role in the integration and synthesis of information to assist in communicating scientific findings and understanding of the Science Plan results to management and stakeholders.

9. ACKNOWLEDGMENTS

The South Florida Water Management District gratefully acknowledges the many professionals who have contributed to the *Science Plan for the Everglades Stormwater Treatment Areas*. This document was developed collaboratively by a team of 47 scientists, modelers, and engineers from across the District with participation and valuable input from the six Restoration Strategies Technical Representatives from the South Florida Water Management District, U.S. Environmental Protection Agency, Florida Department of Environmental Protection, U.S. Army Corps of Engineers, and U.S. Department of Interior and their technical consultants. The professionalism and dedication of this team of high caliber technical experts that prepared this complex and important document is sincerely recognized and appreciated.

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10. GLOSSARY AND ACRONYMS

Accretion: Increase in size as a result of accumulation. Soil accretion results in accumulation of particles and plant material.

Acre-foot (ac-ft): Volume of liquid required to cover 1 acre to a depth of 1 foot, commonly used to express large amounts of water (1 acre-foot = 43,560 cubic feet).

Adaptive management: The application of scientific information and explicit feedback mechanisms to refine and improve future management decisions.

Advanced Treatment Technologies (ATT) Research Program: A comprehensive research program conducted from 1997–2002, which focused on testing and demonstrating potential technologies that could be used in conjunction with cattail-dominated STAs to meet water quality standards in discharges to the Everglades Protection Area. The technologies investigated included Submerged Aquatic Vegetation Treatment System, Periphyton-based Stormwater Treatment Area, Chemical Treatment–Direct Filtration, Chemical Treatment–High Rate Sedimentation, Chemical Treatment–Dissolved Air Flotation/Filtration, Chemical Treatment–Microfiltration/Ultrafiltration, Low Intensity Chemical Dosing, and Managed Wetlands.

Advection: A transport mechanism of a substance or conserved property by a fluid due to the fluid's bulk motion.

Aerial imagery: High-resolution photographs taken by plane. In the STAs, aerial imagery is used to map and estimate emergent vegetation coverage.

Alkalinity: Capability of water to neutralize an acid.

Analyte: Substance of interest measured in an analytical procedure.

Baseline period: Specified period of time during which collected data are used for comparisons with subsequent data.

Basin-Specific Feasibility Studies: As an important step toward development of the Long-Term Compliance Permit application required under the Everglades Forever Act, the SFWMD completed Basin-Specific Feasibility Studies for thirteen Everglades Protection Area (EPA) tributary basins (Burns & McDonnell, 2002).

Benthic: Relating to the ecologic region at the bottom of a water body (e.g., ocean or lake), which includes the sediment surface and some sub-surface layers.

Best Management Practices (BMPs): Land, agricultural, industrial, and waste management techniques that reduce pollutant export from a specified area.

Biogeochemistry: Study of the chemical, physical, geological, and biological processes and reactions that govern the composition of the natural environment (including the biosphere, hydrosphere, pedosphere, atmosphere, and lithosphere), and the cycles of matter and energy that transport the Earth’s chemical components in time and space.

Biomass: Amount of living material in a sample, population, or area, usually measured as dry mass.

Bioturbation: Disturbances caused by living organisms.

Bulk density: Mass of soil per unit volume.

Chemical treatment/solid separation (CTSS): A technology evaluated under the ATT Research Program, which assessed the effectiveness of various chemical amendments (i.e., aluminum or iron salts with polymers, including ferric chloride, polyferric sulfate, polyaluminum chloride, aluminum sulfate, anionic, cationic and nonionic polymers) followed by various solids separation methods (direct filtration, high-rate sedimentation, dissolved-air flotation, microfiltration) to remove phosphorus from the surface water. An evaluation of the residual solids was also a component of this effort.

Compliance monitoring: Sampling and analytical activities to monitor parameters specified in a permit or other official mandate.

Constructed wetlands: Man-made wetlands created by surrounding areas with earthen levees or berms to contain areas inundated by water. Water movement through the wetlands is usually controlled by water control structures, such as pump stations or culverts.

DBKEY: A unique identifier for a data set (or time series) assigned by the District's DBHYDRO database. Each unique combination of station, data type, frequency, statistic type, recorder, operation number, and agency results in a unique DBKEY.

Decomposition: Action of microorganisms breaking down organic compounds into simpler ones, resulting in the release of energy.

Diagenetic processes: Physical and chemical changes occurring during the conversion of sediment to sedimentary rock.

Diel: Variation that occurs regularly every day.

Diffusion: Transport of mass of material in response to a chemical concentration gradient.

Discharge (or flow): Rate of water movement past a reference point, measured as volume per unit time (usually expressed as acre-feet, cubic feet, or cubic meters per second).

Dissolved organic phosphorus (DOP): A form of phosphorus associated with organic matter in a water sample that has been passed through a 0.45 µm membrane filter; usually calculated as DOP = total dissolved phosphorus – soluble reactive phosphorus.

Diurnal: Recurring every day or having a daily cycle (e.g., diurnal animals are active during the day rather than at night; diurnal flowers open during the day and close at night).

Diversion structures: Water control structures that can direct inflow water away from the STAs.

Drawdown: Lowering of the water level in a reservoir or other body of water.

Drought: Extended period of low rainfall, below-normal streamflow, and depleted surface and subsurface storage.

Dryout: Condition in which the water level within the STA cells falls below the average ground elevation.

Ecosystem: Biological communities together with their environment, functioning as a unit.

Effective Treatment Area: Area within an STA that is inundated under normal operational conditions that functions to remove phosphorus from the receiving water. The effective treatment area usually does not include levees or water control structures.

Emergent aquatic vegetation (EAV): Wetland plants that extend above the water surface (e.g., cattail, bulrush, sawgrass).

Enzyme activity: Catalysis or breakdown of organic molecules by organisms. Enzyme activity is measured and reported in terms of the amount of substrate converted to product per unit time under specific reaction conditions.

Epiphytic periphyton (epiphyton): Type of periphyton that grows on submerged portion of plants.

Equilibrium phosphorus concentration (EPC_o): The critical concentration of phosphorus when net phosphorus adsorption equals zero, i.e., adsorption equals desorption and the system is at equilibrium. At this point, the soil exhibits maximum capacity for buffering phosphorus in soil pore water (Reddy and DeLaune, 2008).

Eutrophication: Enrichment of aquatic environments with nutrients like phosphorus and nitrogen, typically from mineral and organic runoff originating in the surrounding watershed. This enrichment results in increased growth of plants and algae that may reduce dissolved oxygen content in the water and can result in die-off of other organisms.

Everglades Construction Project (ECP): The ECP is a requirement of the 1994 Everglades Forever Act and the foundation of a large ecosystem restoration program, composed of various interrelated construction projects between Lake Okeechobee and the Everglades, including the construction of the Everglades Stormwater Treatment Areas (STAs).

Everglades Forever Act (EFA): A 1994 Florida law (Section 373.4592, Florida Statutes), amended in 2003, to promote Everglades restoration and protection. This will be achieved through comprehensive and innovative solutions to issues of water quality, water quantity, hydroperiod, and invasion of nonindigenous species to the Everglades ecosystem. The EFA establishes the plan, the enforceable schedule, and the funding for the various components of the Everglades Program.

Everglades Forever Act (EFA) permit: Stormwater Treatment Area permit issued in accordance with the Everglades Forever Act, Section 373.4592, Florida Statutes, authorizing construction, operation, and maintenance activities for the STAs.

Everglades Protection Area (EPA): As defined in the Everglades Forever Act, the EPA comprises Water Conservation Areas 1, 2A, 2B, 3A, and 3B, the Arthur R. Marshall Loxahatchee National Wildlife Refuge, and Everglades National Park.

Everglades Stormwater Treatment Areas (STAs): Large freshwater treatment wetlands situated south of Lake Okeechobee, constructed to reduce total phosphorus concentration from runoff water prior to entering the Everglades Protection Area. Currently, the Everglades STAs (STA-1 West, STA-1East, STA-2, STA-3/4, and STA-5/6) cover approximately 68,000 acres, including 57,000 acres of effective treatment area.

Fauna: All animal life associated with a given habitat.

Fiscal Year (FY): Period from October 1 through September 30, during which the agency’s annual budget is developed and implemented.

Floating aquatic vegetation (FAV): Wetland plants that have portions floating near or at the water surface (e.g., water lettuce, water hyacinth, water lily).

Floc: A flocculent mass formed in wetlands through settling, precipitation, or aggregation of suspended particles and decomposing plant and detrital materials; this may be comprised of inorganic and organic material.

Flocculent: A woolly or fluffy mass of solids.

Flora: All plant life associated with a given habitat.

Flow Equalization Basin (FEB): Impoundment areas that serve to store or distribute water to the STAs in order to modulate treatment area inflows for vegetation health, optimal water depths, and phosphorus removal efficiency.

Flow path: Planning-level delineation of source basins that are tributary to the existing STAs developed during preparation of the Restoration Strategies Regional Water Quality Plan. The Eastern Flow Path contains STA-1E and STA-1W, the Central Flow Path contains STA-2 (including Compartment B) and STA-3/4, and the Western Flow Path contains STA-5/6 (including Compartment C).

Flow-way: Area within the STA that consists of one or more treatment cells.

Flow-weighted mean (FWM) concentration: Average concentration of a substance in water, corrected for volume of water flow at the time of sampling. Samples taken when flow is high are given greater weight in the average. FWM concentrations are used to calculate mass loading at a particular location.

Geometric mean: A typical measure of the tendency of a data set that is right skewing and is calculated by determining the n^{th} root of the product of values.

Hydraulic loading rate (HLR): Amount of water received by the STA divided by the amount of effective treatment area. HLR is typically expressed as centimeters/day.

Hydraulic residence (or retention) time (HRT): Length of time that water resides in a specified area, usually measured as days. HRT is estimated by dividing the average depth by hydraulic loading rate (inflow volume divided by effective treatment area acreage).

Hydraulics: Study of water or other fluids at rest or in motion.

Hydrology: Scientific study of the properties, distribution, and effects of water on the Earth’s surface, in the soil and underlying rocks, and in the atmosphere.

Hydropattern: Water depth, duration, timing, and distribution of fresh water in a specified area. A consistent hydropattern is critical for maintaining various ecological communities in wetlands and other ecosystems.

Hydroperiod: Duration and frequency of inundation in a wetland area.

Inflow: Act or process of flowing in or into an area. In the Stormwater Treatment Areas, inflow is water flow at the beginning or top of a cell, flow-way, or STA. Inflow may also refer to the structure where treated water exits a cell, flow-way, or STA.

Inoculation: The act of introducing a biological organism into a suitable situation for growth. In the STAs, inoculation is used as a management tool to accelerate SAV recruitment in areas converted from EAV to SAV or in SAV cells undergoing rehabilitation.

Inorganic: Composed of minerals rather than material from living organisms.

Inositol: A cyclic alcohol that is a component of cell membranes and a precursor of various messenger molecules.

Labile: Readily or continually undergoing chemical, physical, or biological change or breakdown.

Labile diesters: Diesters that readily or frequently undergo chemical or physical change. Hydrolysis of labile diesters results in release of inorganic phosphorus.

Labile phosphorus: The form of phosphorus that readily converts to inorganic phosphorus and is a combination of mineral and organic P.

Litter: Plant material that is suspended in the water column or deposited on the soil surface.

Loading (or mass loading): Amount of material carried by water into a specified area, expressed as mass per unit of time. Total phosphorus loading is typically reported in metric tons per year.

Long-Term Plan: The 2003 Long-Term Plan for Achieving Water Quality Goals in the Everglades Protection Area Tributary Basins and subsequent revisions contains a suite of projects, ranging from STA structural enhancements, STA expansions, STA optimization research, STA compliance and operational monitoring (hydraulic and water quality), STA downstream monitoring and research, STA water quality and hydrodynamic modeling, and Best Management Practices/source controls programs.

Low intensity chemical dosing: A technology investigated as part of the ATT Research Program, which assessed the effectiveness of adding small doses of aluminum or iron salts directly into the water column, without the use of rapid mixing, flocculation, or settling basins to remove phosphorus from surface waters.

Macrophytes: Visible (non-microscopic) plants found in aquatic environments.

Managed wetlands: A technology investigated as part of the ATT Research Program, which assessed the effectiveness of coupling chemical treatment with wetlands. The inflow stormwater was mixed with doses of aluminum or iron salts and polymers, followed by high-rate sedimentation or settling ponds, followed by wetlands to remove phosphorus from surface waters.

Marl: A naturally occurring fine crumbly mixture of clay and limestone, often containing shell fragments and sometimes other minerals.

Marsh: Area of soft, wet, low-lying land, characterized by grassy vegetation and often forming a transition zone between water and land.

Median: Middle value in a set of ordered data. The median is often used to express the central tendency value of environmental data when data is not normally distributed or when outliers or non-detected values are present.

Mesocosm: Experimental units or enclosures larger than microcosms but smaller than macrocosms that are used to provide a limited amount of the natural environment under controlled conditions.

Mineralization: To transform organic matter into a mineral matter.

Muck: Dark, organic soil derived from well-decomposed plant biomass.

National Pollutant Discharge Elimination System (NPDES) permit: A wastewater facility permit required under the Clean Water Act that authorizes discharge to waters of the United States. The permit specifies limits on what can be discharged, monitoring and reporting requirements, and other provisions to ensure that the discharge does not impact water quality or human health. For the STAs, an NPDES permit was issued under the provision of Chapter 403, Florida Statutes, and applicable rules of the Florida Administrative Code.

Nutrients: Organic or inorganic compounds essential for survival of an organism. In aquatic environments, nitrogen and phosphorus are key nutrients that affect the growth rate of plants.

Oligotrophic: Aquatic environment depleted of nutrients, resulting in low plant productivity.

Operations plan: Document that guides operation of the STAs under various scenarios such as normal operation, pre-storm, extreme flow, and drought operations and includes descriptions about the facility and water control structures.

Optimization: Action or goal to make something such as a method, process, or mechanism as effective or efficient as possible.

Organic: Relating to, derived from, or characteristic of living things.

Outflow: Act or process of flowing out of an area. In the Stormwater Treatment Areas, outflow is water flow at the end of a cell, flow-way, or STA. Outflow may also refer to the structure where treated water exists a cell, flow-way, or STA.

Parameter: Variable or constant representing a characteristic of interest. For example, conductance is a water quality parameter. Use of this term is highly subjective and varies greatly across disciplines.

Particle impaction: Occurs when particles in the water column have enough inertial force that they hit the plant or soil surface rather than being swept around by the current.

Particle interception: Occurs when the particles in the water column are stuck by the boundary level as they pass by in the current.

Particulate phosphorus (PP): Particulate-bound phosphorus, not passing through a 0.45 µm filter, that can include both organic and inorganic forms; usually a calculated value: PP = total phosphorus – total soluble phosphorus.

Peat: Soils that contain partially decayed plant material. Peat is formed under anaerobic conditions found in inundated wetlands, is rich in humus and known as a histosol.

Periphyton: The biological community of microscopic plants and animals attached to surfaces in aquatic environments, including bacteria, fungi, and algae—the primary component in these assemblages.

Periphyton Stormwater Treatment Area (PSTA): Wetland areas dominated by periphyton assemblages. Sediment may be scrapped away to reduce the amount of phosphorus released into the water column from the soil or porewater. Emergent or submerged aquatic vegetation may also be present.

pH: Dimensionless quantity measured on a scale that is a negative logarithmic representation of the activity of hydrogen ions in the solution.

Phosphatase activity: Hydrolysis of organic phosphorus compounds by extracellular enzymes. Phosphatase enzymes can include monoesterases (acid and alkaline phosphatases) and phosphodiesterases (responsible for hydrolysis of phosphodiesters such as nucleic acids and phospholipids.

Phosphate diesters: Orthophosphate esters that include nucleic acids, phospholipids, and aromatic compounds.

Phosphate monoesters: Orthophosphate esters that include sugar phosphates (e.g., glucose-6-phosphates and phosphophenols, which are intermediates of metabolic pathways), phosphoproteins, mononucleotides, and inositol hexaphosphates.

Phosphorus (P): Element that is essential for life. In freshwater aquatic environments, phosphorus is often in short supply; increased levels can promote the growth of algae and other plants. The Everglades STAs were constructed to remove excess phosphorus from surface waters before they enter into the Everglades Protection Areas.

Phosphorus co-precipitation: The formation of amorphous precipitates as phosphorus reacts with metallic cations such as Ca, Mg, Fe, and Al.

Phosphorus cycling: The repeated pathway of phosphorus transformations and exchanges, mediated by biological, chemical, and physical processes, from the environment through one or more organisms and back to the environment.

Phosphorus flux: The rate of transfer of solutes between soil and overlying water column and from one physical or chemical state to another. The dimensions of flux are M L-2 T-1, where M is mass of material transferred by flux, L is the distance or length, and T is the time. The processes associated with flux are advection (movement of phosphorus with water flow), diffusion (movement between the soil and water column), and dispersion. Diffusive and advective flux between soil and overlying water and elemental uptake by rooted wetland vegetation are the major transport mechanism in which nutrients, metals, and toxic organic compounds are removed from soil and water column. Flux can be between the solid phase and porewater of soils.

Phosphorus loading rate (PLR): Amount of total phosphorus received by the STA divided by the amount of effective treatment area. PLR is usually expressed as grams phosphorus/year.

Photodegradation: The breakdown of compounds by light.

Porewater: Water contained within the spaces between particles within sediments.

Precision: Degree of reproducibility of a measurement. Low precision yields high scatter in data.

Process Development and Engineering (PDE): A central element in the overall strategy in the Long-Term Plan that was included in recognition that achieving the water quality goals involves an adaptive management approach, utilizing the best available information to develop and expeditiously implement incremental improvement measures in a cost effective manner. PDE activities included enhanced control and monitoring of the STAs, refinements to STA water quality modeling tools; investigations into the effectiveness of submerge aquatic vegetation and periphyton; improvement of the reliability of STA inflow forecasts; and long-term and short-term surveys and monitoring (routine and event-driven water quality and spatial soil sampling and analysis, topographic surveys, and vegetation surveys).

Quality assurance (QA): The system of management activities and quality control procedures implemented to produce and evaluate data according to pre-established data quality objectives.

Quality control (QC): The overall system of technical activities that measures the attributes and performance of a process, product, or service against defined standards to verify that they meet the established data quality objectives.

Redox potential: Measure of the oxidation-reduction potential (electron activity) of redox active components in the soil, as measured using platinum electrodes.

Refractory (or recalcitrant): Resistant to chemical, physical, or biological change or breakdown.

Seepage: Water moving into or out of the wetland through the ground, levees, or areas surrounding the water control structures.

Sediment equilibrator (Peeper): A soil porewater measuring device that is used to measure porewater pH and nutrient content along a vertical profile. The sediment equilibrator (also referred to as Peeper) is divided into small chambers that are filled with de-ionized water then covered with a membrane filter and protective cover. The device is inserted into the soil layer for a period of time, then removed from the soil and the water in the chambers are processed for laboratory analysis.

Slough: Depression associated with swamps and marshlands as part of a bayou, inlet, or backwater; it contains areas of slightly deeper water and a slow current, and can be thought of as the broad, shallow rivers of the Everglades.

Soil amendment: Addition or alteration used to improve the ability of soil to capture and bind pollutants (e.g., soil amendments for phosphorus treatment include lime, coagulants, and carbon sources).

Soil management: Process of managing soil to achieve desired phosphorus removal results. Management includes but is not limited to preventing dryout conditions, removing sediments high in nutrient concentrations, adding amendments, and tilling.

Soluble reactive phosphorus (SRP) [also referred to as dissolved inorganic P (DIP)]: The dissolved form of phosphorus analyzed in an undigested water sample using a 0.45 µm membrane filter; generally represents the most readily available form of phosphorus.

Sorption: Taking in or holding of something, either by absorption or adsorption.

Species diversity: Index that incorporated the number of species in an area as well as relative abundance, such as number of individuals or biomass.

Species richness: Number of species occurring in a particular area for a specified sampling period.

Specific conductance (or conductivity): Ability of an aqueous solution to carry an electric current at 25ºC); the higher the concentration of ionic (dissolved) constituents, the high the conductivity.

Stable isotope: Stable isotopes contain an unequal number of neutrons and protons and are not radioactive. Measuring stable isotopes in aquatic systems can aid in understanding source links and process information in the food webs. Commonly analyzed stable isotopes include oxygen, carbon to determine primary production sources responsible for the energy flow in an ecosystem, nitrogen which can indicate tropic levels, hydrogen, and sulfur which is useful in distinguishing benthic versus open water producers.

Stage: Height of a water surface above an established reference point (datum or elevation). This vertical control measurement is usually expressed as feet National Geodetic Vertical Datum of 1929 or feet North American Vertical Datum of 1988.

Structure: Man-made pump stations, reservoirs, channel improvements, canals, levees, and diversion channels. Region-wide water management is accomplished by the agency’s operation and maintenance of over 2,800 miles of canals and levees, over 1,300 water control structures, and 69 pump stations.

Submerged aquatic vegetation (SAV): Wetland plants that exist below the water surface (e.g., hydrilla, *Chara*, southern naiad).

Sustainability: In relation to the STAs, sustainability is the maintenance of phosphorus removal efficiency and vegetation communities.

Total carbon (TC): Estimated carbon concentration in both inorganic and organic forms in a soil sample.

Total nitrogen (TN): Estimated nitrogen concentration in both inorganic and organic forms in a water sample.

Total phosphorus (TP): Estimated phosphorus concentration in both organic and inorganic forms in a water sample. TP generally includes all forms of P (soluble, mineral, organic, particulate-bound).

Total soluble phosphorus (TSP): Total phosphorus in water sample using a 0.45 µm membrane filter, analyzed after sample digestion process; may include soluble reactive P and dissolved organic P.

Transect: Sampling sites established through an area along which ecological measurements are made.

Transpiration: To lose water vapor from a plant surface, especially through leaf stomata.

Translocation: The movement of soluble materials within plants (i.e., the movement of food materials from leaves to the roots or the movement of dissolved minerals upwards from the roots to the leaves).

Tussocks: A thick clump of growing vegetation.

Treatment cell: Area within the STA that functions to remove phosphorus from the receiving water; treatment cells are demarcated by levees.

Turbidity: The measure of light scattered by particles in solution and reported in nephelometric turbidity units, or NTUs.

Vegetation conversion: Process of changing the dominant vegetation within a treatment cell through herbicide application of undesired plants, water depth manipulation, or inoculations. In the Everglades STAs, large-scale vegetation conversions have occurred to convert areas dominated by emergent aquatic vegetation to submerged aquatic vegetation.

Vegetation resistance: Condition in which plant tissues inhibit water movement through the marsh. The amount of vegetation resistance is determined by plant species, height, and density.

Volatilization: To change into a vapor or cause a solid or liquid to be changed into a vapor.

Water Conservation Areas (WCAs): Diked areas of the remnant Everglades that are hydrologically controlled for flood control and water supply purposes. These are one of the primary targets of Everglades restoration and major components of the Everglades Protection Area.

Water quality: Physical, chemical, and biological condition of water as applied to a specific use, typically propagation of fish and wildlife, public water supply, industry, or recreation.

Water Year (WY): Period from May 1 through April 30, during which water quality and other data are collected and reported in agency reports.

Wetland: Area that is inundated or saturated by surface water or groundwater with vegetation adapted for life under those soil conditions (for example, swamps, bogs, and marshes).

Water Quality Based Effluent Limit (WQBEL): Per Chapter 62-650, Florida Administrative Code, the WQBEL is an effluent limitation (discharge limit), which may be more stringent than a technology-based effluent limitation, that has been determined necessary by the FDEP to ensure that water quality standards in a receiving body of water will not be violated. Under the proposed WQBEL for STA discharge into the EPA, total phosphorus concentrations in the discharge from each STA may not exceed either 13 µg/L as an annual flow-weighted mean in more than three out of five years or 19 µg/L as an annual flow-weighted mean.

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Appendix A: Consent Orders and Framework Agreement

Consent Order (OGC No. 12-1148) between SFWMD and FDEP — National Pollution Discharge Watershed Permit for the Everglades STAs

(FDEP NPDES Permit No. FL0778451)

Note: For reader convenience, this attachment (dated August 15, 2012) is being reproduced verbatim and has not been edited or revised.

BEFORE THE STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION,

Complainant,

vs. OGC FILE NO. 12-1148

SOUTH FLORIDA
WATER MANAGEMENT DISTRICT.

Respondent.
_______________________________________/

CONSENT ORDER

This Consent Order is entered into between the State of Florida Department of Environmental Protection ("Department") and the South Florida Water Management District ("Respondent") to reach settlement of certain matters at issue between the Department and the Respondent.

The Department finds and Respondent admits the following:

1. The Department is the administrative agency of the State of Florida having the power and duty to protect Florida's air and water resources and to administer and enforce Chapter 373 and Chapter 403, Florida Statutes ("F.S."), and the rules promulgated and authorized thereunder, Title 62, Florida Administrative Code ("F.A.C."). The Department has jurisdiction over the matters addressed in this Consent Order. The Department is authorized by Section 403.121, Florida Statutes, to institute

administrative proceedings to order the prevention, abatement, or control of the conditions creating a violation of Chapter 403, and to order other appropriate corrective action.

2. Respondent is a public corporation of the State of Florida existing by virtue of Chapter 25270, Laws of Florida, 1949, and operating pursuant to Chapter 373, F.S., and Title 40E, F.A.C., as a multipurpose water management district with its principal office at 3301 Gun Club Road, West Palm Beach, Florida, 33406. Respondent is a person within the meaning of Sections 373.019(15) and 403.031(5), F.S.

3. Respondent is the local sponsor for the Central and Southern Florida Flood Control Project ("C&SF Project") which provides flood control in the EAA, C-139, and other tributary basins and urban, agricultural, and environmental water supply to the Everglades and Lower East Coast of Florida.

4. As authorized pursuant to Section 373.4592, F.S., Respondent built and operates large, state of the art manmade treatment wetlands, known as stormwater treatment areas ("STAs"), to remove excess phosphorus from surface waters that flow from Lake Okeechobee, the EAA, the C-139 Basin, the L-8 Basin and the C-51 West Basin to the Everglades Protection Area ("EPA"). Respondent is required to obtain a National Pollutant Discharge Elimination System ("NPDES") permit from the Department pursuant to 403.0885, F.S., to operate, maintain and discharge from the STAs.

5. Respondent is the operator of STA-1 East and the owner and operator of STA-1 West, STA-2, STA-3/4 and STA-5/6 which discharge into Water Conservation Area ("WCA") 1, 2 and 3 of the EPA. WCA-1, 2 and 3 are designated Class III waters of the State and WCA-1 is also an Outstanding Florida Water pursuant to Rule 62-302.700, F.A.C.

6. Respondent, to date, has constructed approximately 60,000 acres of STAs. While the STAs have greatly reduced the amount of phosphorus entering the EPA, the phosphorus criterion established in Rule 62-302.540, F.A.C., has not been met in all the ambient waters of the EPA.

7. In the accompanying permit (NPDES Permit No. FL0778451-001-GL7A/RA), issued concurrently with this Consent Order, the Department is establishing a water quality based effluent limitation ("WQBEL") for total phosphorus ("TP") discharges from the STAs into the EPA. The WQBEL was derived to ensure that STA discharges do not cause or contribute to exceedance of the Everglades phosphorus criterion in Rule 62-302.540, F.A.C., throughout the EPA (See Exhibit A). The WQBEL consists of two components 1) a maximum TP annual flow-weighted mean ("AFWM") of 19 parts per billion ("ppb"); and, 2) a TP long-term flow-weighted mean ("LTFWM") of 13 ppb not to be exceeded in more than three (3) out of five (5) years.

To date, TP levels in discharges from the best performing STA, STA-3/4, have averaged 17 ppb. No STA has achieved an annual flow-weighted mean of 13 ppb in more than three out of five years. As such, the STAs are not predicted to achieve the

WQBEL without additional corrective actions.

8. While the phosphorus levels in the STA discharges have not yet achieved concentrations necessary to meet the phosphorus criterion, significant reductions in the levels of phosphorus delivered to the EPA have occurred since their initial construction and operation. As of water year 2011 the STAs, in combination with best management practices, have removed 3,800 metric tons of phosphorus from water that would have alternatively been delivered to the EPA untreated. If the STAs cease operations, untreated water would flow directly into the EPA. The Department finds that it is clearly in the public interest to exercise its enforcement discretion to allow the continued operation of STAs while the corrective actions required by this Consent Order are implemented so long as the STAs are operated in compliance with Paragraph 12.

Having reached a resolution of the matter, Respondent and the Department mutually agree and it is,

ORDERED:

9. Respondent shall operate and maintain STA-1 East, STA-1 West, STA-2, STA 3/4 and STA 5/6 in accordance with the terms and conditions of NPDES Permit No.: FL0778451-001-GL7A/RA, except as specified in Paragraph 12 below. This Order does not alter the obligation to comply with the WQBEL for TP in Section I.A.1 of the permit upon its effective date. However, effluent from the STAs is not predicted to

achieve the WQBEL for TP until completion of the corrective actions described in Paragraph 10 below.

10. In order to bring discharges from STA 1 East, 1 West, STA 2, STA 3/4 and STA 5/6 into compliance with the WQBEL, Respondent shall expeditiously proceed with the planning, design, construction and operation of the Eastern (STA-1 East and STA-1 West), Central (STA-2 and STA-3/4) and Western (STA-5/6) Flow-path corrective actions which are more particularly described in Exhibit B. Respondent shall obtain all necessary local, state and federal authorizations, including appropriate Department permits, for these activities. These corrective actions and the associated deadlines for completion and operation are as follows:

Eastern Flow-path Corrective Actions and Deadlines	
Activity	Deadline
Eastern Flow-path: 4,700 Acre Expansion	
Complete land acquisition for expansion	09/30/2013
Initiate design of expansion	09/30/2013
Submit state and federal permit applications for expansion	07/30/2014
Complete design of expansion	07/30/2015
Initiate construction of expansion	01/31/2016
Construction status report	03/01/2017
Construction status report	03/01/2018
Complete construction of expansion	12/31/2018
Initial flooding and optimization period complete	12/31/2020
Eastern Flow-path: S-375 Expansion	
Initiate design of structure expansion	09/30/2013
Complete design of structure expansion	07/30/2015
Initiate construction of structure expansion	01/31/2016
Complete construction of structure expansion	12/31/2018
Eastern Flow-path: L-8 Divide Structure	
Initiate design of structure expansion	10/01/2012
Complete design of structure expansion	09/30/2014
Initiate construction of structure expansion	10/01/2016
Complete construction of structure expansion	09/30/2018

Eastern Flow-path: S-5AS Modifications	
Initiate design of structure modifications	10/01/2012
Complete design of structure expansion	09/30/2014
Initiate construction of structure expansion	10/01/2014
Complete construction of structure expansion	09/30/2016
Eastern Flow-path: 1,800 Acre Expansion	
Complete land acquisition for expansion	03/31/2018
Initiate design for expansion	10/01/2018
Submit state and federal permit applications for expansion	08/01/2019
Complete design of expansion	07/31/2020
Initiate construction of expansion	11/30/2020
Construction status report	03/01/2021
Construction status report	03/01/2022
Complete construction of expansion	12/31/2022
Initial flooding and optimization period complete	12/31/2024
Eastern Flow-path: Flow Equalization Basin (FEB) 45,000 acre-feet	
Submit state and federal permit applications	01/31/2014
Construction status report	03/01/2014
Construction status report	03/01/2015
Completion of construction (multi-purpose operation begins)	12/31/2016[1]
Long-term operations commence	12/31/2022[2]
Eastern Flow-path: Conveyance Improvements	
Initiate design of G-341 and related improvements	10/01/2020
Submit state and federal permit applications for G-341 and related improvements	08/01/2021
Complete land acquisition for G-341 related improvements (if required)	09/30/2021
Complete design of G-341 and related improvements	07/31/2022
Initiate construction of G-341 and related improvements	11/30/2022
Construction status report	03/01/2023
Construction status report	03/01/2024
Completion of construction for G-341 and related improvements	12/31/2024
Eastern Flow-path: Repairs and Modifications of Stormwater Treatment Area 1 East	
Periphyton Stormwater Treatment Area Decommissioning complete	Prior to Long-term operations commencing
Culvert repairs complete	Prior to Long-term Operations Commencing
Cell 5 and 7 improvements complete	Prior to Long-term Operations Commencing
Eastern Flow-path Corrective Action Completion Date	**12/31/2024**

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[1] Multi-purpose operations until replacement storage on-line

[2] Long term operations- replacement storage on-line

Central Flow-path Corrective Actions and Deadlines	
Activity	Deadline
Central Flow-path STA-2 Expansion: Compartment B North and South Build-outs	
Initial flooding and optimization period complete	05/31/2014
Central Flow-path: Flow Equalization Basin (FEB) 54,000 acre-feet	
Initiate design of A-1 FEB	04/01/2012
Submit state and federal permit applications	12/01/2012
Design status report	03/01/2013
Complete design of A-1 FEB	08/01/2013
Initiate construction of A-1 FEB	06/30/2014
Construction status report	03/01/2015
Construction status report	03/01/2016
Complete construction of A-1 FEB	07/30/2016
FEB Operational monitoring and testing period complete	07/29/2018
Central Flow-path Corrective Action Completion Date	**07/29/2018**

Western Flow-path Corrective Actions and Deadlines	
Activity	Deadline
Western Flow-path STA-5/6 Expansion: Compartment C	
Initial flooding and optimization period complete	05/31/2014
Western Flow-path: Internal Stormwater Treatment Area Improvements	
Initiate design of scraping/earthwork improvements	10/31/2019
Submit state and federal permit applications	08/30/2020
Complete design of scraping/earthwork improvements	10/31/2021
Initiate scraping/earthwork activities	01/31/2022
Construction status report	03/01/2023
Construction status report	03/01/2024
Completion of scraping/earthwork activities	12/31/2024
Initial flooding and optimization period complete	12/31/2025
Western Flow-path: Flow Equalization Basin (FEB) 11,000 acre-feet	
Initiate design of FEB	10/31/2018
Submit state and federal permit applications	08/30/2019
Complete design of FEB	10/31/2020
Initiate construction of FEB	01/31/2021
Construction status report	03/01/2021
Construction status report	03/01/2022
Construction status report	03/01/2023
Complete construction of FEB	12/31/2023
Operational monitoring and testing period	12/31/2024
Western Flow-path Corrective Action Completion Date	**12/31/2025**

Unless terminated by mutual consent of the parties, this Consent Order, setting forth the corrective actions, shall remain in effect for all flow-paths until the corrective actions for all flow-paths in this Paragraph are completed and sufficient discharge data required under the permit exists to assess compliance with both components of the WQBEL for all flow-paths.

11. The Respondent commits to expediting the corrective actions set forth in Paragraph 10, to the maximum extent practicable while fulfilling its other agency responsibilities, in an effort to incrementally improve water quality discharges into the EPA.

12. Upon completion of the specific corrective actions identified in Paragraph 10, it is anticipated that the facilities will be discharging consistent with the WQBEL for TP established in Section I.A.1 of the permit. Until such time as the corrective actions identified in Paragraph 10 are completed consistent with the deadlines set forth therein, the Department will exercise its enforcement discretion to allow the STAs to maintain operations. In the interim, the Respondent shall operate and maintain all STA facilities and systems of treatment control in an effort to maximize reductions in TP concentrations to the Everglades Protection Area. Such operations shall be in accordance with any approved operational plan, pollution prevention plan and the accompanying permit.

13. Whereas it is predicted that discharges from the facilities will not achieve the WQBEL until the corrective actions in Paragraph 10 have been completed, this

Order provides the following alternate reporting provisions in lieu of those required in Section I.A.6 through I.A.10 of the permit: 1) The Respondent shall provide, as part of the annual report in Section I.E.6. of the permit, status updates on the activities described in Paragraph 10 and TP AFWM concentrations for each STA over the course of the prior water year (May 1st through April 30th). The TP AFWM shall also be reported in accordance with Section I.A.5. of the permit. In both cases, the TP AFWM shall be calculated in accordance with Section I.A.1. of the permit; and 2) The Respondent shall prepare a weekly STA performance summary (report) that sets forth inflow volumes, inflow FWM TP concentrations, outflow volumes, outflow FWM TP concentrations for the prior 7 day, 28 day and 365 day period of record and inflow and outflow TP load for the prior 28 day and 365 day period of record. The weekly report shall also include the 365 day loading rate, 6 month trend in outflow TP concentrations, and concentration, load and flow in comparison to the period of record observed conditions. Copies of the weekly reports shall be transmitted to the Department and USEPA representatives to be identified in accordance with Paragraph 14. The District shall consult with the representatives on a semi-annual basis to evaluate the STAs performance and the District shall determine what, if any, operational changes may be implemented to ensure compliance with the Operational and Pollution Prevention Plans. Other relevant information collected by the Respondent shall be presented to the representatives of the State and Federal agencies designated under Paragraph 14 prior to their semi-annual consultation to ensure that adequate time is available to review and facilitate informed technical discussions.

Interim reporting requirements established by this Paragraph shall no longer apply subsequent to the Flow-path Corrective Action Completion Deadline.

14. The Respondent shall develop and implement a science plan in order to identify the factors that collectively influence phosphorus reduction and treatment performance in order to meet the WQBEL. The Respondent shall develop the science plan in consultation with representatives as designated by the Department and the United States Environmental Protection Agency, Region IV (USEPA), respectively, on behalf of State and Federal agencies.

After consulting with the representatives, the Respondent shall: 1) identify the critical information gaps and research areas that influence treatment performance; 2) prioritize the science needs; 3) develop and implement the science plan; 4) evaluate the results of ongoing scientific efforts to meet the prioritized science needs; 5) modify the science plan as needed based on results of completed or ongoing scientific studies, and 6) determine how the results of the scientific studies could be implemented to improve phosphorus reductions and treatment performance. Of particular interest is a better understanding of design and operations that sustain outflow concentrations at low phosphorus concentrations (<20 ppb).

Key areas that should be considered for further scientific studies include the effect of the following factors on STA performance: 1) phosphorus loading rates; 2) inflow phosphorus concentration; 3) hydraulic loading rates; 4) inflow water volumes, timing, pulsing, peak flows, and water depth; 5) phosphorus speciation at inflows and outflows; 6) effects of microbial activity and enzymes on phosphorus uptake; 7) phosphorus re-suspension and flux; 8) the stability of accreted phosphorus; 9) phosphorus concentrations and forms in soil and floc; 10) soil flux management measures; 11) influence of water quality constituents such as calcium; 12) emergent and submerged vegetation speciation; 13) vegetation density and cover; 14) weather conditions such as hurricane and drought; and 15) the inter-relationships between those factors.

The representatives will perform only technical functions such as:

- Information gathering and fact-finding regarding scientific studies presented to it.
- Evaluation and comparison of the results of the scientific studies through identification of positive, neutral and negative impacts of any options presented in the results of the scientific studies.
- Provide expert technical opinions regarding viability and outcomes of any options presented in the results of the scientific studies.
- Develop and provide technical opinions on STA interim operational data with regard to observed water year conditions and resulting phosphorus reductions;
- Assess water quality and progress in achieving the corrective actions and deadlines in this Consent Order.

The representatives shall not vote nor shall they make any consensus recommendations or decisions regarding matters that are presented.

The results of scientific studies and interim operational performance will be presented to and evaluated by the representatives and ultimately used by the agency representatives to inform their respective agencies as to how the information could be utilized to optimize phosphorus reduction and treatment performance.

The Respondent shall convene regular meetings of the representatives as often as needed, but no less than once every six (6) months. The first meeting of the representatives shall take place no later than six (6) months after the date of permit issuance. The Respondent shall develop a detailed science plan including a work plan and schedules within nine (9) months of issuance of the permit. The Respondent shall begin to implement studies and research identified in the work plan within twelve (12) months of issuance of the permit.

15. Respondent shall conduct monthly monitoring at a series of sites downstream of STA-1E, STA-1W and STA-2 in order to characterize the effects of the STAs' discharge on the receiving water bodies. The tables below identify thirty one (31) downstream sampling sites. Of the thirty one (31) sites, eighteen (18) are located in areas currently identified as impacted (i.e., sediment TP concentration greater than 500 mg/kg) and ten (10) sites are located in areas currently identified as unimpacted. Three sampling sites are located in the Rim Canal. Upon demonstration that an additional sampling site or removal of an existing sampling site or parameter is warranted, the

Respondent may request a modification to the monitoring program as appropriate. The Department shall review and approve such requests on a case by case basis after consultation with USEPA. Any alteration in the monitoring program must be approved by the Department. The Department will assess whether continuance of, modifications to, or elimination of downstream monitoring efforts are warranted prior to the conclusion of this Order.

All water quality, sediment, and vegetation samples shall be collected and reported for the parameters and at the frequency specified in the Respondent's March 2012 "Downstream STA1W, STA1E, and STA2 Transect Monitoring Plan (Project Code: STAT) SFWMD-FIELD-MP-078-01".

Transect Monitoring for STA-1E			
Station	Latitude	Longitude	Category
LOXA-135	26° 37′ 24.1″ N	80° 18′ 58.0″ W	Rim Canal
LOXA-136	26° 37′ 7.7″ N	80° 19′ 7.2″ W	Impacted
LOXA-137	26° 36′ 54.4″ N	80° 19′ 18.1″ W	Impacted
LOXA-138	26° 36′ 24.5″ N	80° 19′ 36.0″ W	Unimpacted
LOXA-139	26° 35′ 36.0″ N	80° 20′ 13.8″ W	Unimpacted

Transect Monitoring for STA-1W			
Station	Latitude	Longitude	Category
LOXA-104	26° 35′ 52.7″ N	80° 26′ 24.2″ W	Rim Canal
LOXA-104.5	26° 35′ 38.8″ N	80° 26′ 20.8″ W	Impacted
LOXA-105	26° 35′ 30.8″ N	80° 26′ 9.9″ W	Impacted
LOXA-106	26° 35′ 31.9″ N	80° 25′ 52.6″ W	Impacted
LOXA-107	26° 35′ 14.6″ N	80° 25′ 17.2″ W	Impacted
LOX-107U	26° 34′ 52.3″ N	80° 24′ 43.2″ W	Unimpacted
LOXA-108	26° 34′ 40.7″ N	80° 24′ 21.1″ W	Unimpacted
Z-0[3]	26° 28′ 1.1″ N	80° 26′ 31.8″ W	Rim Canal
Z-1[3]	26° 28′ 5.9″ N	80° 26′ 24.4″ W	Impacted

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[3] Monitoring of the Z transect station, in accordance with the parameters and frequencies in the March 2012 'Downstream STA-1W, STA-1E and STA-2 Transect Monitoring Plan' shall not commence until such time as the Respondent initiates construction activities associated with the 1,800 acre STA Expansion identified in Paragraph 10 of this Order.

Z-2[3]	26° 27′ 52.3″ N	80° 25′ 40.6″ W	Impacted
Z-3[3]	26° 27′ 29.9″ N	80° 24′ 31.0″ W	Impacted
Z-4[3]	26° 26′ 46.2″ N	80° 23′ 18.6″ W	Unimpacted

Transect Monitoring for STA-2			
Station	Latitude	Longitude	Category
2AN.25	26° 27′ 14.34″ N	80° 27′ 23.34″ W	Impacted
2AN1	26° 24′ 43.39″ N	80° 28′ 16.97″ W	Impacted
2AN2	26° 26′ 20.28″ N	80° 27′ 14.46″ W	Impacted
2AN4	26° 25′ 21.48″ N	80° 27′ 01.38″ W	Impacted
2AN5	26° 24′ 49.54″ N	80° 26′ 52.69″ W	Unimpacted
2AN6	26° 24′ 18.12″ N	80° 26′ 44.08″ W	Unimpacted
2AC0.25	26° 25′ 34.68″ N	80° 28′ 30.90″ W	Impacted
2AC2	26° 24′ 43.39″ N	80° 28′ 16.97″ W	Impacted
2AC4	26° 23′ 42.54″ N	80° 28′ 05.10″ W	Unimpacted
2AC5	26° 23′ 09.50″ N	80° 28′ 00.97″ W	Unimpacted
2AFS.25	26° 20′ 44.77″ N	80° 31′ 36.59″ W	Impacted
2AFS1	26° 20′ 38.46″ N	80° 31′ 10.32″ W	Impacted
2AFS3	26° 20′ 15.84″ N	80° 30′ 01.62″ W	Impacted
CA 29	26° 19′ 31.40″ N	80° 28′ 21.54″ W	Unimpacted

16. Except as provided for in Paragraph 17, Respondent agrees to pay the Department stipulated penalties in the amount of $1,000.00 per day for each and every day Respondent fails to complete any of the corrective actions by the respective deadlines identified in Paragraph 10 of this Order. A separate stipulated penalty shall be assessed for each violation of this Consent Order. Within 30 days of written demand from the Department, Respondent shall make payment of the appropriate stipulated penalties to the "State of Florida Department of Environmental Protection" by cashier's check or money order and shall include thereon the notations "OGC Case No. 12-1148" and "Ecosystem Management and Restoration Trust Fund." The Department may make demands for payment at any time after violations occur. Nothing in this Paragraph shall prevent the Department from filing suit to specifically enforce any of

the terms of this Consent Order. If the Department is required to file a lawsuit to recover stipulated penalties under this Paragraph, the Department will not be foreclosed from seeking civil penalties for violations of this Consent Order in an amount greater than the stipulated penalties due under this Paragraph.

17. If any event occurs which causes delay or the reasonable likelihood of delay in complying with the requirements of this Order, Respondent shall have the burden of proving that the delay was or will be caused by circumstances beyond the reasonable control of the Respondent and could not have been or cannot be overcome by Respondent's due diligence. Upon occurrence of such an event, or upon becoming aware of a potential for delay, Respondent shall notify the Department orally within seven (7) days and as soon thereafter as possible shall notify the Department and USEPA in writing of the anticipated length and cause of the delay, the measures taken or to be taken to prevent or minimize the delay, and the timetable by which Respondent intends to implement these measures. If the Department agrees that the delay or anticipated delay has been or will be caused by circumstances beyond the reasonable control of Respondent, the Department will notify the Respondent in writing that the time for performance for specified project activities in this Consent Order shall be extended for a period equal to the agreed delay resulting from such circumstances, including all reasonable measures necessary to avoid or minimize future delay.

18. Entry of this Consent Order does not relieve Respondent of the need to comply with applicable federal, state or local laws, regulations or ordinances.

19. The terms and conditions set forth in this Consent Order may be enforced in a court of competent jurisdiction pursuant to Sections 120.69, 373.129 and 403.121 and 403.131, F.S. Failure to comply with the terms of this Order shall constitute a violation of Sections 373.430 and 403.161, F.S.

20. Respondent is fully aware that a violation of the terms of this Order may subject Respondent to judicial imposition of damages, civil penalties of up to $10,000 per day per violation and criminal penalties.

21. The Department and Respondent hereby irrevocably, knowingly, voluntarily, and intentionally waive their right to trial by jury with respect to any litigation based wholly or partially on the enforcement of this Consent Order.

22. Persons who are not parties to this Consent Order but whose substantial interests are affected by this Consent Order have a right, pursuant to Sections 120.569 and 120.57, F.S., to petition for an administrative hearing on it. The Petition must contain the information set forth below and must be filed (received) at the Department's Office of General Counsel, 3900 Commonwealth Boulevard, MS# 35, Tallahassee, Florida 32399-3000 within 21 days of receipt of this notice. A copy of the Petition must also be mailed to the Office of Ecosystem Projects, Program Coordination and Regulation Section, 3900 Commonwealth Boulevard, MS 24, Tallahassee, Florida 32399-3000. Failure to file a petition within the 21 days constitutes a waiver of any right such person has to an administrative hearing pursuant to Section 120.57, F.S.

The petition shall contain the following information:

a) OGC No. 12-1148 and the county in which the subject matter is located;

b) The name, address, and telephone number of each petitioner; the name, address, and telephone number of the petitioner's representative, if any, which shall be the address for service purposes during the course of the proceeding;

c) An explanation of how the petitioner's substantial interests will be affected by the Consent Order;

d) A statement of when and how the petitioner received notice of the Consent Order;

e) A statement of all material facts disputed by the petitioner, if any;

f) A statement of the specific facts the petitioner contends warrant reversal or modification of the Consent Order;

g) A statement of which rules or statutes the petitioner contends require reversal or modification of the Consent Order; and

h) A statement of the relief sought by the petitioner, stating precisely the action petitioner wishes the Department to take with respect to the Consent Order.

If a petition is filed, the administrative hearing process is designed to formulate agency action. Accordingly, the Department's final action may be different from the position taken by it in this Consent Order. Persons whose substantial interests will be affected by any decision of the Department with regard to the subject Consent Order have the right to petition to become a party to the proceeding. The petition must conform to the requirements specified above and be filed (received) within 21 days of receipt of this notice in the Department's Office of General Counsel at the address specified above. Failure to file a petition within the allowed timeframe constitutes a waiver of any right such person has to request a hearing under Sections 120.569 and 120.57, F.S., and to participate as a party to this proceeding. Any subsequent intervention will only be at the approval of the presiding officer upon motion filed pursuant to Rule 28-106.205, F.A.C.

23. Because this Consent Order accompanies and references NPDES Permit No. FL0778451-001-GL7A/RA, this Consent Order shall not be effective until NPDES Permit No. FL0778451-001-GL7A/RA becomes effective.

24. The Department hereby expressly reserves the right to initiate appropriate legal action to prevent or prohibit any violations of applicable statutes, or the rules promulgated thereunder that are not specifically addressed by the terms of this Consent Order.

25. The Department, for and in consideration of the complete and timely performance by Respondent of the obligations agreed to in this Consent Order, hereby waives its right to seek judicial imposition of damages or civil penalties for alleged violations addressed in this Consent Order.

26. Respondent acknowledges and waives its right to an administrative hearing pursuant to Sections 120.569 and 120.57, F.S., on the terms of this Consent Order. Respondent acknowledges its right to appeal the terms of this Consent Order

pursuant to Section 120.68, F.S., and waives that right upon signing this Consent Order. Respondent waives no other rights or defenses other than those explicitly addressed in this Consent Order.

27. This document constitutes the entire agreement and understanding of the parties to this Consent Order concerning settlement of the above-captioned action and there are no representations, warranties, covenants, terms or conditions agreed upon between the parties other than those expressed in this Consent Order. Nothing in this Consent Order shall prohibit the Respondent from petitioning for other available relief, waiver, or variance provisions provided for under Chapters 120 or 403, F.S., and the rules promulgated there under.

28. No modifications of the terms of this Consent Order shall be effective until reduced to writing and executed by Respondent and the Department. The corrective actions and deadlines identified in Paragraph 10 (as in effect on the effective date of this Order) are incorporated by reference as separately and independently enforceable requirements in NPDES Permit No. FL0778451-001-GL7A/RA. Modifications of this Consent Order do not automatically modify the NPDES permit requirements. This Consent Order gives no rights or benefits to any third party beneficiary and shall not serve as a waiver of any claims Respondent may have against any third parties. This Consent Order cannot be assigned by Respondent.

29. This Consent Order is issued in conjunction with Consent Order 12-1149. The material provisions in these Orders are non severable. This Order shall not become effective until the date Consent Order 12-1149 becomes effective.

30. All submittals and payments required by this Consent Order to be submitted to the Department, unless otherwise indicated, shall be sent to the Department of Environmental Protection, Office of Ecosystem Projects, 3900 Commonwealth Boulevard, MS 24, Tallahassee, Florida 32399-3000.

31. This Consent Order is a settlement of the Department's civil and administrative authority arising under Florida law to resolve the matters addressed herein. This Consent Order is not a settlement of any criminal liabilities that may arise under Florida law, nor is it a settlement of any violation that may be prosecuted criminally or civilly under federal law.

32. This Consent Order is a final order of the Department pursuant to Section 120.52(7), F.S., and it is final and effective as provided in Paragraphs 23 and 29 and when filed with the Clerk of the Department.

South Florida Water Management District
OGC No.: 12-1148
FDEP NPDES Permit No.: FL0778451-001-GL7A/RA

FOR THE RESPONDENT

8/10/12
DATE

Melissa L. Meeker, Executive Director
South Florida Water Management District

DONE AND ORDERED this 15th day of August, 2012, in Tallahassee, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Herschel T. Vinyard Jr.

Herschel T. Vinyard Jr.
Secretary

Filed, on this date, pursuant to Section 120.52, F.S., with the designated Department Clerk, receipt of which is hereby acknowledged.

Kay Buchanan
CLERK

8/15/12
DATE

cc: Lea Crandall, Agency Clerk (Mail Station 35)

Consent Order (OGC No. 12-1149) between SFWMD and FDEP — Everglades Forever Act Watershed Permit for the Everglades STAs

(FDEP EFA Permit No. 0311207)

Note: For reader convenience, this attachment (dated August 15, 2012) is being reproduced verbatim and has not been edited or revised.

BEFORE THE STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION,

Complainant,

vs. OGC FILE NO. 12-1149

SOUTH FLORIDA
WATER MANAGEMENT DISTRICT.

Respondent.
_____________________________________/

CONSENT ORDER

This Consent Order is entered into between the State of Florida Department of Environmental Protection ("Department") and the South Florida Water Management District ("Respondent") to reach settlement of certain matters at issue between the Department and the Respondent.

The Department finds and Respondent admits the following:

1. The Department is the administrative agency of the State of Florida having the power and duty to protect Florida's air and water resources and to administer and enforce Chapter 373 and Chapter 403, Florida Statutes ("F.S."), and the rules promulgated and authorized thereunder, Title 62, Florida Administrative Code ("F.A.C."). The Department has jurisdiction over the matters addressed in this Consent Order. The Department is authorized by Section 403.121, Florida Statutes, to institute administrative proceedings to order the prevention, abatement, or control of the

conditions creating a violation of Chapter 403, and to order other appropriate corrective action.

2. Respondent is a public corporation of the State of Florida existing by virtue of Chapter 25270, Laws of Florida, 1949, and operating pursuant to Chapter 373, F.S., and Title 40E, F.A.C., as a multipurpose water management district with its principal office at 3301 Gun Club Road, West Palm Beach, Florida, 33406. Respondent is a person within the meaning of Sections 373.019(15) and 403.031(5), F.S.

3. Respondent is the local sponsor for the Central and Southern Florida Flood Control Project ("C&SF Project") which provides flood control in the EAA, C-139, and other tributary basins and urban, agricultural, and environmental water supply to the Everglades and Lower East Coast of Florida.

4. As authorized pursuant to Section 373.4592, F.S., Respondent built and operates large, state of the art manmade treatment wetlands, known as stormwater treatment areas ("STAs"), to remove excess phosphorus from surface waters that flow from Lake Okeechobee, the EAA, the C-139 Basin, the L-8 Basin and the C-51 West Basin to the Everglades Protection Area ("EPA"). Respondent is required to obtain an Everglades Forever Act ("EFA") permit from the Department pursuant to 373.4592, F.S., to construct, operate, maintain and discharge from the STAs.

5. Respondent is the operator of STA-1 East and the owner and operator of STA-1 West, STA-2, STA-3/4 and STA-5/6 which discharge into Water Conservation Area ("WCA") 1, 2 and 3 of the EPA. WCA-1, 2 and 3 are designated Class III waters of

the State and WCA-1 is also an Outstanding Florida Water pursuant to Rule 62-302.700, F.A.C.

6. Respondent, to date, has constructed approximately 60,000 acres of STAs. While the STAs have greatly reduced the amount of phosphorus entering the EPA, the phosphorus criterion established in Rule 62-302.540, F.A.C., has not been met in all the ambient waters of the EPA.

7. In the accompanying permit (EFA Permit No. 0311207-001), issued concurrently with this Consent Order, the Department is establishing a water quality based effluent limitation ("WQBEL") for total phosphorus ("TP") discharges from the STAs into the EPA. The WQBEL was derived to ensure that STA discharges do not cause or contribute to exceedance of the Everglades phosphorus criterion in Rule 62-302.540, F.A.C., throughout the EPA (See Exhibit A). The WQBEL consists of two components 1) a maximum TP annual flow-weighted mean ("AFWM") of 19 parts per billion ("ppb"); and, 2) a TP long-term flow-weighted mean ("LTFWM") of 13 ppb not to be exceeded in more than three (3) out of five (5) years.

To date, TP levels in discharges from the best performing STA, STA-3/4, have averaged 17 ppb. No STA has achieved an annual flow-weighted mean of 13 ppb in more than three out of five years. As such, the STAs are not predicted to achieve the WQBEL without additional corrective actions.

8. While the phosphorus levels in the STA discharges have not yet achieved concentrations necessary to meet the phosphorus criterion, significant reductions in the levels of phosphorus delivered to the EPA have occurred since their initial construction and operation. As of Water year 2011 the STAs, in combination with best management practices, have removed 3,800 metric tons of phosphorus from water that would have alternatively been delivered to the EPA untreated. If the STAs cease operations, untreated water would flow directly into the EPA. The Department finds that it is clearly in the public interest to exercise its enforcement discretion to allow the continued operation of STAs while the corrective actions required by this Consent Order are implemented so long as the STAs are operated in compliance with Paragraph 12.

Having reached a resolution of the matter, Respondent and the Department mutually agree and it is,

ORDERED:

9. Respondent shall operate and maintain STA 1 East, 1 West, STA-2, STA-3/4 and STA-5/6 in accordance with the terms and conditions of EFA Permit No.: 0311207-001, except as specified in Paragraph 12 below. This Order does not alter the obligation to comply with the WQBEL for TP in Table 1 of the permit upon its effective date. However, effluent from the STAs is not predicted to achieve the WQBEL for TP until completion of the corrective actions described in Paragraph 10 below.

10. In order to bring discharges from STA 1 East, STA-1 West, STA-2, STA-3/4 and STA-5/6 into compliance with the WQBEL, Respondent shall expeditiously proceed with the planning, design, construction and operation of the Eastern (STA-1 East and STA-1 West), Central (STA-2 and STA-3/4) and Western (STA-5/6) Flow-path corrective actions which are more particularly described in Exhibit B. Respondent shall obtain all necessary local, state and federal authorizations, including appropriate Department permits, for these activities. These corrective actions and the associated deadlines for completion and operation are as follows:

Eastern Flow-path Corrective Actions and Deadlines	
Activity	Deadline
Eastern Flow-path: 4,700 Acre Expansion	
Complete land acquisition for expansion	09/30/2013
Initiate design of expansion	09/30/2013
Submit state and federal permit applications for expansion	07/30/2014
Complete design of expansion	07/30/2015
Initiate construction of expansion	01/31/2016
Construction status report	03/01/2017
Construction status report	03/01/2018
Complete construction of expansion	12/31/2018
Initial flooding and optimization period complete	12/31/2020
Eastern Flow-path: S-375 Expansion	
Initiate design of structure expansion	09/30/2013
Complete design of structure expansion	07/30/2015
Initiate construction of structure expansion	01/31/2016
Complete construction of structure expansion	12/31/2018
Eastern Flow-path: L-8 Divide Structure	
Initiate design of structure expansion	10/01/2012
Complete design of structure expansion	09/30/2014
Initiate construction of structure expansion	10/01/2016
Complete construction of structure expansion	09/30/2018
Eastern Flow-path: S-5AS Modifications	
Initiate design of structure modifications	10/01/2012
Complete design of structure expansion	09/30/2014
Initiate construction of structure expansion	10/01/2014
Complete construction of structure expansion	09/30/2016
Eastern Flow-path: 1,800 Acre Expansion	

Complete land acquisition for expansion	03/31/2018
Initiate design for expansion	10/01/2018
Submit state and federal permit applications for expansion	08/01/2019
Complete design of expansion	07/31/2020
Initiate construction of expansion	11/30/2020
Construction status report	03/01/2021
Construction status report	03/01/2022
Complete construction of expansion	12/31/2022
Initial flooding and optimization period complete	12/31/2024
Eastern Flow-path: Flow Equalization Basin (FEB) 45,000 acre-feet	
Submit state and federal permit applications	01/31/2014
Construction status report	03/01/2014
Construction status report	03/01/2015
Completion of construction (multi-purpose operation begins)	12/31/2016[1]
Long-term operations commence	12/31/2022[2]
Eastern Flow-path: Conveyance Improvements	
Initiate design of G-341 and related improvements	10/01/2020
Submit state and federal permit applications for G-341 and related improvements	08/01/2021
Complete land acquisition for G-341 related improvements (if required)	09/30/2021
Complete design of G-341 and related improvements	07/31/2022
Initiate construction of G-341 and related improvements	11/30/2022
Construction status report	03/01/2023
Construction status report	03/01/2024
Completion of construction for G-341 and related improvements	12/31/2024
Eastern Flow-path: Repairs and Modifications of Stormwater Treatment Area 1 East	
Periphyton Stormwater Treatment Area Decommissioning complete	Prior to Long-term Operations Commencing
Culvert repairs complete	Prior to Long-term Operations Commencing
Cell 5 and 7 improvements complete	Prior to Long-term Operations Commencing
Eastern Flow-path Corrective Action Completion Date	**12/31/2024**

Central Flow-path Corrective Actions and Deadlines

Activity	Deadline
Central Flow-path STA-2 Expansion: Compartment B North and South Build-outs	
Initial flooding and optimization period complete	05/31/2014
Central Flow-path: Flow Equalization Basin (FEB) 54,000 acre-feet	
Initiate design of A-1 FEB	04/01/2012
Submit state and federal permit applications	12/01/2012
Design status report	03/01/2013
Complete design of A-1 FEB	08/01/2013

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[1] Multi-purpose operations until replacement storage on-line

[2] Long term operations- replacement storage on-line

Initiate construction of A-1 FEB	06/30/2014
Construction status report	03/01/2015
Construction status report	03/01/2016
Complete construction of A-1 FEB	07/30/2016
FEB Operational monitoring and testing period complete	07/29/2018
Central Flow-path Corrective Action Completion Date	**07/29/2018**

Western Flow-path Corrective Actions and Deadlines	
Activity	Deadline
Western Flow-path STA-5/6 Expansion: Compartment C	
Initial flooding and optimization period complete	05/31/2014
Western Flow-path: Internal Stormwater Treatment Area Improvements	
Initiate design of scraping/earthwork improvements	10/31/2019
Submit state and federal permit applications	08/30/2020
Complete design of scraping/earthwork improvements	10/31/2021
Initiate scraping/earthwork activities	01/31/2022
Construction status report	03/01/2023
Construction status report	03/01/2024
Completion of scraping/earthwork activities	12/31/2024
Initial flooding and optimization period complete	12/31/2025
Western Flow-path: Flow Equalization Basin (FEB) 11,000 acre-feet	
Initiate design of FEB	10/31/2018
Submit state and federal permit applications	08/30/2019
Complete design of FEB	10/31/2020
Initiate construction of FEB	01/31/2021
Construction status report	03/01/2021
Construction status report	03/01/2022
Construction status report	03/01/2023
Complete construction of FEB	12/31/2023
Operational monitoring and testing period	12/31/2024
Western Flow-path Corrective Action Completion Date	**12/31/2025**

Unless terminated by mutual consent of the parties, this Consent Order, setting forth the corrective actions, shall remain in effect for all flow-paths until the corrective actions for all flow-paths in this Paragraph are completed and sufficient discharge data required under the permit exists to assess compliance with both components of the WQBEL for all flow-paths.

11. The Respondent commits to expediting the corrective actions set forth in Paragraph 10, to the maximum extent practicable while fulfilling its other agency responsibilities, in an effort to incrementally improve water quality discharges into the EPA.

12. Upon completion of the specific corrective actions identified in Paragraph 10, it is anticipated that the facilities will be discharging consistent with the WQBEL for TP established in Table 1 of the permit. Until such time as the corrective actions identified in Paragraph 10 are completed consistent with the deadlines set forth therein, the Department will exercise its enforcement discretion to allow the STAs to maintain operations. In the interim, the Respondent shall operate and maintain all STA facilities and systems of treatment control in an effort to maximize reductions in TP concentrations to the Everglades Protection Area. Such operations shall be in accordance with any approved operational plan, pollution prevention plan and the accompanying permit.

13. Whereas it is predicted that discharges from the facilities will not achieve the WQBEL until the corrective actions in Paragraph 10 have been completed, this Order provides the following alternate reporting provisions in lieu of those required in Specific Condition 15.B. through 15.F. of the permit: 1) The Respondent shall provide, as part of the annual report in Specific Condition 25 of the permit, status updates on the activities described in Paragraph 10 and TP AFWM concentrations for each STA over the course of the prior water year (May 1st through April 30th). The TP

AFWM shall also be reported in accordance with Specific Condition 15.A. of the permit. In both cases, the TP AFWM shall be calculated in accordance with Table 1 of the permit; and 2) The Respondent shall prepare a weekly STA performance summary (report) that sets forth inflow volumes, inflow FWM TP concentrations, outflow volumes, outflow FWM TP concentrations for the prior 7 day, 28 day and 365 day period of record and inflow and outflow TP load for the prior 28 day and 365 day period of record. The weekly report shall also include the 365 day loading rate, 6 month trend in outflow TP concentrations, and concentration, load and flow in comparison to the period of record observed conditions. Copies of the weekly reports shall be transmitted to the Department and USEPA representatives to be identified in accordance with Paragraph 14. The District shall consult with the representatives on a semi-annual basis to evaluate the STAs performance and the District shall determine what, if any, operational changes may be implemented to ensure compliance with the Operational and Pollution Prevention Plans. Other relevant information collected by the Respondent shall be presented to the representatives of the State and Federal agencies designated under Paragraph 14 prior to their semi-annual consultation to ensure that adequate time is available to review and facilitate informed technical discussions.

Interim reporting requirements established by this Paragraph shall no longer apply subsequent to the Flow-path Corrective Action Completion Deadline.

14. The Respondent shall develop and implement a science plan in order to identify the factors that collectively influence phosphorus reduction and treatment performance in order to meet the WQBEL. The Respondent shall develop the science plan in consultation with representatives as designated by the Department and the United States Environmental Protection Agency, Region IV (USEPA), respectively, on behalf of State and Federal agencies.

After consulting with the representatives, the Respondent shall: 1) identify the critical information gaps and research areas that influence treatment performance; 2) prioritize the science needs; 3) develop and implement the science plan; 4) evaluate the results of ongoing scientific efforts to meet the prioritized science needs; 5) modify the science plan as needed based on results of completed or ongoing scientific studies, and 6) determine how the results of the scientific studies could be implemented to improve phosphorus reductions and treatment performance. Of particular interest is a better understanding of design and operations that sustain outflow concentrations at low phosphorus concentrations (<20 ppb).

Key areas that should be considered for further scientific studies include the effect of the following factors on STA performance: 1) phosphorus loading rates; 2) inflow phosphorus concentration; 3) hydraulic loading rates; 4) inflow water volumes, timing, pulsing, peak flows, and water depth; 5) phosphorus speciation at inflows and outflows; 6) effects of microbial activity and enzymes on phosphorus uptake; 7) phosphorus re-suspension and flux; 8) the stability of accreted phosphorus; 9) phosphorus concentrations and forms in soil and floc; 10) soil flux management measures; 11) influence of water quality constituents such as calcium; 12) emergent and submerged vegetation speciation; 13) vegetation density and cover; 14) weather conditions such as hurricane and drought; and 15) the inter-relationships between those factors.

The representatives will perform only technical functions such as:

- Information gathering and fact-finding regarding scientific studies presented to it.
- Evaluation and comparison of the results of the scientific studies through identification of positive, neutral and negative impacts of any options presented in the results of the scientific studies.
- Provide expert technical opinions regarding viability and outcomes of any options presented in the results of the scientific studies.
- Develop and provide technical opinions on STA interim operational data with regard to observed water year conditions and resulting phosphorus reductions;
- Assess water quality and progress in achieving the corrective actions and deadlines in this Consent Order.

The representatives shall not vote nor shall they make any consensus recommendations or decisions regarding matters that are presented.

The results of scientific studies and interim operational performance will be presented to and evaluated by the representatives and ultimately used by the agency representatives to inform their respective agencies as to how the information could be utilized to optimize phosphorus reduction and treatment performance.

The Respondent shall convene regular meetings of the representatives as often as needed, but no less than once every six (6) months. The first meeting of the representatives shall take place no later than six (6) months after the date of permit issuance. The Respondent shall develop a detailed science plan including a work plan and schedules within nine (9) months of issuance of the permit. The Respondent shall begin to implement studies and research identified in the work plan within twelve (12) months of issuance of the permit.

15. Respondent shall conduct monthly monitoring at a series of sites downstream of STA-1E, STA-1W and STA-2 in order to characterize the effects of the STAs' discharge on the receiving water bodies (See Exhibit C). The tables below identify thirty one (31) downstream sampling sites. Of the thirty one (31) sites, eighteen (18) are located in areas currently identified as impacted (i.e., sediment TP concentration greater than 500 mg/kg) and ten (10) sites are located in areas currently identified as unimpacted. Three sampling sites are located in the Rim Canal. Upon demonstration that an additional sampling site or removal of an existing sampling site or parameter is warranted, the Respondent may request a modification to the monitoring program as appropriate. The Department shall review and approve such requests on a case by case basis after consultation with USEPA. Any alteration in the monitoring program must be approved by the Department. The Department will assess whether continuance of,

modifications to, or elimination of downstream monitoring efforts are warranted prior to the conclusion of this Order.

All water quality, sediment, and vegetation samples shall be collected and reported for the parameters and at the frequency specified in the Respondent's March 2012 "Downstream STA1W, STA1E, and STA2 Transect Monitoring Plan (Project Code: STAT) SFWMD-FIELD-MP-078-01".

Transect Monitoring for STA-1E			
Station	Latitude	Longitude	Category
LOXA-135	26° 37′ 24.1″ N	80° 18′ 58.0″ W	Rim Canal
LOXA-136	26° 37′ 7.7″ N	80° 19′ 7.2″ W	Impacted
LOXA-137	26° 36′ 54.4″ N	80° 19′ 18.1″ W	Impacted
LOXA-138	26° 36′ 24.5″ N	80° 19′ 36.0″ W	Unimpacted
LOXA-139	26° 35′ 36.0″ N	80° 20′ 13.8″ W	Unimpacted

Transect Monitoring for STA-1W			
Station	Latitude	Longitude	Category
LOXA-104	26° 35′ 52.7″ N	80° 26′ 24.2″ W	Rim Canal
LOXA-104.5	26° 35′ 38.8″ N	80° 26′ 20.8″ W	Impacted
LOXA-105	26° 35′ 30.8″ N	80° 26′ 9.9″ W	Impacted
LOXA-106	26° 35′ 31.9″ N	80° 25′ 52.6″ W	Impacted
LOXA-107	26° 35′ 14.6″ N	80° 25′ 17.2″ W	Impacted
LOX-107U	26° 34′ 52.3″ N	80° 24′ 43.2″ W	Unimpacted
LOXA-108	26° 34′ 40.7″ N	80° 24′ 21.1″ W	Unimpacted
Z-0[3]	26° 28′ 1.1″ N	80° 26′ 31.8″ W	Rim Canal
Z-1[3]	26° 28′ 5.9″ N	80° 26′ 24.4″ W	Impacted
Z-2[3]	26° 27′ 52.3″ N	80° 25′ 40.6″ W	Impacted
Z-3[3]	26° 27′ 29.9″ N	80° 24′ 31.0″ W	Impacted
Z-4[3]	26° 26′ 46.2″ N	80° 23′ 18.6″ W	Unimpacted

Transect Monitoring for STA-2			
Station	Latitude	Longitude	Category
2AN.25	26° 27′ 14.34″ N	80° 27′ 23.34″ W	Impacted
2AN1	26° 24′ 43.39″ N	80° 28′ 16.97″ W	Impacted
2AN2	26° 26′ 20.28″ N	80° 27′ 14.46″ W	Impacted
2AN4	26° 25′ 21.48″ N	80° 27′ 01.38″ W	Impacted

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[3] Monitoring of the Z transect station, in accordance with the parameters and frequencies in the March 2012 'Downstream STA-1W, STA-1E and STA-2 Transect Monitoring Plan' shall not commence until such time as the Respondent initiates construction activities associated with the 1,800 acre STA Expansion identified in Paragraph 10 of this Order.

2AN5	26° 24′ 49.54″ N	80° 26′ 52.69″ W	Unimpacted
2AN6	26° 24′ 18.12″ N	80° 26′ 44.08″ W	Unimpacted
2AC0.25	26° 25′ 34.68″ N	80° 28′ 30.90″ W	Impacted
2AC2	26° 24′ 43.39″ N	80° 28′ 16.97″ W	Impacted
2AC4	26° 23′ 42.54″ N	80° 28′ 05.10″ W	Unimpacted
2AC5	26° 23′ 09.50″ N	80° 28′ 00.97″ W	Unimpacted
2AFS.25	26° 20′ 44.77″ N	80° 31′ 36.59″ W	Impacted
2AFS1	26° 20′ 38.46″ N	80° 31′ 10.32″ W	Impacted
2AFS3	26° 20′ 15.84″ N	80° 30′ 01.62″ W	Impacted
CA 29	26° 19′ 31.40″ N	80° 28′ 21.54″ W	Unimpacted

16. Respondent shall enforce the requirements of the Everglades Source Control Program described under Ch. 40E-63, F.A.C. Part IV. The objectives of this rule are to: 1) Implement and continuously improve through adaptive management, a BMP program for reducing and controlling phosphorus discharges from the C-139 Basin; 2) Provide a water quality monitoring program, performance measures and a compliance methodology to evaluate the effectiveness of the BMP program in reducing phosphorus discharges; 3) Establish a BMP compliance verification and enforcement program to ensure that phosphorus discharges from the basin do not exceed the historic base period levels; and, 4) Conduct research and demonstration projects to improve and confirm the effectiveness of BMPs for reducing phosphorus.

If, during the interim period between enactment of this Order and construction completion, the Respondent determines, in accordance with Rule 40E-63, Part IV, F.A.C., the C-139 Basin is out of compliance and is not tracking towards compliance and sufficient information from the implementation of the Eastern and Central Flow-path projects does not provide reasonable assurance that the Western Flow-path projects will ultimately result in compliance with the WQBEL, Respondent shall take steps to enforce the provisions of the Rule or develop and submit a water quality improvement plan with specific schedules and strategies to refine the design of the currently proposed projects described in Paragraph 10 so that the final outcome will result in compliance with the WQBEL.

17. Except as provided for in Paragraph 18, Respondent agrees to pay the Department stipulated penalties in the amount of $1,000.00 per day for each and every day Respondent fails to complete any of the corrective actions by the respective deadlines identified in Paragraph 10 of this Order. A separate stipulated penalty shall be assessed for each violation of this Consent Order. Within 30 days of written demand from the Department, Respondent shall make payment of the appropriate stipulated penalties to the "State of Florida Department of Environmental Protection" by cashier's check or money order and shall include thereon the notations "OGC Case No. 12-1149" and "Ecosystem Management and Restoration Trust Fund." The Department may make demands for payment at any time after violations occur. Nothing in this Paragraph shall prevent the Department from filing suit to specifically enforce any of the terms of this Consent Order. If the Department is required to file a lawsuit to recover stipulated penalties under this Paragraph, the Department will not be foreclosed from seeking civil penalties for violations of this Consent Order in an amount greater than the stipulated penalties due under this Paragraph.

18. If any event occurs which causes delay or the reasonable likelihood of delay in complying with the requirements of this Order, Respondent shall have the burden of proving that the delay was or will be caused by circumstances beyond the reasonable control of the Respondent and could not have been or cannot be overcome by Respondent's due diligence. Upon occurrence of such an event, or upon becoming aware of a potential for delay, Respondent shall notify the Department orally within seven (7) days and as soon thereafter as possible shall notify the Department and USEPA in writing of the anticipated length and cause of the delay, the measures taken or to be taken to prevent or minimize the delay, and the timetable by which Respondent intends to implement these measures. If the Department agrees that the delay or anticipated delay has been or will be caused by circumstances beyond the reasonable control of Respondent, the Department will notify the Respondent in writing that the time for performance for specified project activities in this Consent Order shall be extended for a period equal to the agreed delay resulting from such circumstances, including all reasonable measures necessary to avoid or minimize future delay.

19. Entry of this Consent Order does not relieve Respondent of the need to comply with applicable federal, state or local laws, regulations or ordinances.

20. The terms and conditions set forth in this Consent Order may be enforced in a court of competent jurisdiction pursuant to Sections 120.69, 373.129 and 403.121 and 403.131, F.S. Failure to comply with the terms of this Order shall constitute a violation of Sections 373.430 and 403.161, F.S.

21. Respondent is fully aware that a violation of the terms of this Order may subject Respondent to judicial imposition of damages, civil penalties of up to $10,000 per day per violation and criminal penalties.

22. The Department and Respondent hereby irrevocably, knowingly, voluntarily, and intentionally waive their right to trial by jury with respect to any litigation based wholly or partially on the enforcement of this Consent Order.

23. Persons who are not parties to this Consent Order but whose substantial interests are affected by this Consent Order have a right, pursuant to Sections 120.569 and 120.57, F.S., to petition for an administrative hearing on it. The Petition must contain the information set forth below and must be filed (received) at the Department's Office of General Counsel, 3900 Commonwealth Boulevard, MS# 35, Tallahassee, Florida 32399-3000 within 21 days of receipt of this notice. A copy of the Petition must also be mailed to the Office of Ecosystem Projects, Program Coordination and Regulation Section, 3900 Commonwealth Boulevard, MS 24, Tallahassee, Florida 32399-3000. Failure to file a petition within the 21 days constitutes a waiver of any right such person has to an administrative hearing pursuant to Section 120.57, F.S.

The petition shall contain the following information:

a) OGC No. 12-1149 and the county in which the subject matter is located;

b) The name, address, and telephone number of each petitioner; the name, address, and telephone number of the petitioner's representative, if any, which shall be the address for service purposes during the course of the proceeding;

c) An explanation of how the petitioner's substantial interests will be affected by the Consent Order;

d) A statement of when and how the petitioner received notice of the Consent Order;

e) A statement of all material facts disputed by the petitioner, if any;

f) A statement of the specific facts the petitioner contends warrant reversal or modification of the Consent Order;

g) A statement of which rules or statutes the petitioner contends require reversal or modification of the Consent Order; and

h) A statement of the relief sought by the petitioner, stating precisely the action petitioner wishes the Department to take with respect to the Consent Order.

If a petition is filed, the administrative hearing process is designed to formulate agency action. Accordingly, the Department's final action may be different from the position taken by it in this Consent Order. Persons whose substantial interests will be affected by any decision of the Department with regard to the subject Consent Order have the right to petition to become a party to the proceeding. The petition must conform to the requirements specified above and be filed (received) within 21 days of receipt of this notice in the Department's Office of General Counsel at the address specified above. Failure to file a petition within the allowed timeframe constitutes a waiver of any right such person has to request a hearing under Sections 120.569 and 120.57, F.S., and to participate as a party to this proceeding. Any subsequent intervention will only be at the approval of the presiding officer upon motion filed pursuant to Rule 28-106.205, F.A.C.

24. Because this Consent Order accompanies and references EFA Permit No. 0311207, this Consent Order shall not be effective until EFA Permit No. 0311207 becomes effective.

25. The Department hereby expressly reserves the right to initiate appropriate legal action to prevent or prohibit any violations of applicable statutes, or the rules promulgated thereunder that are not specifically addressed by the terms of this Consent Order.

26. The Department, for and in consideration of the complete and timely performance by Respondent of the obligations agreed to in this Consent Order, hereby waives its right to seek judicial imposition of damages or civil penalties for alleged violations addressed in this Consent Order.

27. Respondent acknowledges and waives its right to an administrative hearing pursuant to Sections 120.569 and 120.57, F.S., on the terms of this Consent Order. Respondent acknowledges its right to appeal the terms of this Consent Order pursuant to Section 120.68, F.S., and waives that right upon signing this Consent Order. Respondent waives no other rights or defenses other than those explicitly addressed in this Consent Order.

28. This document constitutes the entire agreement and understanding of the parties to this Consent Order concerning settlement of the above-captioned action and there are no representations, warranties, covenants, terms or conditions agreed upon between the parties other than those expressed in this Consent Order. Nothing in this Consent Order shall prohibit the Respondent from petitioning for other available relief, waiver, or variance provisions provided for under Chapters 120 or 403, F.S., and the rules promulgated there under.

29. No modifications of the terms of this Consent Order shall be effective until reduced to writing and executed by Respondent and the Department. This Consent Order gives no rights or benefits to any third party beneficiary and shall not serve as a waiver of any claims Respondent may have against any third parties. This Consent Order cannot be assigned by Respondent.

30. This Consent Order is issued in conjunction with Consent Order 12-1148. The material provisions in these Orders are non severable. This Order shall not become effective until the date Consent Order 12-1148 becomes effective.

31. All submittals and payments required by this Consent Order to be submitted to the Department, unless otherwise indicated, shall be sent to the Department of Environmental Protection, Office of Ecosystem Projects, 3900 Commonwealth Boulevard, MS 24, Tallahassee, Florida 32399-3000.

32. This Consent Order is a settlement of the Department's civil and administrative authority arising under Florida law to resolve the matters addressed

herein. This Consent Order is not a settlement of any criminal liabilities that may arise under Florida law, nor is it a settlement of any violation that may be prosecuted criminally or civilly under federal law.

33. This Consent Order is a final order of the Department pursuant to Section 120.52(7), F.S., and it is final and effective as provided in Paragraphs 24 and 30 and when filed with the Clerk of the Department.

FOR THE RESPONDENT

8/10/12
DATE

Melissa L. Meeker, Executive Director
South Florida Water Management District

DONE AND ORDERED this 15th day of August, 2012, in Tallahassee, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Herschel T. Vinyard Jr.
Secretary

Filed, on this date, pursuant to Section 120.52, F.S., with the designated Department Clerk, receipt of which is hereby acknowledged.

Kay Buchanan
CLERK

8/15/12
DATE

cc: Lea Crandall, Agency Clerk (Mail Station 35)

Everglades Water Quality Restoration Framework Agreement between USEPA, Region IV, and FDEP

Note: For reader convenience, this attachment (dated June 12, 2012) is being reproduced verbatim and has not been edited or revised.

EVERGLADES WATER QUALITY RESTORATION FRAMEWORK AGREEMENT BETWEEN U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION IV, AND FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

WHEREAS, the Florida Department of Environmental Protection (FDEP), the South Florida Water Management District (SFWMD), and the United States Environmental Protection Agency (USEPA) seek prompt restoration of water quality in the Florida Everglades;

WHEREAS, Florida has constructed approximately 60,000 acres of large, state of the art manmade treatment wetlands, known as stormwater treatment areas ("STAs"), to remove excess phosphorus from surface waters that flow into the Everglades Protection Area ("EPA");

WHEREAS, the STAs have greatly reduced the amount of phosphorus entering the EPA, but the State's water quality criterion for phosphorus has not been met in all the ambient waters of the EPA;

WHEREAS, pursuant to the Clean Water Act, USEPA has authorized FDEP to administer the National Pollutant Discharge Elimination System (NPDES) permitting program in accordance with the NPDES Memorandum of Agreement between the State of Florida and USEPA Region 4 (Nov. 30, 2007) (the "MOA");

WHEREAS, pursuant to the MOA, FDEP is responsible for drafting, providing public notice, and issuing NPDES permits;

WHEREAS, FDEP prepared and submitted certain permits and other documents intended to authorize the operation of the STAs, including certain expansions and USEPA, after review, submitted objections to those permit documents;

WHEREAS, FDEP has incorporated into these prepared permits a water quality based effluent limit ("WQBEL") for total phosphorus discharges from the STAs into the EPA which would ensure that the STA discharges do not cause or contribute to exceedances of Florida's water quality standard for total phosphorus in the Everglades and the WQBEL would become effective and enforceable on the effective date of the permit;

WHEREAS, SFWMD and FDEP have agreed upon a suite of projects consisting of flow equalization basins, STA expansions and infrastructure and conveyance improvements, and a schedule for construction of the projects which DEP has determined provides reasonable assurance that the WQBEL will be achieved;

WHEREAS, FDEP has provided to USEPA a technical support document for the WQBEL and proposed projects, in accordance with a detailed schedule for the planning, design, construction and operation of the projects, which are intended to assure compliance with FDEP's permit and incorporated WQBEL;

WHEREAS, FDEP and USEPA agree that as the projects are constructed the SFWMD shall develop and implement a plan that will: evaluate the scientific and technical factors that influence phosphorus treatment; investigate key factors that influence STA treatment performance; improve the understanding of the design and operation of the STAs; and identify additional research and studies to support efforts to improve STA performance;

WHEREAS, FDEP and SFWMD have identified the costs associated with implementation of the projects, as well as a plan to finance that implementation;

WHEREAS, FDEP and SFWMD have negotiated proposed enforcement orders on consent (Consent Orders) that would require SFWMD to implement corrective actions according to a sequence of detailed deadlines;

WHEREAS, the requirement to implement the proposed corrective actions according to the deadlines would also be incorporated into, and made separately enforceable through, the NPDES permit;

WHEREAS, FDEP has developed an enforceable framework designed to achieve compliance with the WQBEL and this framework includes (1) FDEP's issuance of an NPDES permit that would incorporate the immediately effective WQBEL and would incorporate by reference the corrective actions and deadlines from the Consent Orders, as well as a State law Everglades Forever Act (EFA) permit, and (2) the associated Consent Orders that become enforceable and effective under Florida law;

WHEREAS, USEPA retains its independent federal oversight and enforcement authorities under the Clean Water Act and the MOA, including the ability to enforce the WQBEL directly, as well as the corrective actions and deadlines incorporated into the NPDES permit;

WHEREAS, FDEP's notice of the NPDES and EFA permits and Consent Orders will provide opportunities for public participation;

IT IS AGREED:

A. General Provisions:

1. If FDEP expeditiously takes action to enter the Consent Orders and issue the EFA and NPDES permits, USEPA would agree that the FDEP will retain its leadership role in assuring Everglades water quality restoration for purposes of, and consistent with, the Clean Water Act;

2. FDEP commits to take prompt final action to issue NPDES and EFA permits and accompanying Consent Orders to the SFWMD for discharges from the STAs. In the event any permit or Consent Order is challenged in a state administrative or judicial proceeding, FDEP also

commits to exercise its best efforts to move for expedited consideration, and to oppose any request for continuance or abatement of any such administrative or judicial proceedings.

3. If any permit or order is challenged, FDEP commits to seek relief from the relevant hearing tribunal to the extent necessary to begin implementation of the remedies identified in the orders pending completion of such challenge. If the NPDES permit provisions are substantively modified as a result of such challenge, then before the NPDES permit becomes final FDEP will submit the permit to USEPA for review in accordance with the MOA.

4. FDEP will notify USEPA as soon as practicable after receiving a request from SFWMD to modify the NPDES and/or EFA permit or accompanying orders to accommodate requests for substitution of remedial measures or extension of remedial schedules identified in Paragraph 10 of the NPDES Consent Order and incorporated by reference into the NPDES permit. FDEP will request USEPA's comment on the proposed modification prior to FDEP agreeing to modification of any provision of either Consent Order.

5. FDEP and USEPA agree that the corrective actions and deadlines incorporated by reference into the NPDES permit are incorporated as in effect on the date that the accompanying NPDES Consent Order becomes effective. Modification of any provision of Paragraph 10 in the Consent Order is considered a major modification and does not automatically modify the requirements of the NPDES permit that are incorporated by reference from Paragraph 10 of the Consent Order. The parties agree that to modify the requirements of the NPDES permit requires compliance with NPDES permit modification procedures. To the extent that any of the NPDES requirements that are incorporated by reference are themselves modified, those NPDES requirements will be processed as permit modifications subject to USEPA review under Clean Water Act section 402(d).

7. FDEP will file a motion to stay its appeals, Nos. 10-12752 and 11-12455, until such time as the NPDES and EFA permits and associated Consent Orders are effective and no longer subject to judicial review in State court; and then upon lapse of such stay FDEP may pursue or withdraw its appeals. In any appeal arising from *Miccosukee Tribe of Indians of Florida v. United States,* Case No. 04-21448 (S.D. Fla.) FDEP will not challenge the validity of, the authority to issue or the effectiveness and enforceability of the permits or consent orders issued pursuant to this Agreement, nor will it argue any issue that would delay or prevent the NPDES and EFA permits proposed pursuant to this Agreement as well as the associated Consent Orders from becoming final and effective.

8. Nothing in this Agreement governs or supersedes any requirements of the Consent Decree or other orders of the Court in United States v. SFWMD, No. 88-1886-CIV-MORENO (S.D. Fla.).

B. Agreement to Meet

The Regional Administrator, USEPA Region IV, and the Secretary of FDEP (Principals), and appropriate staff as needed, shall meet twice annually to discuss Everglades water quality conditions and progress toward attainment of water quality standards until each of the STAs meets the WQBEL necessary to meet water quality standards for total phosphorus in the Everglades. One or both of the Principals may invite the SFWMD Executive Director to such meetings, including appropriate staff as needed. The Everglades water quality conditions to be discussed will include: TP concentrations and loads entering each of the STAs; TP concentrations and loads discharged from or diverted around each of the STAs; monitoring results for downstream monitoring (as described in paragraph 14 of the NPDES Consent Order results from research conducted in accordance with the Science Plan described below and in paragraph 13 of the NPDES Consent Order); progress of the SFWMD in achieving the milestones in the NPDES permits; enforcement matters as noted in section F below; and resolution, as necessary, of any differing technical opinions of the science representatives of the USEPA, FDEP and the SFWMD.

C. Information and Reporting

In addition to the monitoring and reporting requirements described in the permits and respective accompanying Consent Orders, USEPA and the FDEP agree to the following:

1. Anticipated delay or actual failure to achieve any of the deadlines identified in either of the respective Consent Orders, including the deadlines identified in the NPDES Consent Order and specifically incorporated by reference as independently enforceable conditions of the NPDES permit, shall be reported to USEPA (either by SFWMD directly or by FDEP) within the time frames described in the permits and accompanying Consent Orders;

2. Monitoring, notification, and written reports required under the NPDES permit Sections I.A.5-10; I.E.4, 6, 9 and 10; VIII.17, 19, 20, 21 and 22; and as described in the accompanying Consent Order paragraphs 11, 12, 13, 14, 18, and 19, shall also be provided to USEPA in accordance with the timeframes contained in the permits.

D. Scientific Review

1. FDEP and USEPA, in consultation with appropriate federal and State agencies, will identify in writing to each other, within 30 days of this Agreement, technical expert representatives who will meet at least twice annually or more often as needed, to assess water quality and progress in achieving the deadlines in the permits and accompanying Consent Orders, review the results of research conducted under the Science Plan described in Section E, evaluate the ongoing operation of the STAs, and provide input to their respective Principals identified in section B above, prior to their semi-annual meetings.

2. The individual representatives may report to their Principals both on matters where there is technical consensus and matters where there is not technical consensus, but particularly on any of the latter matters which in the representatives' opinion warrant heightened consideration by the Principals, including the identification of information gaps and priority research needs, the adequacy of existing monitoring approaches, and the application of new data or information to evaluation of existing or proposed-but-not-yet-completed treatment technology.

E. Science Plan Development and Implementation

1. The NPDES Consent Order at paragraph 14 would require the SFWMD to develop and implement a Science Plan in accordance with its terms. FDEP and USEPA agree the Science Plan described in paragraph 13 of that NPDES Consent Order should be developed collaboratively and in consultation with the agency representatives described in Section D.

2. The objective of the Science Plan is to identify the critical factors that collectively govern phosphorus treatment performance; to maximize the understanding that can be gained from existing data, designs and operations; to identify the critical information gaps and research areas that will further treatment objectives in order to meet the WQBEL at each STA.

3. The Consent Orders will require SFWMD to convene regular meetings of the representatives as often as needed, but no less than once every six (6) months. The first meeting of the representatives shall take place no later than six (6) months after the date of permit issuance. The results of scientific studies and the interim operational performance will be presented to and evaluated by the representatives and ultimately used by the representatives to inform their respective agencies as to how the information could be utilized to optimize phosphorus reduction and treatment performance.

F. Enforcement

1. The FDEP issued permits and accompanying Consent Orders identify deadlines for the design, construction and completion of Stormwater Treatment Areas 1W, 1E, 2, 3/4, and 5/6, associated conveyances and flow equalization basins.

2. Based upon the information provided to USEPA by FDEP and under present circumstances, the NPDES permit and consent order (as attached to this agreement), if expeditiously issued and final after public participation, would represent timely and appropriate enforcement action by FDEP, and, the parties acknowledge under the express terms of the attached proposed Consent Orders, unless terminated by mutual consent of the parties, the Consent Order, setting forth corrective actions, shall remain in effect for all flow-paths and until the corrective actions for all flow-paths described in the Consent Order are completed and sufficient discharge data required under the permit exists to assess compliance with both components of the WQBEL for all flow paths.

3. Any future USEPA enforcement of the FDEP issued NPDES permits will be consistent with the provisions of Section IV of the MOA, including USEPA's determination of the timeliness and appropriateness of FDEP enforcement actions to respond to concerns that would otherwise warrant USEPA enforcement;

4. FDEP and USEPA agree that FDEP will promptly notify USEPA as soon as FDEP is notified by the SFWMD regarding the possibility of delays in meeting the deadlines, failure to meet the deadlines, and upon termination of each Consent Order.

5. In the event there is disagreement between FDEP and USEPA at the staff level about the appropriateness of modification of either the NPDES or EFA Consent Orders or whether an enforcement action should be initiated (including the appropriateness of corrective actions and/or deadlines to be pursued in such enforcement), the parties agree to refer these matters to the Principals for discussion for the purpose of resolution. The parties retain independent discretion authorized by law in their respective enforcement decisions.

6. In the event the parties do not resolve any disagreement about whether an enforcement action should be initiated (including the appropriateness of corrective actions and/or deadlines to be sought), FDEP and USEPA acknowledge that pursuant to Section VI. B of the MOA, USEPA retains the authority under the CWA to take direct enforcement action for any alleged violation of the FDEP-issued NPDES permit.

Herschel T. Vinyard Jr.
Secretary
Florida Department of Environmental Protection

Date 6/12/12

Gwendolyn Keyes-Fleming
Regional Administrator, Region IV
U.S. Environmental Protection Agency

Date 6/12/12

Appendix B:
STA Schematic Maps

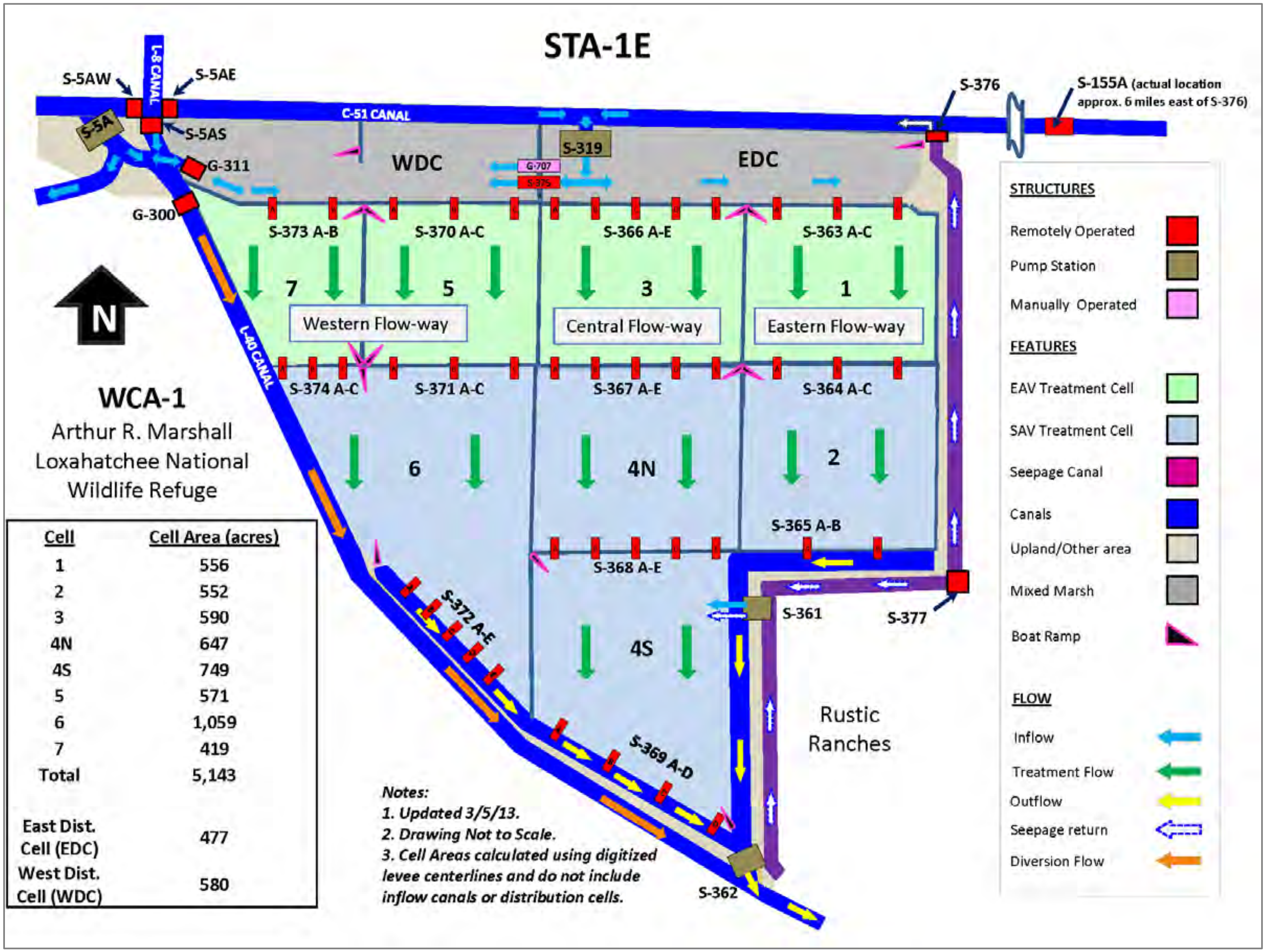
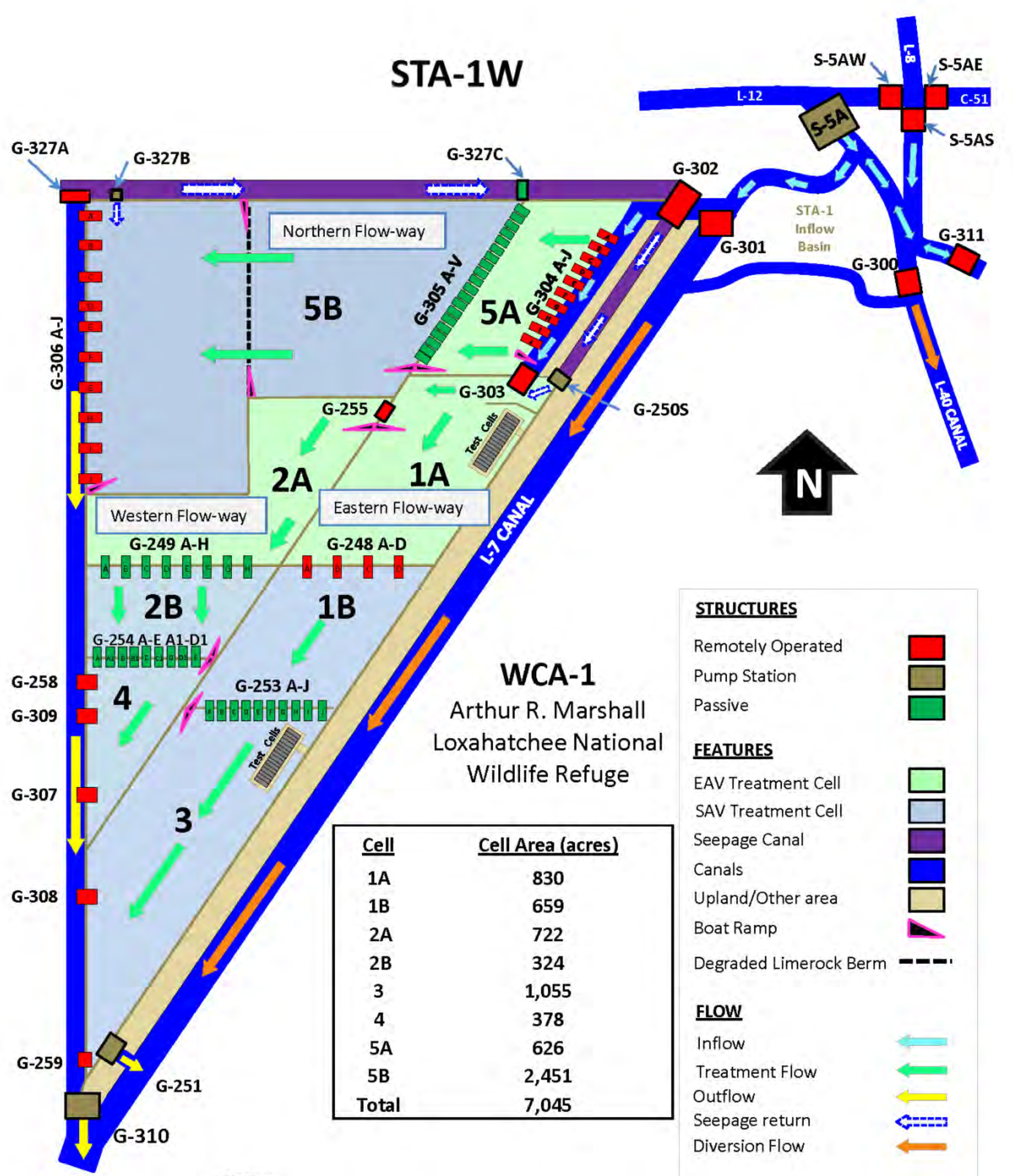


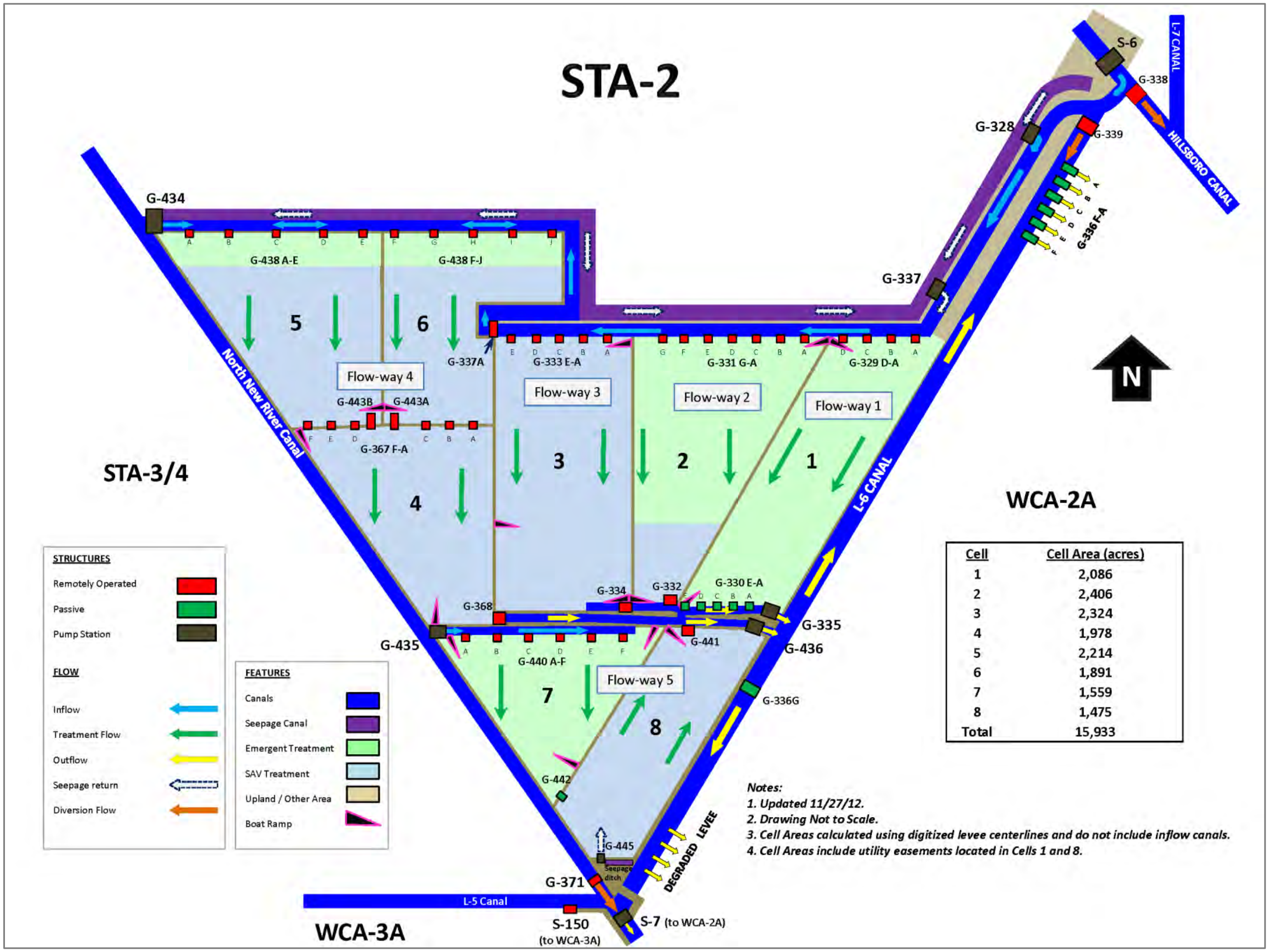
Figure B-1. Stormwater Treatment Area 1 East (STA-1E) schematic showing configurations of the treatment cells, flow direction, dominant vegetation type, and locations of flow structures.



Cell	Cell Area (acres)
1A	830
1B	659
2A	722
2B	324
3	1,055
4	378
5A	626
5B	2,451
Total	7,045

Notes:
1. Updated 9/12/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.
4. Cell Areas include utility easements and test cells located in Cells 1A, 1B, and 3.

Figure B-2. Stormwater Treatment Area 1 West (STA-1W) schematic showing configurations of the treatment cells, flow direction, dominant vegetation type, and locations of flow structures.



Cell	Cell Area (acres)
1	2,086
2	2,406
3	2,324
4	1,978
5	2,214
6	1,891
7	1,559
8	1,475
Total	15,933

Notes:

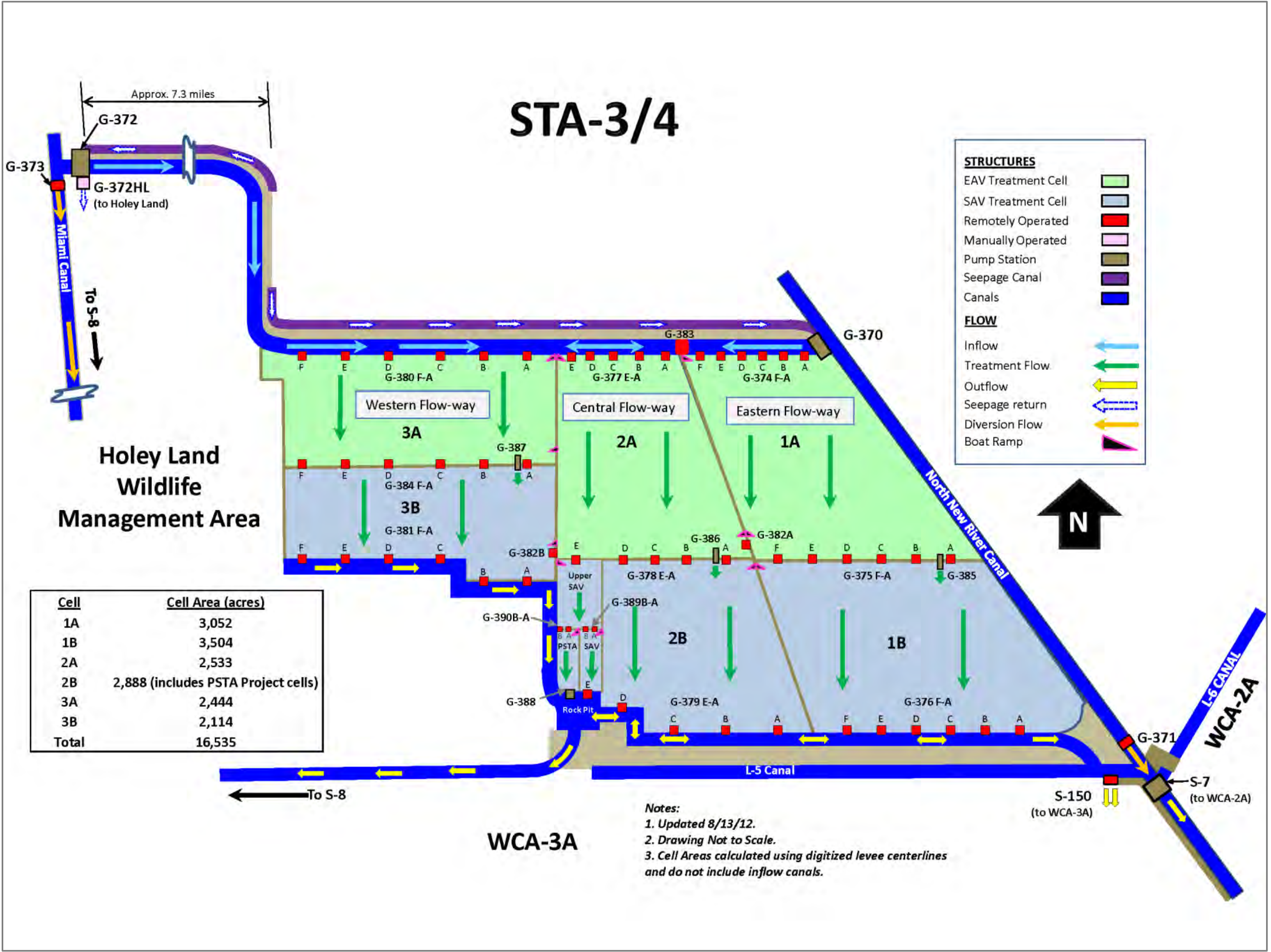
1. Updated 11/27/12.

2. Drawing Not to Scale.

3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.

4. Cell Areas include utility easements located in Cells 1 and 8.

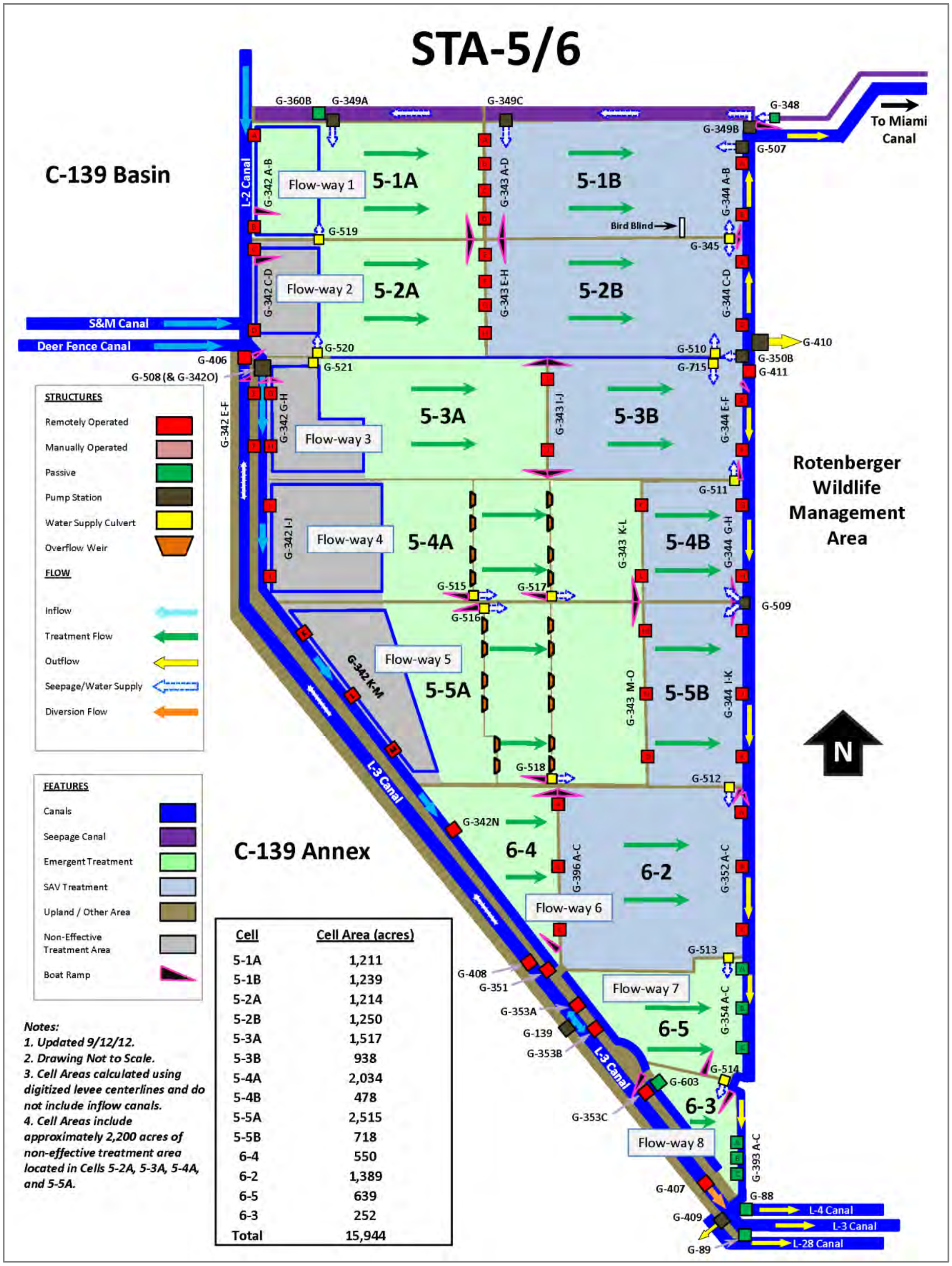
Figure B-3. Stormwater Treatment Area 2 (STA-2) schematic showing configurations of the treatment cells, flow direction, dominant vegetation type, and locations of flow structures.



Cell	Cell Area (acres)
1A	3,052
1B	3,504
2A	2,533
2B	2,888 (includes PSTA Project cells)
3A	2,444
3B	2,114
Total	16,535

Notes:
1. Updated 8/13/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.

Figure B-4. Stormwater Treatment Area 3/4 (STA-3/4) schematic showing configurations of the treatment cells, flow direction, dominant vegetation type, and locations of flow structures.



STRUCTURES

Remotely Operated	🟥
Manually Operated	▨
Passive	🟩
Pump Station	■
Water Supply Culvert	🟨
Overflow Weir	▽

FLOW

Inflow	⇦
Treatment Flow	⇦
Outflow	⇦
Seepage/Water Supply	⇦
Diversion Flow	⇦

FEATURES

Canals	🟦
Seepage Canal	🟪
Emergent Treatment	🟩
SAV Treatment	🟦
Upland / Other Area	🟫
Non-Effective Treatment Area	⬜
Boat Ramp	◣

Notes:
1. Updated 9/12/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.
4. Cell Areas include approximately 2,200 acres of non-effective treatment area located in Cells 5-2A, 5-3A, 5-4A, and 5-5A.

Cell	Cell Area (acres)
5-1A	1,211
5-1B	1,239
5-2A	1,214
5-2B	1,250
5-3A	1,517
5-3B	938
5-4A	2,034
5-4B	478
5-5A	2,515
5-5B	718
6-4	550
6-2	1,389
6-5	639
6-3	252
Total	15,944

Figure B-5. Stormwater Treatment Area 5/6 (STA-5/6) schematic showing configurations of the treatment cells, flow direction, dominant vegetation type, and locations of flow structures.

Appendix C:
Five-Year Work Plan

Implementation of the initial study plans in the Science Plan will be guided by the Five-Year Work Plan. The Work Plan currently provides an overview of nine study plans that are proposed to be conducted over the first five-year planning cycle, along with project schedules. This plan describes a suite of studies, including background information, study hypotheses and objectives, proposed methodology, activities and milestones, and estimated schedules. This initial suite of studies, along with the corresponding key questions and sub-questions that the studies address, are presented in **Table C-1**. **Table C-2** provides an estimated schedule for the nine studies over the next five-year planning horizon. To date, three studies have been reviewed and have received approval to be funded in FY2013-FY2014 and move forward by the Restoration Strategies Steering Group, while the remaining six are awaiting review and authorization (as highlighted in **Tables C-1** and **C-2**). Looking ahead, this document, including future study plan efforts, will be updated annually or as needed by the Science Plan Team.

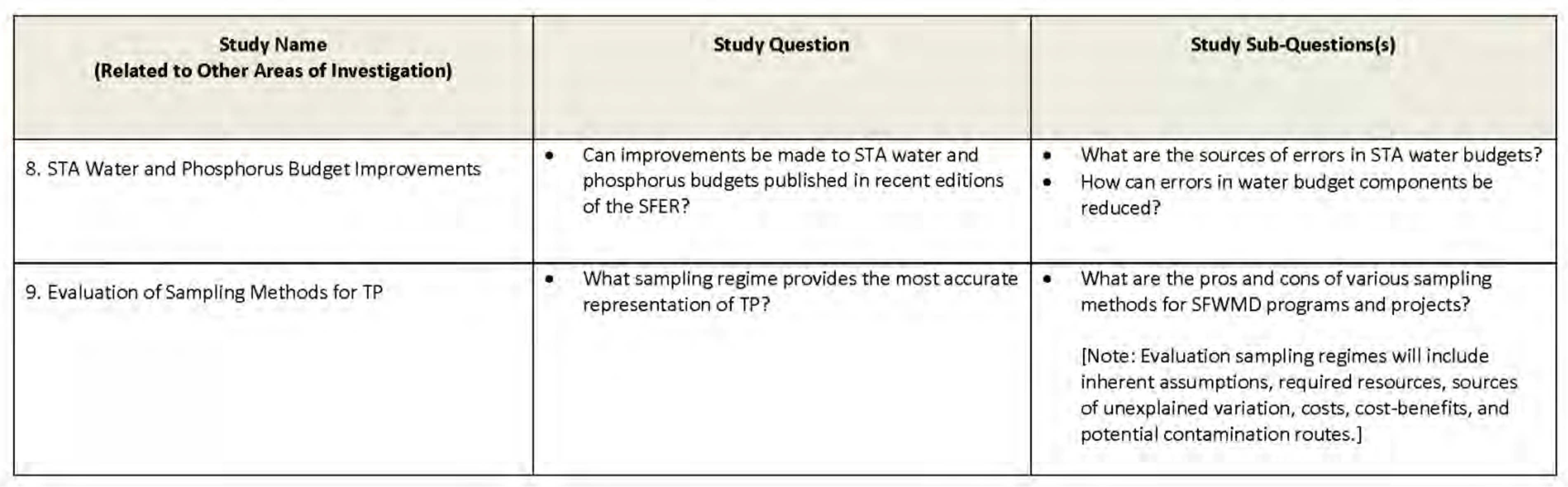
Table C-1. Proposed studies for the initial five-year cycle of the Work Plan along with the corresponding key questions and sub-questions. [Note: To date, three proposed studies with an asterisk (*) have been approved by the Restoration Strategies Steering Group. Study plans have been developed for Key Questions 1–5 and the two other areas of investigation; the complete list of the six key questions and their associated sub-questions are presented in **Table 3**; the two other areas of investigation are covered in Section 3.4.]

Study Name (Related to Key Questions)	Sub-Question(s) Study Addresses	Associated Key Question(s)
1. Use of Soil Amendments/Management to Control P Flux	• What are the treatment efficacy, long-term stability, and potential impact of floc and soil management?	2) How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?
2. Evaluation of P Removal Efficacy of Water Lily and Sawgrass in a Low Nutrient Environment of the STAs*	• What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P? • Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: can *Cladium jamaicense, Nymphaea odorata*, and periphyton mats enhance P uptake and removal in SAV cells?	2) How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains? 3) What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?
3. Development of Operational Guidance for FEB and STA Regional Operation Plans*	• How should storage in the FEBs be managed throughout the year so water can be delivered to the STAs in a manner that allows them to achieve desired low outflow P concentrations?	1) How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management? 5) What operational or design refinements could be implemented at existing STAs and future features (i.e., STA expansions, FEBs) to improve and sustain STA treatment performance.
4. Evaluate P Sources, Forms, Flux, and Transformation Processes in the STAs	• What are the sources (internal/external, plants, microbial, wildlife), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to those observed in the natural system? • What are the key physical-chemical factors influencing P cycling at very low concentrations? • Are there things that can be done in the STAs to enhance settling, filtering, and treatment of DOP and PP in the water column?	2) How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains? 4) How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?

Table C-1. Continued.

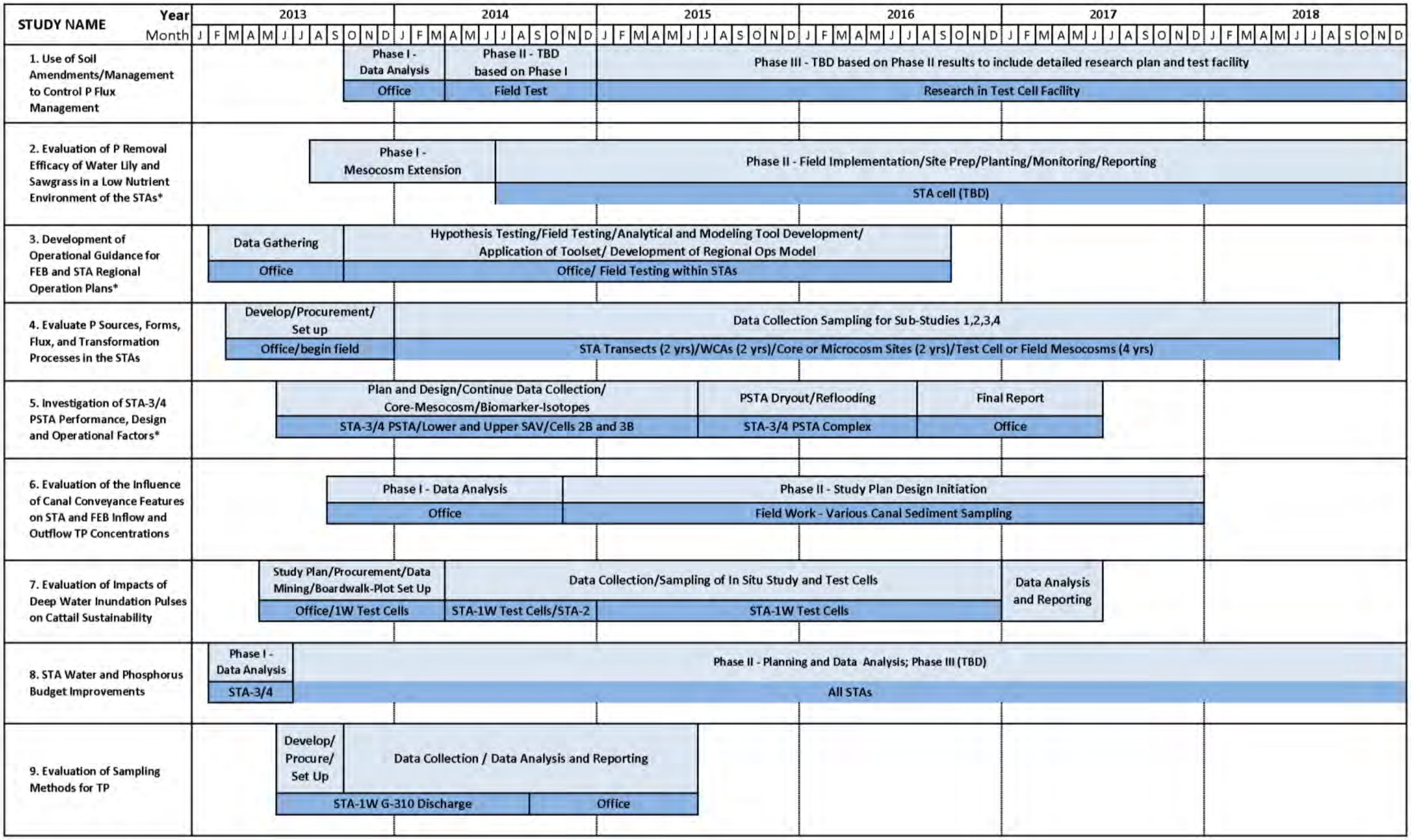
Study Name (Related to Key Questions)	Sub-Question(s) Study Addresses	Associated Key Question(s)
5. Investigation of STA-3/4 PSTA Performance, Design and Operational Factors*	• What are the treatment efficacy, long-term stability, and potential impact of floc and soil management? • What are the sources (internal/external, plants, microbial, wildlife), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system? • What are the key physical-chemical factors influencing P cycling at very low concentrations? • Are there things that can be done in the STAs to enhance settling, filtering, and treatment of DOP and PP in the water column?	2) How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains? 4) How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?
6. Evaluation of the Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow TP Concentrations	• Would changes in canal management or design improve STA and FEB performance?	1) How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management?
7. Evaluation of Impacts of Deep Water Inundation Pulses on Cattail Sustainability	• How does water depth affect sustainability of dominant vegetation?	3) What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?

Table C-1. Continued.



Study Name (Related to Other Areas of Investigation)	Study Question	Study Sub-Questions(s)
8. STA Water and Phosphorus Budget Improvements	• Can improvements be made to STA water and phosphorus budgets published in recent editions of the SFER?	• What are the sources of errors in STA water budgets? • How can errors in water budget components be reduced?
9. Evaluation of Sampling Methods for TP	• What sampling regime provides the most accurate representation of TP?	• What are the pros and cons of various sampling methods for SFWMD programs and projects? [Note: Evaluation sampling regimes will include inherent assumptions, required resources, sources of unexplained variation, costs, cost-benefits, and potential contamination routes.]

Table C-2. Estimated schedule for the nine proposed studies over the initial five-year planning horizon. [Note: Three proposed studies with an asterisk (*) have been approved to date by the Restoration Strategies Steering Group. Light blue shaded areas represent proposed work and dark blue shaded areas indicate proposed location. Information in this table continues to be reviewed/updated and is subject to revision.]



STUDY NAME Year	2013	2014	2015	2016	2017	2018
Month	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
1. Use of Soil Amendments/Management to Control P Flux Management	Phase I - Data Analysis	Phase II - TBD based on Phase I	Phase III - TBD based on Phase II results to include detailed research plan and test facility			
	Office	Field Test	Research in Test Cell Facility			
2. Evaluation of P Removal Efficacy of Water Lily and Sawgrass in a Low Nutrient Environment of the STAs*	Phase I - Mesocosm Extension	Phase II - Field Implementation/Site Prep/Planting/Monitoring/Reporting				
		STA cell (TBD)				
3. Development of Operational Guidance for FEB and STA Regional Operation Plans*	Data Gathering Hypothesis Testing/Field Testing/Analytical and Modeling Tool Development/ Application of Toolset/ Development of Regional Ops Model					
	Office Office/ Field Testing within STAs					
4. Evaluate P Sources, Forms, Flux, and Transformation Processes in the STAs	Develop/Procurement/ Set up	Data Collection Sampling for Sub-Studies 1,2,3,4				
	Office/begin field	STA Transects (2 yrs)/WCAs (2 yrs)/Core or Microcosm Sites (2 yrs)/Test Cell or Field Mesocosms (4 yrs)				
5. Investigation of STA-3/4 PSTA Performance, Design and Operational Factors*	Plan and Design/Continue Data Collection/ Core-Mesocosm/Biomarker-Isotopes		PSTA Dryout/Reflooding	Final Report		
	STA-3/4 PSTA/Lower and Upper SAV/Cells 2B and 3B		STA-3/4 PSTA Complex	Office		
6. Evaluation of the Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow TP Concentrations	Phase I - Data Analysis	Phase II - Study Plan Design Initiation				
	Office	Field Work - Various Canal Sediment Sampling				
7. Evaluation of Impacts of Deep Water Inundation Pulses on Cattail Sustainability	Study Plan/Procurement/Data Mining/Boardwalk-Plot Set Up	Data Collection/Sampling of In Situ Study and Test Cells			Data Analysis and Reporting	
	Office/1W Test Cells	STA-1W Test Cells/STA-2	STA-1W Test Cells			
8. STA Water and Phosphorus Budget Improvements	Phase I - Data Analysis Phase II - Planning and Data Analysis; Phase III (TBD)					
	STA-3/4 All STAs					
9. Evaluation of Sampling Methods for TP	Develop/ Procure/ Set Up Data Collection / Data Analysis and Reporting					
	STA-1W G-310 Discharge	Office				

Initial Study Plan Overview

File 1_RSSP_Soil-Amendments-Management_Jun13.docx

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Use of Soil Amendments/Management to Control P Flux

Principal Investigator: Mike Chimney

Key Question Study Addresses:

- How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?

Sub-question(s) Study Addresses:

- What are the treatment efficacy, long-term stability, and potential impact of floc and soil management?

Background: Biogeochemical cycling of nutrients in wetlands is mediated by a number of factors, one of which is the flux of dissolved material from the soil to the overlying water column. It is an often held belief that if the flux of dissolved P from the soil in the STAs is reduced then the concentration of P in surface water at the outflow will correspondingly decrease. It is also assumed that reducing soil P flux during STA startup will shorten the time required for the wetland to achieve its startup criterion. The SFWMD and DB Environmental, Inc. have investigated a number of approaches to reducing soil P flux in the STAs, including removing all soil down to the caprock layer, covering the soil with a layer of low-P material (such as limerock), deep tilling the soil surface horizon down into the underlying soil layers and adding soil amendments, either by broadcasting on top of or incorporation into the soil.

Study Hypotheses and Objectives:

H_0: Reducing the flux of dissolved P from the soil in an operating STA will lead to a reduction of P concentration in surface water at the outflow.

H_0: Reducing the flux of dissolved P from the soil during startup of a new STA will shorten the time required for the wetland to achieve it start-up criteria.

In practice, this study may include a number of separate sub-studies, each of which will be focused on a particular aspect of the key question. These sub-studies may include, but not be limited to:

1. Investigate the use of soil amendments to reduce soil P flux in the existing STAs. The objective would be to reduce the outflow total P concentration and achieve the WQBEL;
2. Further investigate using deep tilling to reduce soil P flux during the start-up of a new STA. The objective would be to reduce the time required for the STA to achieve its start-up criteria and begin flow-through operation; and
3. Further investigate using soil amendments to reduce soil P flux during the start-up of a new STA. The objective would be to reduce the time required for the STA to achieve its start-up criteria and begin flow-through operation.
4. Further investigate the use of adding a layer of limerock (locally obtained limestone) to cap the soil layer and reduce P flux to the water column in the existing STAs and in the additional STA-1W area.

Proposed Methodology:

Scope & Schedule

It is envisioned that this study will be conducted in three phases. Phase I is proposed to be conducted by existing staff with no need for contractual funds. The cost for conducting Phase II and Phase III studies is primarily for construction, instrumentation and O&M of new test facilities.

Phase I will entail initial efforts to:

1. Summarize data and findings of past SFWMD and DB Environmental, Inc. studies on controlling soil P flux in wetlands [1 month duration];
2. Expand the preliminary literature review on technologies for controlling soil P flux in wetlands that was produced for a Science Plan subcommittee [4 month duration]; and
3. Assess the engineering, logistical and economic feasibility of applying any of these technologies in the STAs [1 month duration]. Stakeholder and public comments received on this study plan will be addressed during Phase I and will include, but not be limited to, questions concerning the cost of implementation, logistics of applying amendments to the STAs, the long-term treatment efficacy of amendments, potential downstream toxicity, and other "marsh readiness" issues.

The results and findings from Phase I and recommendations for continuing the study will be compiled in a report. A stop/go decision then will be made whether to initiate Phase II of the study.

If the stop/go decision is affirmative, **Phase II** investigations will use soil cores or small mesocosms to screen different soil amendments, soil management methods and amendment application methods to reduce flux of dissolved P to the overlying water in short-term (days to weeks) trials [8 month duration]. Test soil may be collected from both operating STAs and the footprint of new STAs or FEBs. The results and findings from Phase II and recommendations for continuing the study will be compiled in a report. Another stop/go decision will be made based on the success of the Phase II trials whether to proceed to Phase III.

If this stop/go decision is affirmative, **Phase III** will begin with the preparation of a detailed research plan and a request for engineering support. Phase III investigations will involve long-term field trials using the most promising soil amendment(s), soil management method(s) or some combination of both. Field-trials focused on reducing outflow P concentration in existing STAs may be conducted in the STA-1W Test Cells (0.5 acre) or in new experimental wetlands (5-10 acre) constructed within an operating STA, while field-trials investigating reducing soil P flux during STA startup will, by necessity, have to be conducted within the footprint of a new STA or FEB prior to inundation. The primary analytical approach will be to compare differences in surface water P concentrations at the outflow of treatment enclosures vs. at least one control wetland (assumes that all wetlands receive that same quality of inflow water). If feasible, we will supplement the surface water data with in situ measurements of soil P flux to the water column. To the extent practicable, the field-scale wetlands will be operated to mimic the hydraulic conditions experienced in the STAs (e.g., water depth regime, flow pulsing frequency, hydraulic retention time, etc.). Data will be analyzed using a paired watershed approach. Duration of the Phase III field trials will be 4-5 years. The results and findings from Phase III and recommendations for full-scale implementation of these technologies in the STAs will be compiled in a report.

Activities and Milestones:	**Phase I:** Initiate Phase 1 – October 2013 Complete Phase 1 – March 2014 **Phase II:** To be determined, as needed **Phase III:** To be determined, as needed

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Evaluation of P Removal Efficacy of Water Lily and Sawgrass in a Low Nutrient Environment of the STAs

Principal Investigator: ShiLi Miao

Key Questions Study Addresses:

- How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?
- What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?

Subquestion(s) Study Addresses:

- What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P?
- Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types: can *Cladium jamaicense, Nymphaea odorata*, and periphyton mats enhance P uptake and removal in SAV cells?

Background:

STAs have achieved significant P reduction, but further reductions in outflow P concentrations are required. Further P removal, however, is increasingly difficult and challenging. Some of the critical obstacles are: (1) outflows consist of extremely low SRP (soluble reactive phosphorus) with a significant amount of organic P and particulate P, and (2) SAV has a quick turnover time and high decomposition rates. It is imperative to search for alternative vegetation types other than SAV that are capable of growing in a low-P condition and possess specific P uptake mechanisms (e.g., phosphatase enzymatic hydrolysis to utilize organic P) and efficient P retention strategies to accumulate P in their plant tissues, particularly in belowground components. The historical Everglades as well as the current reference areas of the Water Conservation Areas are characterized by oligotrophic P with high organic matter. Sawgrass (*Cladium jamaicense*) ridge and water lily (*Nymphaea odorata*) sloughs are dominant vegetation adapted to this low P environment. Also, various existing STA cells already contain thriving water lily (e.g., STA-1W Cell 5B and STA-2 Cell 3) and sawgrass populations (STA-3/4 Cell 1B and STA-2 Cells 1, 2, and 3). Numerous published studies revealed that sawgrass and water lily plants developed (1) critical P uptake kinetics and high phosphatase activities to utilize organic P to support their growth; (2) typical life history strategies of resource allocation, utilization, and storage allowing them to accumulate much higher tissue P relative to external habitat; and (3) vital resource retention strategies such as long life span, slow turnover and decomposition rates. The mechanisms and strategies applied by these native vegetation types provide insights to search for alternative vegetation types to maximize treatment performance in the SAV cells.

The SFWMD initiated a three-year, proof-of-concept study to investigate nutrient removal efficacy and underlying mechanisms using several native macrophyte vegetation in the oligotrophic Everglades, including sawgrass and water lily, in Fiscal Year 2010 (FY2010). The essential goal of the study is to compare the P removal of several native Everglades plant communities and test the critical hypothesis that they are able to further remove P to a lower level than the current SAV cells. The study is located at STA-1W Research facility. There are mesocosms consisting of cattail, sawgrass, and water lily monocultures, a mixture of water lily and spikerush (*Eleocharis cellulosa*), a SAV with *Najas guadalupensis* and *Chara* sp., and a control with soil (no vegetation was added). Each of the six mesocosm treatments is replicated three times, resulting in a total of 18 replicates. The study has been implemented in mesocosms utilizing the STA-1W outflow as an inflow water source and measuring major processes and functions in water, vegetation, and soil related to P removal including above- and below-ground biomass and phosphatase enzyme activities. The preliminary data obtained by the study indicates that the water lily treatment exhibited a gradual reduction of outflow TP and its TP averaged

12.4 µg/L between the period from November 2012–February 2013. Also, water lily plants generally exhibited higher phosphatase enzyme activities than other vegetation treatments evaluated. The current approach is to extend the mesocosm study for a year to evaluate whether these species have the potential for reducing phosphorus outflow concentrations in SAV cells. The expansion of this study to another platform (test cell or larger scale) will be dependent on results of the expansion study. If positive, results will be validated at a larger scale (to be determined) to further evaluate P removal efficacy and underlying P uptake and retention mechanisms of both species. The present study largely focuses on tasks that will be completed during the extension period (Phase I), while those related to the large-scale expansion (Phase II) will be addressed briefly.

Study Hypotheses and Objectives:

Hypotheses: (1) water lily and sawgrass vegetation will reduce concentrations of the recalcitrant P fractions of the outflow to levels lower than what are achieved via SAV treatment; (2) a combination of greater extracellular phosphatase enzyme activities, high P storage in belowground tissue, and slow decomposition for water lily and sawgrass is the major mechanism to achieve extremely low P levels; and (3) lack of dense roots, quick turnover rate, fast decomposition, and high tissue P concentration may constrain SAV performance in low P environment.

Objectives: (1) evaluate nutrient removal efficacy of water lily and sawgrass vegetation under a very low P condition; (2) examine major processes and mechanisms affecting P removal in water, soil and plants; and (3) identify and compare major nutrient pathways and storages in each vegetation type.

Proposed Methodology:

Location, Scope, and Duration

The ongoing mesocosm study is located at STA-1W Research Site and mesocosm work will be extended to November 2013 (Phase I Mesocosm extension). The study has been designed and implemented at the District under the close supervision of District scientists since the inception three years ago. District scientists also have participated in various sampling activities and the water quality samples have been analyzed by the District Lab. Tasks implemented during the extension phase will be conducted via a contract to continue monitoring water quality, conduct two-time intense sampling events, and develop a P dynamic model. The model will be developed and tested using the data obtained from the mesocosm study including the P capture pathways and storages in each of the vegetation treatments. The model will be utilized to evaluate the P retention mechanisms. The data analysis and report associated with the extension will be completed by July 2014. The expansion of the study to large-scale in field condition will be implemented after July 2014 (Phase II field implementation). This phase most likely will consist of four major components: site and plant preparation, plant planting and establishment, monitoring, and final reporting.

Phase		Brief Scope	Duration
1	**Mesocosm extension**	- Biweekly WQ,YSI, redox measurements (including internal P gradient and P process modeling)	9 months
		- Two-time intense sampling events (including P enzyme, stable carbon isotope, plant productivity and leaf tissue, and diel DO), data analysis, and P dynamic modeling	8 months
		- Conduct final study harvest including soil sampling and plant harvest	4 months
		- Final data compiling, analysis, and reporting on the mesocosm experiments. Upon completion of the analysis and reporting of the experimental data, a	4 months

		feasibility report will be developed covering the activities, challenges and probable expenses of a field scale implementation of the mesocosm work. A Go/Stop decision will be made at this point.	
2	**Field implementation**		
	Site and plant Preparation	- Site preparation: Site survey and water structure preparations: 1) prepare the physical layout site; 2) conduct a leak test; 3) check or fix inflow and out flow structure, build water flow system to ensure various flows and water depths (40-60 cm) flow test about the flow rate control - Plant preparation: Prepare or purchase enough water lily and sawgrass plants	6 months
	Planting and establishment	- Planting: Measure initial plant and soil nutrient analysis, water levels and flow rates, internal plot measurements (plant above-ground growth measurements and tissue nutrient), and biweekly WQ sampling	8 months (may vary depending on plant growth)
	Monitoring	- Water depth and flow rate will be approximately 40-50 cm and 2.6 - 5.2 cm per day, respectively -Start plant above-ground growth measurements and tissue nutrient analysis, biweekly WQ sampling, diel YSI , and P enzyme measurements	36 months
	Final data analysis and Report	- Data compiling, analysis, and final report	6 months

Parameters to be tested:

1) WQ and turbidity measurement
2) Post-WQ YSI and redox measurement
3) P enzyme measurement and analysis
4) Stable carbon isotope analysis
5) One time above-ground leaf nutrient analysis
6) Final study harvest including soil P species in floc and soil profile, plant harvest including above- and below-ground tissues

Activities and Milestones:	**Phase I: Mesocosm study extension** 1.1 Study implementation and biweekly WQ sampling January–November 2013 1.2 Two-time intense sampling events, and development of P dynamic model June 2013–March 2014 1.3 Final harvest – November 2013–February 2014 1.4 Final data compiling, analysis, and reporting – March–July 2014 Draft Reporting – May 2014 Final Reporting – July 2014 **Phase II: Field implementation** 2.1 Site and plant preparation –August–December 2014 2.2 Planting and establishment – January 2015–August 2015 2.3 Monitoring – September 2015–September 2018 2.4 Reports – Middle-term project reporting – December 2017 Final Reporting – December 2018

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Development of Operational Guidance for FEB and STA Regional Operation Plans

Principal Investigator: Akin Owosina

Key Questions Study Addresses:

- How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management?
- What operational or design refinements could be implemented at existing STAs and future features (i.e., STA expansions, FEBs) to improve and sustain STA treatment performance.

Sub-question(s) Study Addresses: How should storage in the FEBs be managed throughout the year so water can be delivered to the STAs in a manner that allows them to achieve desired low outflow P concentrations?

Background:

The SFWMD is implementing the Restoration Strategies program to complete projects that will create more than 6,500 acres of new Stormwater Treatment Areas (STAs) and 110,000 acre-feet of additional water storage through construction of Flow Equalization Basins (FEBs) in order to achieve desired low phosphorus (P) concentrations for discharges from the STAs to the Everglades.

This work plan will outline the efforts to pursue modeling assisted development of operational guidance for the Restoration Strategies program. This is a three and a half year effort that will be conducted at SFWMD headquarters by SFWMD staff and will include hydrologic, hydraulic and water quality modeling in support of the development of initial operational guidance for the A-1, L-8 and C-139 Annex FEBs, associated STAs and the surrounding regional water management infrastructure. The current proposed study is expected to be the first phase of work within a larger series of efforts spread across the construction, implementation and monitoring work associated with the Restoration Strategies program. This timeline is illustrated in **Figure 1**.

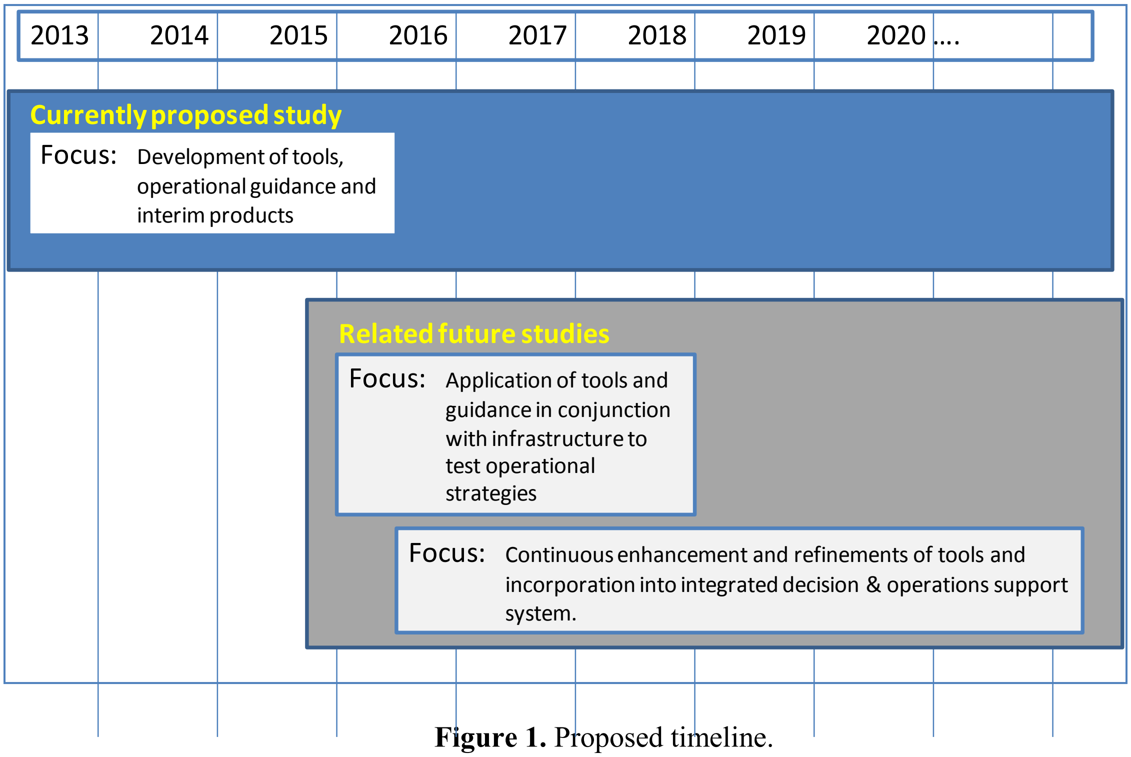


Figure 1. Proposed timeline.

FEBs and STAs can be considered as engineering systems that are designed to provide a quantifiable level of performance in terms of flood control, P treatment, other regulatory compliances and environmental sustainability. Information gathering, field testing and model hypothesis testing will be performed in order to improve the understanding of FEB/STA system dynamics in terms of response times, response delays, attenuation rates, and numerous other relationships between control variables (gate openings) and state variables (water level, P concentration). Development and implementation of analytic and computer models at varying temporal and spatial scales will help to incorporate improved understanding of the system dynamics into tools that can assist in analyzing infrastructure design and in optimizing operational control algorithms.

This effort will at times support studies that are also being conducted in the Science Plan and may also leverage work performed by others into operating protocols and decision support tools that clarify real-time operating protocols by integrating multiple system considerations with the goal of achieving consistent, sustainable low outflow P concentrations. It is also anticipated that staff across the SFWMD, will work with the modeling resources to help develop and review FEB and STA operational guidance language. It is anticipated that these protocols will also be revisited over time as FEBs are constructed and operated and additional experience is gained.

Study Hypotheses and Objectives:

Hypotheses: N/A

Objectives: The study scope shall include the development of operational guidance for FEBs/STAs in a manner that allows STAs to achieve the lowest outflow phosphorus concentrations, and the development of regional operational plans. 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. The primary questions to be answered by this effort include the following:

1. How should the individual FEBs and STAs be operated within the constraints of the larger water management infrastructure to maximize the potential to meet the WQBELs for the STAs?
2. How should inflows and outflows to and from the STAs be managed to achieve desired low outflow phosphorus concentration?
3. How should storage in the FEBs be managed throughout the year so that water can be delivered to the STAs in a manner that allows them to achieve desired low outflow phosphorus concentration?
4. How should vegetation management and hydraulic considerations be factored into operational protocols?
5. How are non-STA regional objectives (flood protection, water supply, environmental deliveries, etc.) considered in STA management protocols?
6. To what extent are pulsed versus continuous operations critical to phosphorus uptake performance and does this affect the need for remote system controls?
7. Which FEB filling and release strategies minimize STA dry-out or bypass?
8. Are there operational strategies to minimize the effects of episodic events or to address STA rehydration following a dry-out?

It is recognized that requirements will evolve over the course of the effort, so continuous project reporting and requirements gathering is envisioned and outlined in the Progress Reporting and Coordination section of this study plan. Additionally, effort is needed to help identify performance metrics to help assess progress toward answering these questions and measuring progress toward objectives.

Proposed Methodology:

Tasks

The Restoration Strategies program planning relied primarily on the Dynamic Model for Stormwater Treatment Areas (DMSTA) for water quality modeling, predicated on underlying hydrology provided by the South Florida Water Management Model (SFWMM). While this approach was appropriate for and will continue to be used for planning purposes, real time operations support will focus on consolidating multiple sources of information into a broader set of modeling and decision support tools including the

Regional Simulation Model (RSM).

This effort, to be performed primarily by members of the Systems Modeling Unit (SMU) of the Hydrologic and Environmental Systems Modeling (HESM) Section, is aimed at integrating multiple considerations of regional hydrology and FEB and STA performance dynamics into operational decision support tools. The work includes, but is not limited to, development and application of hydrologic, hydraulic and water quality modeling to test guidance for operation plans. The following work tasks will be implemented throughout the course of the effort toward achieving the project requirements:

- Information Gathering
  - Field tests: Hydraulics & water quality (to be performed or coordinated by HESM staff)
  - Incorporation of information from other forums
- Development of hydraulics, hydrologic and operational model parameters
- Development of local (STAs/FEBS) operating strategies and rules
  - Formulation of overarching operation strategies
  - Local gate opening / pump criteria
  - Application of system optimization tools
- Development of the regional system operating strategies and rules
  - Formulation of overarching operation strategies
  - Regional routing decision trees or algorithms
  - Application of system optimization tools
- Project documentation including scientific articles

Approach

A generalize lifecycle process is shown in **Figure 2** below that encompasses the proposed workflow for the project and organizes the project tasks.

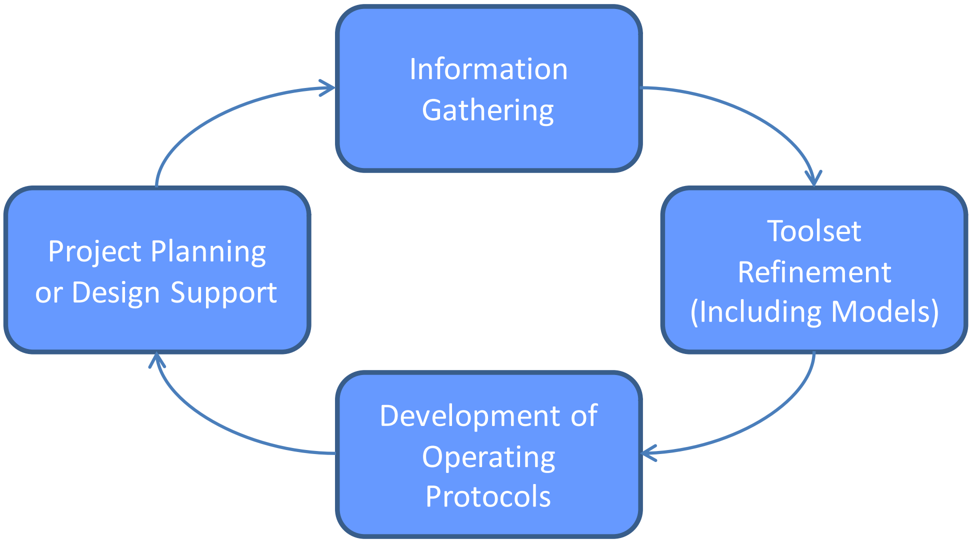


Figure 2. Lifecycle Process

There are currently no "comprehensive design and operating manuals" for STAs or FEBs, which can systematically achieve the desired low phosphorus concentrations at the outflow. By continuously cycling through these tasks, it is possible to expand knowledge of STAs/FEBs hydraulic, vegetation resistance and water quality performance and then to bring this information to bear quickly within the Restoration Strategies project implementation timeline. The information gathering step will include extensive historical data analysis and will take advantage of available data and studies to begin the development of a framework for operational decision making. The project will continue to utilize new information as it becomes available from multiple forums, including but not limited to outcomes of the Restoration Strategies Project Science Plan, updated project plan features/detailed designs, constraints or objectives identified in project permits and coordination with control room operators and water managers to understand where operational flexibility exists. To gain additional information, this study shall also include design and implementation of a series of field experiments targeted at further identifying key hydrologic or water quality parameters for tool development and refinement.

The data obtained through the various information gathering efforts will be applied to develop new or improve upon existing analytical tools (including models) that seek to represent the complex water quantity and water quality aspects of FEB and STA operation. It is anticipated that the toolset refinement aspect of this project will primarily utilize the RSM due to its relative architectural and input flexibility, but will also consider improvements to implementations of the SFWMM, DMSTA, and hydraulic/hydrodynamic tool suite (e.g., TUFLOW).

This study will use models at the appropriate scale, complexity, and rigor to support development of operating protocols that allow a balancing of the various operational objectives and outcomes in a manner that can inform timely decision making. Planned efforts will consider tools used for existing models and any useful tool that could help accomplish the intended role for models in this study.

As tools continue to be refined and are available for project support, a decision support framework will be developed to identify operational guidance for projects and water managers. A key aspect of this step of the work will include the use of inverse modeling and system optimization tools (such as the iModel) to identify mechanisms by which multivariate, competing objectives can be balanced, The decision support system will be developed to consider both short and long-term goals of FEB and STA management and will also attempt to explicitly identify potential risks or benefits of decisions in the context of permit compliance. The decision support system will be designed in a way to facilitate transparent dissemination of information, providing context to users on why & how certain protocols were selected to help facilitate acceptance or feedback.

It is anticipated that implementation of this lifecycle will, at a minimum, result in the following advancements:

1. Improved understanding and formulation of vegetation resistance
2. Improved understanding of flow dynamics (e.g., governing equations of flow)
3. Improved terms and definitions and STA/FEB operations
4. Development of analytical tools for STAs/FEBs monitoring
5. Development of tools for STAs/FEBs structures automation
6. Development of analytical/numerical tools for STA and FEB designs
7. Development of analytical tools for STA/FEB operations
8. Improved parameterization and formulation of computer models
9. Development of a decision support framework for operational guidance
10. Improved application of analytical and modeling tools in project planning and design support
11. Development of communication products to explain project outcomes

Initial Work Breakdown

This section of the work plan will outline the initial project startup work breakdown. The project will begin with an initial period of information gathering followed by an initiation of the project lifecycle (identified in Figure 3.2.1). Once the lifecycle is initiated, quarterly work tasking will be performed under the existing HESM Work Intake System (WIS) procedures. Project guidance and feedback will be sought through the reporting framework identified in the Progress Reporting and Coordination section of this study plan.

A primary initial objective of the information gathering step is to further understanding of how vegetation roughness changes within STAs and FEBs (as a function of water depth, vegetation density, and vegetation type) and how the flow conditions change under various extreme operational conditions (i.e., flood control vs. phosphorus treatment). While historical data analysis will be performed and can provide some answers, a series of structured fieldwork is proposed to help determine both bulk vegetation resistance and vegetation resistance spatial distributions within STAs and FEBs. The bulk resistance is useful in understanding the overall systems response (e.g., how long would it take to empty or fill an STA/FEB). The spatial and temporal variation of resistance is important during the management of hydraulics within STAs and FEBs, the management of water depth (stage duration) and short-circuiting. Outcomes from these tests will be combined with other sources of information by late-2013 and used to identify proposed toolset refinement, thus initiating the project lifecycle.

Initial WBS Task 1: Information gathering

1) Review of literature / project data
    Review available literature on STA operations management
2) Historical Data Analysis
    a) Collect, review and analyze historical flow data related to the STAs for applicability to current Restoration Strategies objectives
    b) Collect, review and analyze historical water quality data related to the STAs for applicability to current Restoration Strategies objectives.
3) SMU Meetings with SFWMD Subject Matter Experts
    a) Obtain input from SFWMD project managers, modelers, water managers, permit compliance staff, etc., with experience in operational decision support and meet to gather perspective
        i) KBMOS
        ii) Big Cypress real-time Mike modeling
        iii) Lake Okeechobee operations/objectives
        iv) Others
    b) Summarize findings in brief memoranda

Initial WBS Task 2: Field test execution

1) Site Identification
    a) Identify STA sites that world be suitable representative for investigations to determine vegetation resistance, fate and transport characteristics, and similar parameters necessary for conceptualizing and parameterizing an STA model (e.g., SAV, EV, open water, etc.)
    b) Develop a brief summary report of available test locations and reasons for site selections
2) Design and carry out wave experiments
    a) Develop a brief summary report of experiment design
    b) Determine equipment, field work, and control room and pump station crews support needed for experiment and summarize expected test outcomes
    c) Implement field experiments

Initial WBS Task 3: Identification of potential model refinements

1) Field Test Data Analysis
    a) Identifying and quantifying vegetation and topography characteristics that will be used to understand the STA hydraulics by analyzing and classifying the data
    b) Develop a brief summary report of data collected, methods used for data analysis, results, and its implication to FEB/STA operation protocols and consolidate data into a database for use by other efforts
    c) Develop analytical formulas relating the results of multiple field tests to response times, residence times, peak inflow and outflow rates, hydraulic efficiency and treatment efficiency
2) Identify Modeling Tools
    a) Review existing HESM project production models, the HESM Water Quality Modeling Strategy and current modeling contract reviews to identify candidate models for tool enhancement
    b) Meet with project team leads to agree on tool refinement strategy
    c) Initiate a stand-alone RSM application to test model parameterization
    d) Work with developers of other models considered candidates for refinement

Progress Reporting and Coordination

Multiple avenues will be utilized to report on project progress, to identify potentially beneficial cross-over collaborations with other SFWMD projects and to continually check and refine project requirements:

- Within HESM, project progress will be reported at the regularly scheduled Restoration Strategies Update Bi-weekly Meeting and project tasking & resource decisions will be vetted though the HESM Work Intake System. Technical findings will be presented to the HESM Technical Solutions Forum (TSF) for review.
- Project status will be reported to the Restoration Strategies Science Plan Coordination forum at least quarterly and technical findings will be presented for review and feedback as products are developed.
- Major technical findings will be made and presented for internal and external review.
- The primary forum for inter-SFWMD coordination of this effort will be the Restoration Strategies Modeling Coordination Meetings which include representatives from the Everglades Policy & Coordination, Engineering and Operations groups at the SFWMD.

Activities and Milestones:

This project will span a three and a half year timeframe comprised of an initial seven month startup period of information gathering beginning in March 2013 and then a continuous, repeating process of testing, tool development and project planning/design support (as shown in Figure 3.2.1) through FY2016. Within the information gathering phase, each field testing cycle is expected to be on the order of three months from initial study design through final execution. These tests will be followed by a multiple-month data analysis and algorithm development period.

The project deliverables and schedule are shown below:

Task #	**Deliverable**	**Due Date**
1	Information gathering and review of SFWMD & external operating strategies. Review of permit guidance/constraints.	Ongoing through September 30, 2013
2	Assessment and hypothesis testing of managed wetland system dynamics through field experimentation. Testing will encompass STA cells with varying vegetation and FEBs as they come online.	Ongoing through June 30, 2016
3	Analytical and modeling tool development and testing. Work will seek to incorporate information from field testing, science plan and project planning/design arenas into a project support toolset including models.	Ongoing through September 30, 2016
4	Application of toolset to aid in FEB/STA design. As project planning and design progress, tools ready for production work will be applied.	Ongoing through September 30, 2016
5	Development of FEB/STA/regional operating protocols; will continue to evolve over time as various phases of design, permitting and operation are achieved and as tools reach maturity	Ongoing through September 30, 2016

Initial Study Plan Overview
File 4_RSSP_P-Sources-Forms-Flux_Jun13.docx

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Evaluate P Sources, Forms, Flux, and Transformation Processes in the STAs

Principal Investigator: Delia Ivanoff

Key Question Study Addresses:

- How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?
- How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?

Sub-question(s) Study Addresses:

- What are the sources (internal/external, plants, microbial, wildlife), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to those observed in the natural system?
- What are the key physical-chemical factors influencing P cycling at very low concentrations?
- Are there things that can be done in the STAs to enhance settling, filtering, and treatment of DOP and PP in the water column?

Background: High P concentrations and loading influence STA performance, particularly at the front end of the treatment flow-ways. Programs such as BMPs and sub-regional controls that reduce inflow loads are considered in the mix of management options, and will continue to be researched and refined in the District's BMP program. However, many years of STA performance data demonstrates definitively that internal processes are critical to STA outflow TP levels These previous analyses show that at the lower end of the treatment train, where the concentration and load have already been reduced significantly, inflow P concentration and loading do not have any significant correlation with outflow P concentration, suggesting that other factors (e.g. internal flux, etc.) might be the key influencing factors.

Biogeochemical cycling of P within the STAs is controlled by various mechanisms and influenced by several physical, chemical, and biological factors. While numerous publications address these mechanisms and factors in both natural and constructed wetlands, there is limited information identifying the key drivers and the magnitude of their influence in low phosphorus treatment wetland systems. A better understanding of the mechanisms and key factors is essential in formulating management strategies to further reduce and sustain low outflow TP concentrations in the STAs.

Total phosphorus in natural waters is generally comprised of soluble reactive P (SRP, an operationally defined parameter, also referred to as dissolved inorganic P, DIP), particulate P (PP), and organic P. SRP or DIP is the form that is generally accepted as readily available for plant and microbial uptake, and is measured analytically in water that has been filtered through a >0.45 µm filter. PP, which is the portion of total P associated with particulates, is generally comprised of both living organisms (e.g. bacteria, phytoplankton), detrital, and other non-living particulates (Noe et. al, 2007). Organic P is the form of P associated with organic molecules, and is oftentimes categorized as either labile (e.g., simple monoesters) or stable (complex organic compounds or diesters). Dissolved organic P (DOP) is operationally defined as the fraction of organic P that passes through a >0.45 µm filter. Additional organic P may be associated with particulate matter in the water.

Historical data indicates that while the inflow TP is comprised largely of SRP and PP, the outflow TP of a well-performing STA cell or flow-way has very low SRP concentrations and is primarily comprised of PP and DOP. Outflow SRP concentrations can also be significant when a cell or flow-way is not working properly, for example, during the first flow event after long periods of no flow, or after rehydration after dry conditions. Additional historical data analysis will be conducted to verify these findings at the cell and flow-way levels.

The sources of phosphorus in STA outflows consist of the following (Kadlec and Wallace, 2009):

- Residual P from inflow that has not settled (PP), been converted via biogeochemical transformations (PP and DOP), and excess SRP that was not consumed by microorganisms, periphyton, or plants or has not reacted with cations such as Ca.

- Phosphorus from organic matter decomposition and upward flux from soils within the STA
- Phosphorus associated with suspended particulates including suspended solids, plankton, and detritus

Some of the unknowns related to the key questions are:

- The actual composition of PP (e.g. biomass, necromass, inorganic matter) and DOP (monoesters, diesters, more complex molecules) in STA outflow water
- Origin of outflow residual SRP, PP, and DOP
- Factors influencing residual TP concentrations at flow-way and STA outflows
- Equilibrium P concentration (concentration of P in the water column at which there is no net flux from the soil to the water column)
- Phosphorus diffusion coefficients from the soil to the water column
- Actual role of enzymes in P cycling and factors affecting enzyme activities in the STAs
- Influence of P translocation by macrophytes on water column P concentrations
- Phosphorus cycling and spiraling patterns, particularly at the end of the STAs
- Stability of accreted P. Previous studies indicate that recently accreted soil is primarily composed of diesters (Turner et al., 2006; Pant et. al, 2002), which are easily degraded in most soils
- Optimal condition or strategies that can help further reduce residual TP at the outflow

References:

Kadlec, R.H. and S.D. Wallace. 2009. Treatment Wetlands, Second Edition. Taylor and Francis Group, Boca Raton, FL.

Noe, G.B., J.W. Harvey, and J.E. Saiers. 2007. Characterization of suspended particles in Everglades wetlands. Limnology and Oceanography 52:1166-1178.

Pant, H. K., K. R. Reddy, and F. E. Dierberg. 2002. Bioavailability of Organic Phosphorus in a submerged Aquatic Vegetation-Dominated Treatment Wetland. J. Environ. Qual. 31:1748-1756.

Turner, B.L., S. Newman, and J.M. Newman. 2006. Organic phosphorus sequestration in subtropical treatment wetlands. Environmental Science and Technology 40:727-733.

Study Hypotheses and Objectives:

The initial list of hypotheses for this study are listed below:

1. The residual P composition at the outflow varies among the different STAs and is less recalcitrant than those observed in similar trophic zones in the natural areas.
2. Because of greater productivity, the biological sources of P (i.e. flora and fauna) in the outflow cells of the STAs are proportionally greater and less tightly coupled than those within mesotrophic and unenriched ecosystems in the natural areas.
3. Biotic transformations of residual dissolved organic P (DOP) and particulate P (PP) will be maximized by increased vegetative and microbial activity.
4. Breakdown of residual organic P will be enhanced by increased UV radiation within the cells.
5. Shallow conditions within SAV dominated communities will increase the proportion of P precipitated as Ca-phosphates.
6. Increased water column phosphomono- and phosphodiester activity will result in greater turnover of the water column DOP pool, and greater turnover of floc DOP.
7. Enzyme activity will be optimized in the areas with greater divalent cation concentrations and during higher seasonal temperatures.
8. The lowest TP concentrations in the outflow cells will be accomplished via a vegetative mosaic of emergent and SAV/periphyton communities.
9. Organic acids produced by wetland plants can influence P solubility.
10. Major ions such as calcium, magnesium, iron, and sulfate have a strong influence on the outflow P species composition and concentration.

Additional hypotheses may be developed prior to initiation of the sub-studies.

This study has multiple objectives: (1) characterize the different P forms and cycling along the STA inflow to outflow gradient, (2) understand the composition of the residual P at the outflow, (3) determine the factors affecting P cycling along the gradient, (4) understand the differences in P forms, factors, and processes among different flow-ways (best-performing versus poor-performing), and (5) compare the findings with natural areas (WCAs). Information and findings from this study will serve as basis for recommendations to improve STA performance.

Proposed Methodology:

Prior to initiating any field studies, existing data will be compiled (from different sources), reviewed and analyzed. The final study plan, including sampling design will be based on previous findings and information gaps to help address the specific study questions.

Location, Scope, and Duration

Due to the complexity of the question and the investigations needed to answer these questions the following sub-studies are suggested:

Substudy	Location	Brief Scope	Duration
1	STA transects	Sampling at limited locations along transects to quantify and characterize the sources and different forms of P, enzyme activities, and key factors that influence P storage and cycling (physico-chemical, hydrologic, microbial, biota). Include best performing and poor performing cells and flow-ways.	2 years
2	WCAs	Focused sampling at discrete sites that capture different habitat and trophic conditions to identify P sources, quantify and characterize the different forms of P, associated enzyme activities, and key factors influencing P storage and mobilization for comparison with the findings in the STAs.	2 years
3	Core (or microcosm) Studies	Multiple soil cores will be collected along the study transects and incubated with various treatments that could isolate further the key influencing factors. For example, add calcium, magnesium, sulfate and iron, vary water depths/UV exposure, with and without biota.	2 years*
4	Test cell or field mesocosms	Manipulative studies (test cell scale) to isolate and test the influence of key variables, e.g. to compare with and without vegetation differences, test response for when SAV dies off and decomposes, test soil accretion characteristics, etc.	4 years*

*Sub-studies 3 & 4 will be best conducted after the historical data analysis and preliminary surveys, so that the most appropriate test variables can be determined.

In addition, a comparison of properties and mechanisms within a soil-less treatment area (STA-3/4 PSTA project site; see separate study plan) will be included in the historical data analysis and in the evaluation phase of this study, prior to conducting substudies 3 and 4.

Detailed Activities: The approach to implementing the studies is as follows:

1) Refine conceptual models (**Figures 1** and **2**)
2) Historical data analysis
3) Methodological assessments
4) Study implementation for sub-studies 1 and 2
5) Study implementation for sub-studies 3 and 4

Some of these steps will occur concurrently, while others will be sequential.

1. Given the complexities of P cycling and the multiple scales (microbial through landscape), multi-tiered conceptual models (**Figures 1** and **2**) will be refined and used to focus the historical data analysis efforts and help prioritize research studies.

2. Any existing data collected in the STAs and WCAs related to the parameters that will be measured and hypotheses to be tested will be compiled, reviewed based on usability, and then analyzed. Study sites will be selected based on the outcome of the historical data analysis

activities. Historical data analysis will be conducted in a way that internal processes can be linked to the STA cell outflow TP results.

3. Many of the noted uncertainties in P cycling are because of methodological limitations. Thus, as part of the Science Plan methodological advancements will be evaluated and those that appear to help answer the key hypotheses will be tested. Specific examples include: DOP speciation in the water column, methods of P analysis with lower minimum detection limits (MDL), methods of total suspended solids quantification with lower MDL, methods to measure diffusion rates independent of other fluxes, metrics of biomarkers versus stable isotopes.

4. Sub-studies 1 and 2 -STA transects, along the flow direction that represents the entire flow-way, will be established, which will include more frequent sampling stations in the polishing cells. Flow-way selection criteria will include: (1) best-performing vs. poor performing flow-ways, (2) old vs. new flow-ways, (3) sandy soil versus peat soil areas, and (4) historic P loading. Current transect studies may be included in this project, but with additional parameters and more frequent sampling to better address project questions.

   Discrete sites in WCA that reflect different habitats and trophic levels will be selected. Site selection criteria will include: (1) sites that reflect background, moderately and highly enriched conditions, with greatest emphasis placed on sites near transitional zones, (2) different habitat conditions, e.g., open water/SAV versus EAV marshes, and (3) peat versus marl sites. Current study sites, such as those in the active marsh improvement projects, may be incorporated into this project.

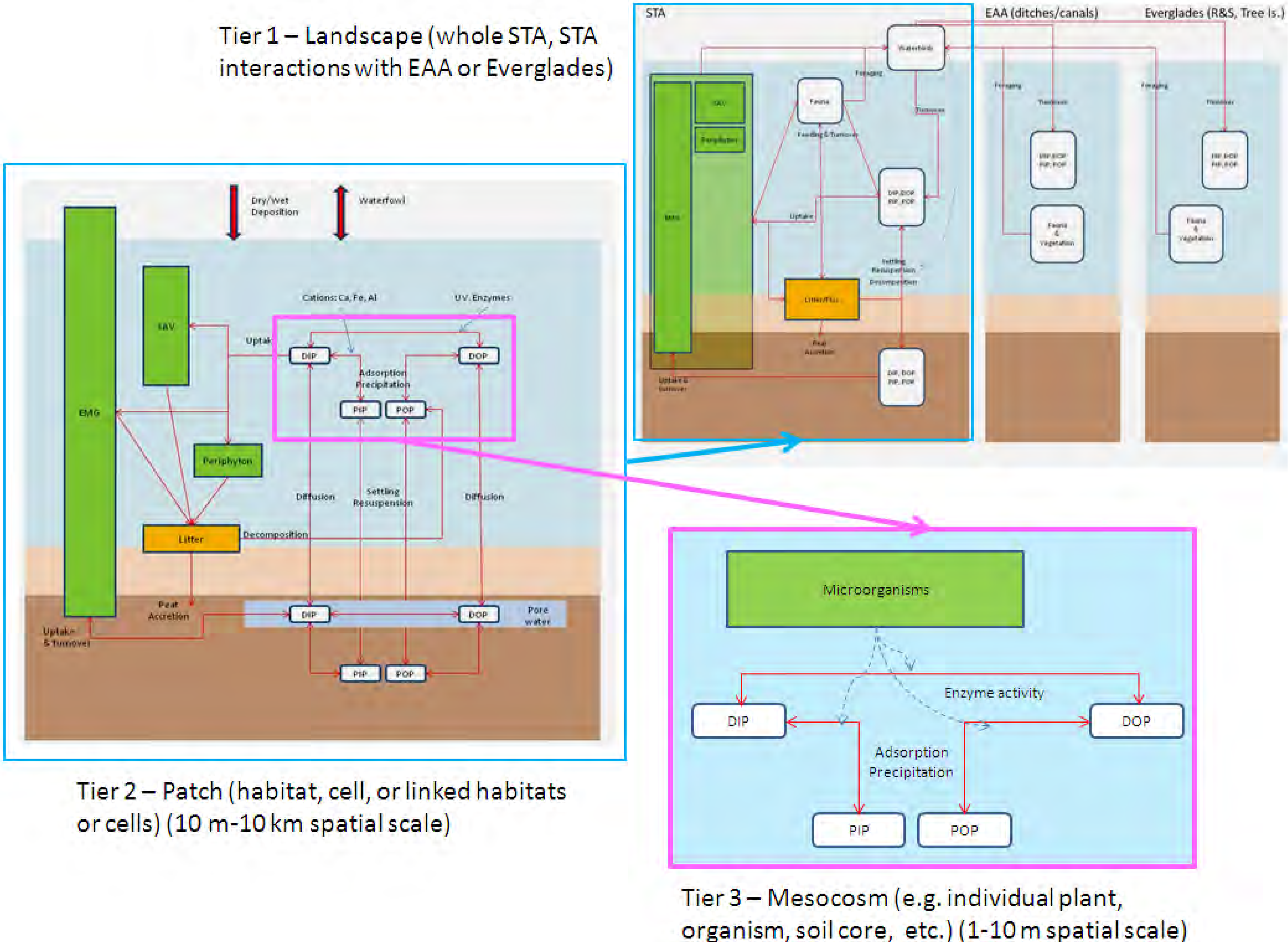
Parameters to be tested:

1. *Surface Water.* P species in water column along the STA, PSTA, and WCA transects. To minimize the uncertainties due to variables such as nutrient and hydraulic loading, variable concentrations of inflow water, and temporal variability, sampling will have to be at a frequency that can capture various flow conditions. More detailed examination of the nature and composition of residual particulates and organic P will be part of this study. Other parameters relevant to P cycling will also be analyzed, e.g., calcium, magnesium, ammonia, nitrate, organic carbon, iron, sulfate, sulfide, pH, DO, etc. Parameters relevant to water and particulate movement will also be measured (e.g., specific conductivity, chloride).
2. *Soil and Porewater.* Soil and porewater samples will be collected along the STA, PSTA, and WCA transects. Multi-level wells will be installed to enable repeated porewater sample collection at multiple depths; target collection frequency is monthly. Soil samples will be collected at multiple locations along the transects.
3. *P sources, Movement and Cycling Rates*. Biomarkers (e.g., lipids of sediment and plant tissues) and/or stable isotopes (e.g. stable isotopes of carbon, nitrogen, and oxygen). This will help understand sources and pattern of particulate and organic P movement along the flow-ways.
4. *Microbial Activity*. The activity of key enzymes associated with organic P turnover in the STA, PSTA, and WCA sites. This will help with understanding the cycling of organic P in the study areas and will be conducted at different wet/dry and growing season time periods.
5. *Biota Surveys.* Surveys of biota at distinct trophic and habitat sites will be conducted to establish density, distribution and frequency of occurrence of key species. In addition, at a subset of sites, samples will be collected from multiple quadrats (e.g., 1 m^2 scale) and analyzed for species, biomass and tissue composition.
6. *Hydraulic and Hydrologic.* Flows into and out of the flow-ways are already routinely measured. Water depths will be estimated using stage and ground elevations within the cell. Water depth will also be measured during each surface water transect sampling event. Pressure transducers maybe installed in selected locations to provide a more frequent verification of water depth within the cells. Flow vectors and velocity measurements during different flow scenarios will also be required for some of the study areas.

The parameters for substudies 3 and 4 will be determined using the findings from historical data analysis and sub-studies 1 and 2.

Activities and Milestones:	Review current study plan/design and findings to date (data mining); revise plan/design if necessary – June–Sept. 2013 Continuation of data collection (water quality, flow, transects, vegetation, soil, periphyton) – July 2013–June 2015 Continuation of core and mesocosm studies – July 2013–June 2015 Biomarkers and/or stable isotopes – July 2014–June 2015 PSTA dryout/re-flooding – June 2015–July 2016 Final report – June 2017

Figure 1. Multi-tiered conceptual models of P cycling.

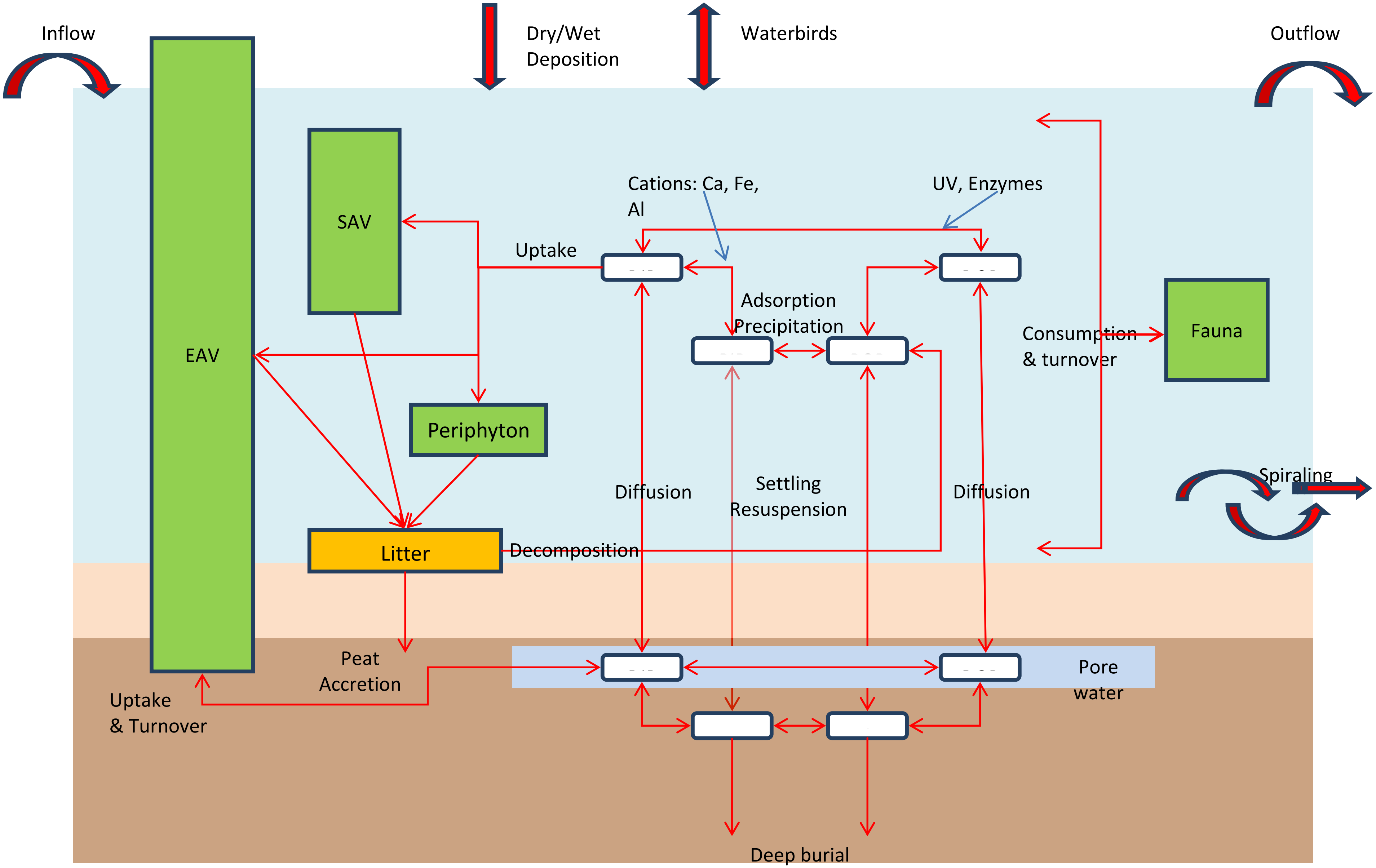


Tier 1 – Landscape (whole STA, STA interactions with EAA or Everglades)

Tier 2 – Patch (habitat, cell, or linked habitats or cells) (10 m-10 km spatial scale)

Tier 3 – Mesocosm (e.g. individual plant, organism, soil core, etc.) (1-10 m spatial scale)

Figure 2. Example of Tier 2 (10 m - 10 km scale) conceptual model.



RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Investigation of STA-3/4 PSTA Technology Performance, Design and Operational Factors

Principal Investigator: Felipe Zamorano

Key Question Study Addresses:

- How can internal loading of phosphorus to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?
- How can the biogeochemical or physical mechanisms be managed to further reduce soluble reactive, particulate, and dissolved organic phosphorus concentrations at the outflow of the STAs?

Sub-question(s) Study Addresses:

- What are the treatment efficacy, long-term stability, and potential impact of floc and soil management?
- What are the sources (internal/external, plants, microbial, wildlife), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system?*
- What are the key physical-chemical factors influencing P cycling at very low concentrations?*
- Are there things that can be done in the STAs to enhance settling, filtering, and treatment of DOP and PP in the water column?

**These questions are also being addressed in a separate study on internal P cycling/factors, involving other STA cells. Results from STA-3/4 PSTA, will be included in the overall analysis of P cycling/factors, providing a basis of comparison as a soil-less treatment.*

Background:

The STA-3/4 PSTA Project, which was constructed in 2005, is a 400-acre project in the western portion of Cell 2B (**Figure 1**). The total project area consists of an upstream 200-acre cell (Upper SAV cell) and two adjacent downstream 100-acre cells (lower SAV and PSTA cells). Peat was scraped from the 100-acre PSTA cell to the caprock, removing a potential source of upward P flux. Emergent vegetation strips were planted perpendicular to flow with the goal of improving the PSTA cell's hydraulic efficiency. Over the first four water years (WY2008-WY2011) of operation, the PSTA cell achieved an average annual FWM TP concentration of approximately 10 ppb. However, concerns over the quality of hydraulic data prevented an accurate assessment of PSTA cell's performance. Some of these concerns were: (1) high uncertainty in the flow data, (2) the amount of seepage entering the PSTA cell was not known but was assumed to be quite large based on higher outflow than inflow volumes, (3) the P content of the seepage water was not known, making it difficult to calculate the P budget for the PSTA cell, and (4) over its period of operation, there was only one year (WY2010) during which the PSTA cell was operated year round. Therefore, in WY2012, various efforts were initiated to improve understanding of the PSTA cell's performance, including structural and operational improvements, as well as improvements to data evaluation and research efforts. In addition to the efforts to improve the hydraulic data quality, scientific investigations are being implemented to provide more accurate assessment of PSTA technology.

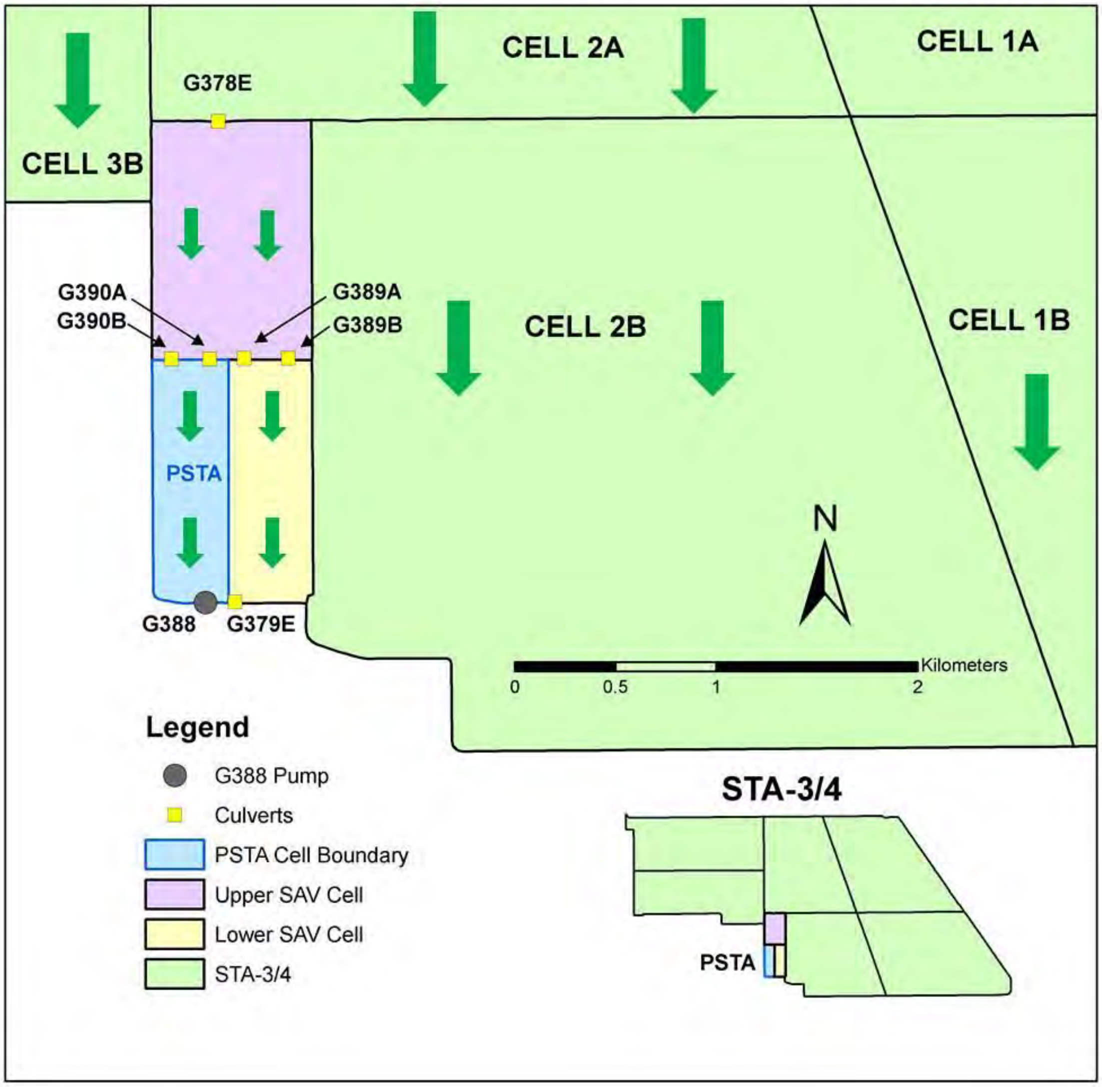


Figure 1. Schematic of PSTA project located in the western portion of Cell 2B of STA-3/4.

Study Hypotheses and Objectives:

The STA-3/4 PSTA study's primary objective is to conduct a detailed assessment of PSTA technology performance and to determine design and operational factors that contribute to that performance and opportunities for full scale replication. Aside from addressing the Science Plan key questions listed above, the PSTA study is also intended to achieve the following objectives:

1. Determine the important design elements and biogeochemical characteristics that enable the PSTA cell to achieve ultra-low outflow TP levels
2. Identify the key operational ranges that enable the PSTA cell to achieve ultra-low outflow TP levels
3. Identify management practices that are required to sustain the PSTA cell's performance
4. Consideration of the feasibility of larger scale implementation upon completion of this study. This effort would most likely be initiated as a separate study.

Proposed Methodology:

The PSTA study has multiple components that will be used to collectively answer the study questions and achieve the study objectives:

1. Surface water quality monitoring

Surface water quality samples are routinely collected at inflow and outflow structures of the PSTA cell, adjacent Cells 2B and 3B (for SAV with soil substrate comparison), and the Upper and Lower SAV Cells. In addition, diel trends (recording at 3-hr interval) in TP concentrations at the PSTA Cell inflow and outflow locations are monitored using remote P analyzers. RPAs were also installed in STA-3/4 Cell 2B and Cell 3B outflow locations. Monitoring of surface water P species under various flow conditions is also being done along the inflow-to-outflow gradient in the PSTA cell. When coupled with vegetation surveys, internal water quality monitoring enables comparison of vegetation cover and health with treatment performance. A more in-depth characterization of the forms and origin of dissolved organic P and particulate P found within and upstream/downstream of the PSTA cell and the pattern of floc movement will also be conducted. In-situ diel monitoring for pH, temperature, conductivity, dissolved oxygen, and turbidity is also being conducted during various flow condition. YSI multi-parameter units are installed at cell interior locations.

2. Hydraulic monitoring and hydraulic loading rate analysis

Flow is monitored at inflow and outflow structures of the PSTA cell, adjacent Cells 2B and 3B, and the Upper and Lower SAV Cells. Hydraulic loading rates (HLR) are calculated on an annual basis. Flow pulse tests have been conducted in the PSTA cell in WY2013; flow rates for the PSTA cell were targeted to achieve the relative peak flows observed historically in Cell 2B and to evaluate the affect of the peak flows on the PSTA cell's performance. Another hydraulic evaluation is underway to determine potential impediment to conveyance of water through the PSTA cell resulting from the existing vegetation strips. For this purpose, pressure transducers are deployed at various locations throughout the PSTA cell and data is collected every 15 minutes. Additional measurements may be needed to determine the influence of advection and diffusion through the caprock on observed outflow TP concentrations. See also study component #9 for water depth studies.

3. Calculation of water and phosphorus budget and phosphorus loading rate

Water and P budget will be calculated using improved hydraulics data and seepage information. Seepage P concentration is being determined by analyzing samples from wells along the PSTA cell levees. In addition, the approximate source of seepage water is being determined using an ionic mass balance analysis of major ions in the well samples.

4. Biomarkers or stable isotope (carbon (C), nitrogen (N), and oxygen (O)) analysis

This task will be conducted to better understand the sources and transport of organic materials (in dissolved and particulate forms) along the flow-ways. This will give a better understanding of the type and sources of carbon, particularly in different vegetation regions within the cell. Because the cycling of C, N, and O is linked to the cycling and availability of P, the study can be useful in evaluating the P sources and pathways along a relatively soil-less system.

5. Determine the effects of dryout on PSTA performance

After the flow pulse testing is complete, two dryout events followed by re-flooding will be implemented. Specifically, the dryout-reflood events will address the following: i) the magnitude of P flux, ii) changes in P species pools and concentrations, iii) duration of P flux; iv) changes in vegetation, soil, and periphyton composition.

6. Soil sampling and analysis

Accreted soil depth and P concentrations were measured in WY2011 and will be measured bi-annually along the inflow to outflow gradient of the PSTA cell. Soil samples will be analyzed to estimate P storage in the system, determine the stability of accrued P, and for other physico-chemical characteristics.

7. SAV and algae characterization

A semi-quantitative vegetation monitoring program will be conducted within the PSTA cell and adjoining SAV cells to determine the relative density and coverage of dominant SAV species. SAV samples will also be collected twice a year along the inflow to outflow gradient to assess standing crop biomass, as well as tissue N, P, C and Ca concentrations. Periphyton will also be sampled at inflow, mid- and outflow stations and analyzed for nutrient concentrations. Phosphatase enzyme activity will be assayed in conjunction with the periphyton taxonomic effort. In addition, periphytometers will be deployed to calculate the algal biomass growth rate within the PSTA cell and the outflow regions of Cells 2B and 3B.

8. Soil core studies

A series of intact core studies will be carried out. Core Study #1 will compare P flux or uptake by newly accrued sediments to areas where the organic muck soils remained intact. This study addresses whether existing muck soils are more or less stable with respect to sequestered P, than the newly accrued sediment material in the PSTA cell. Core Study #2 is established using the cores from Core study #1, and STA 3/4 Cell 2A outflow water. Half of these cores will contain SAV, while the other half will have no SAV. Core Study #3 compares *Chara* and periphyton communities. To the unvegetated cores from Core Study #2, periphyton from the PSTA cell will be added. Data will be used to assess the effect of the presence of *Chara* and periphyton on surface water TP concentrations and alkaline phosphatase activity. Additional core studies will be performed in FY 2013 and FY 2014, to evaluate factors such as the ability of PSTA communities to achieve ultra-low outflow TP levels when provided with SAV cell outflow waters from other STA locations.

9. Evaluation of influence of substrates type, water depth, and P loading rates and concentration

This effort will evaluate effects of substrate characteristics, water depth and P concentration/loading on PSTA vegetation communities and performance. As soil (marl and other particulates) accrue in the PSTA cell over time, temporal changes in performance may occur.

Another sub-study, which will be conducted at a microcosm scale, will also evaluate effects of static (1.5 ft) or variable water depths (1 to 3 ft) on PSTA vegetation communities and treatment performance. The initial study, which began in WY2012, consists of fifteen 30-cm diameter cylinders, containing sediments with an overlying water column. The four substrate treatments are: (1) exposed limerock from the PSTA cell; (2) limerock covered in accrued sediment from the PSTA outflow region; (3) muck soil from the Lower SAV cell with the accrued layer removed, with the upper muck layer exposed to the water column; and (4) muck soil from the Lower SAV cell with accrued layer and upper muck removed, so that the lower muck layer is exposed to the water column. Water column P concentrations, periphyton and macrophyte characteristics, and phosphatase enzyme activities will be monitored over time. In later studies, waters of varied inflow P concentrations, at various inflow P loading regimes, will be used as the flood water to the microcosms.

The effects of deeper water levels (>1.5 feet) will also be tested within the PSTA cell. Response will be measured in terms of vegetation density and coverage, periphyton establishment, and P species concentration.

10. Phosphorus Reduction Process Modeling and Long-term PSTA performance Prediction

To improve the understanding of the mechanisms controlling the P fate and transport processes, one or more simple process models will be used to quantify and predict the P interactions. These models will be used to integrate the field measurements and experimental results and provide feedback. Developed early in the study, this modeling will provide useful insight to for experimental design. These models will provide a basis for improving the prediction of the long term performance of the PSTA. This will be conducted in conjunction with the study on internal P cycling. While data that is being collected will be useful in improving the PSTA calibration data in DMSTA, recent analyses have indicated limitations with using DMSTA as the outflow concentration approaches natural background concentrations (Juston and DeBusk, 2011). Development and implementation of another analytic and computer model may be needed. Areas of investigation include incorporating a non-linear relationship between P loading and P removal, calibration data sets for SRP, DOP and PP, the P removal impacts of dryout and rewetting, and any new data obtained from the different studies.

Activities and Milestones:	Review current study plan/design and findings to date (historical data analysis); revise plan/design if necessary: June–September 2013 Continuation of data collection/sampling (water quality, flow, transects, vegetation, and soil): July 2013–June 2015 Continuation of core and mesocosm studies: July 2013–June 2015 Biomarkers or stable isotopes: July 2014–June 2015 PSTA dryout/re-flooding: June 2015–July 2016 Final Report: June 2017

Initial Study Plan Overview

File 6_RSSP_Canal-Study_Jun13.docx

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Evaluation of the Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow TP Concentrations

Principal Investigator: Hongying Zhao

Key Question Study Addresses:

- How can the FEBs be designed and operated to moderate phosphorus concentrations and optimize phosphorus loading rates and hydraulic loading rates entering the STAs, possibly in combination with water treatment technologies, or inflow canal management?

Sub-question Study Addresses:

- Would changes in canal management or design improve STA and FEB performance?

Background: Changes in surface water TP concentration have been observed in inflow canals of multiple STAs. For example, surface water TP concentrations have been observed increasing and decreasing from the inflow pump stations to the inflow structures at the upstream side of the STA flow-ways. There is also some evidence that TP concentrations may increase as water moves from the treatment cell flow-ways to the permit compliance discharge structures at some STAs. Suspended solids (TSS) are a component of stormwater and are present in STA inflow and outflow canals. Particulate phosphorus may adhere to suspended solids and settle in these canals. High velocities can induce sediment re-suspension resulting in elevated TP in inflow water and/or elevated TP in the outflow collection canals. During severe droughts, water levels in some canals are significantly lowered to the extent that portions of the canal sediments are exposed for periods of time. When re-wetted, the effects of sediment P flux to the overlying water column could also influence the water TP concentrations observed at the inflow and outflow structure sampling locations. Seepage of water into or out of STA canals to or from adjacent water bodies might also be a contributing factor in changes in surface water TP concentration. Other influences may be considered as well.

Study Hypotheses and Objectives:

Hypotheses:

1) Physico-chemical characteristics of canal sediments influence TP concentrations at inflow and outflow waters from the STAs and FEBs.
2) TP concentration in STA or FEB treated water can increase via sediment resuspension or P flux along the outflow collection canal and at the outflow structure.
3) Resuspension and transport of particulates and P at inflow and outflow canal waters during flow events may affect STA or FEB performance.
4) Seepage to or from adjacent water bodies or groundwater is conveying additional TP to or away from inflow and outflow canals connected to STAs and FEBs.

Objectives:

1) Determine through a review of water quality and flow data if TP concentrations change when conveyed through STA inflow or outflow canals.
2) Determine through a review of water quality and flow data if seepage to or from adjacent water bodies or groundwater is influencing canal TP concentrations.
3) Determine through a review of water quality and flow data if there may be other factors influencing canal P concentrations.
4) If warranted based on the objectives above, a second phase consisting of the development of field and laboratory studies which may lead to recommendations for remedial field work (eg. dredging), new operational recommendations and/or design and structural changes in conveyance and/or structure configurations.

Proposed Methodology:

Description

This study will initiate in the office with a significant historical data analysis effort. The results of this data analysis will determine if and where field work might proceed.

Scope

The initial phase of this study (Phase I) will consist of historical data analysis. All available data representing water quality and flow from primary inflow points to each STA and the inflow control structures at the upper end of each flow-way should be analyzed to determine if and under what conditions that TP concentrations in the inflow water may change between the primary inflow point and the treatment flow-ways. For example, for STA-2, do TP concentrations change between pump station S-6 and flow-way control structures G-329A-D, G-331A-G, or G-333A-E? If changes are confirmed can they be correlated with flow rates, time of year, stages in adjacent canals or other factors for which data are available? The Phase I historical data analysis effort may also include development of a water budget and TP budget for the subject canals, depending on the amount of available data (e.g., TP data, seepage information). The analysis will include documentation of the assumptions used to develop water budget terms such as seepage.

Similar analyses should be performed at the outfall of the flow-ways and primary discharge structures.

Phase II of this study may start before the completion of historical data analysis. If preliminary analyses indicate accumulated sediments may be the cause of TP concentration changes in canal surface water, appropriate sediment field work may by identified and initiated. Seepage to and from adjacent water bodies and groundwater may also be a significant influence on canal surface water TP concentrations. As the data analysis phase progresses and results are obtained that indicate seepage or other factors could be influencing canal TP concentrations, appropriate seepage measurements or other field work may be identified and initiated.

Duration

The historical data analysis phase of this project is expected to last for 1 year, including reporting. Phase II of this study is expected to last for 1 to 2 years, depending on the complexity and volume of the field work identified during the initial phase of the study.

Detailed Activities

The principal investigator and other involved staff and consultants will select appropriate data, periods of record and analysis techniques/statistical methods to determine correlations between changes in TP concentration and factors which may influence or cause changes in TP concentration in canals under investigation. Staff will develop quarterly reports of their analysis and make recommendations for additional data analysis and field work if warranted. A final report will be prepared at the conclusion of historical data analysis effort approximately one year from initiation of this study. This report will recommend a termination of the study or additional field and laboratory work if warranted. The subsequent report including appropriate analyses on the field and laboratory data will make recommendations for remedial work if warranted.

Activities and Milestones:	Develop study plan/design: September 2013 Quarterly reports on progress of data analysis: January, April, July, and October 2014 Phase II study plan design initiation (if warranted): May 2014

Initial Study Plan Overview

File 7_RSSP_Deep-Water-Pulsing-Cattail-Study_Jun13.docx

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Evaluation of Impacts of Deep Water Inundation Pulses on Cattail Sustainability

Principal Investigator: Hongjun Chen

Key Question Study Addresses:

- What measures can be taken to enhance vegetation-based treatment in the STAs and FEBs?

Sub-question Study Addresses:

- How does water depth affect sustainability of dominant vegetation?

Background:

Water stages for different STA cells are currently managed based on a target depth of 1.3 ft. However, peak flows in the wet season, particularly during and/or following storm events often occur and cause water level pulsing of >3.0 ft with a frequency of up to 5 times during the wet season in treatment cells. Shallow water (<50 cm) or small changes in water level (i.e., ±1.0 ft from the target depth) may not greatly affect cattail growth (Miao and Zou, 2012; Sorrell et al., 2012), but greater than ±1.5 ft of water level fluctuations adversely reduce cattail biomass by >50% (Deegan et al., 2007). Where water level pulsing occurs quickly, cattail may not have an opportunity to morphologically adjust to rising water levels before water levels change once again requiring a different set of responses to optimize resource capture. Knowledge of how cattail growth relates to water level pulsing is valuable and this information is vital in understanding and predicting the responses of cattail community to hydrologic regimes for STA management practices. Recent mesocosm studies indicate that six-week inundation at >3.0ft water depths negatively impacted cattail health (Chen et al., 2010; Chen et al., 2012), but little research on the impact of water level pulsing to cattail community sustainability is available for the STAs although water level pulsing often occurs.

References:

Chen, H, Zamorano, MF, Ivanoff I. 2013. Effect of deep flooding on nutrients and non-structural carbohydrates of mature *Typha domingensis* and its post-flooding recovery. Ecological Engineering 53:267-274.

Chen, H, Zamorano, MF, Ivanoff I. 2010. Effect of flooding depth on growth, biomass, photosynthesis, and chlorophyll fluorescence of *Typha domingensis*. Wetlands 30: 957–965

Deegan, BM, White, SD, Ganf, GG. 2007. The influence of water level fluctuation on the growth of four emergent macrophyte species. Aquatic Botany 86: 309-315

Miao, SL, Zou, CB. 2012. Effects of inundation on growth and nutrient allocation of six major macrophytes in the Florida Everglades. Ecological Engineering 42:10–18.

Sorrell, BK, Tanner CC, Brix H. 2012. Regression analysis of growth responses to water depth in three wetland plant species. AoB PLANTS 2012: pls043; doi:10.1093/aobpla/pls043.

Study Hypotheses and Objectives:

The study is designed to evaluate how the survival, growth, and propagation of cattail communities are influenced by the frequency of deep water pulsing. Specifically, the growth, photosynthesis, reproduction, and nutrient (N, P) uptake of cattail in response to deep water level pulses, similar to what occurs in the STAs will be evaluated.

Results of this study will be utilized to refine targets depths for Flow Equalization Basins (FEBs) and for emergent vegetation cells within the STAs. Rules or operational guidance for releases from FEBs to STAs may also be refined based upon outcomes of this study.

Proposed Methodology:

Location
This proposed study will be conducted in the test cells of STA-1W.

Duration
Expected start and end dates will be May 2013 – June 2017.

Scope
Due to the complexity, three sub-studies are anticipated:

1. **Historical Data Analysis**

Historical stage data and ground elevation information will be examined to determine the range of water level fluctuations (frequency, timing, depth, and duration of water level pulsing) in the emergent aquatic vegetation (EAV) cells of STA-1W, STA-2, and STA-3/4. The analysis of data on water level fluctuations will help define the characteristics of water level pulses occurring in the EAV cells and provide information for the experimental design of the test-cell study in the following.

2. **Test-cell Study:**

In this proposed study, healthy cattail communities will be established in test cells and then the eco-physiological response of the cattail communities to water level pulsing treatments will be assessed. Inflow and outflow P concentrations will also be measured to determine the effects of deep water pulsing on cattail P treatment performance.

Preliminary observation indicates that pulses at depths of 3.0 ft often occur in the wet season (July through October). It is assumed that a 3.0 ft water level pulse has approximately one-week detention time in the EAV cell. It is also assumed that it takes approximately three days to reach a 3-ft water level pulse from the 1.3 ft target depth (pre-pulsing) and it takes approximately five days to return to the target depth (post-pulsing).

The experiment will have one factor (pulsing) with four treatment levels: 1.3ft water depth without any pulsing (control), two pulses occurring in July and August, respectively, three pulses occurring in July, August, and September, and four pulses occurring in July, August, September, and October, with three replicates (totally 12 test cells). *It is noted that the frequency, depth, and duration of water level pulsing in this experimental study will be adjusted based on the analysis of historical data on water level fluctuations in the EAV cells described above.*

Establishment of Cattail Community
Phase I (May 2013–October 2014):
It is estimated that establishing a uniform, healthy cattail community takes two years. Test cells will be established with uniform soil type (organic soil) and fertility (approximately 400−500 mg/kg P) and a 30-cm soil layer. In the period of cattail community establishment, inundation depth will be maintained at 1.3ft in the test cells prior to the initiation of the experimental plan.

Two board walks will be constructed and 20 2m×2m plots will be established in each test cell. Soil (0 − 10 cm) samples will be collected and analyzed for selected variables. Sediment redox potential (Eh) and water depth will be measured in the field. Cattail growth, photosynthesis, shoot density, and shoot height will be measured. Initial harvesting will be conducted when a uniform healthy cattail community is established and/ or prior to the initiation of the experimental plan.

Experimental Plan
Phase II (2015):
Implement the experimental treatments in the wet season (July through October) in the test cells as described above. Surface water and vegetation surveys will be conducted and sediment Eh and water depth will be measured in the field. Photosynthesis will be measured during the water level pulsing. Vegetation harvest and soil sampling will be conducted by the end of 2015.

Phase III (January 2016–June 2017):
Monitoring and measurement will continue as in Phase II in 2016.

From January to June 2017, final data analysis, presentation, and reporting will be conducted.

Parameters to Be Tested:

Surface Water. Total P, SRP, TDP, total N, ammonia, nitrate, calcium, organic carbon, pH, and DO in inflow, interior, and outflow of the test cells.

Soil/Sediment. Soil (0 − 10 cm) samples will be collected annually and be measured for pH, bulk density, total C, bioavailable N, total N, bioavailable P, and total P. Sediment Eh will be measured in the field.

Vegetation Survey. Three to five plots will be randomly harvested with a 0.25 m^2 quadrat at the end of 2014, 2015, and 2016. Biomass will be measured and tissue samples will be collected to determine nutrient uptake. Leaf, rhizome, shoot base, and root and dead plant material samples will be analyzed for TC, TN, and TP. Cattail growth, photosynthesis, shoot density, shoot elongation, and shoot height will be measured. Initial vegetation harvesting will be conducted when a uniform healthy cattail community is established and/ or prior to the initiation of the experimental plan.

Aboveground shoot harvesting may be conducted following each of pulsing events during the experimental period to examine nutrient uptake. Field vegetation survey (non-destructive sampling) including photosynthesis measurement will be conducted pre-pulsing, during water level pulsing and post-pulsing.

Hydrology. Flows into and out of the test cells will be measured. Water depths will be estimated using stage and ground elevations within the cell. Water depth in plots will also be measured during each vegetation survey event.

3. **In-situ Study:**

This proposed sub-study will be conducted in STA-1W, STA-2 and STA-3/4 in the summer of 2014 and 2015. The specific objective of this sub-study is to identify the relationship between the normalized difference vegetation density (NDVI) calculated based on historical aerial vegetation imagery and historical hydrology (including water level pulsing). Random vegetation plots will be established in the EAV cells in those three STAs to measure vegetation density in the EAV cells. The regression between the NDVI and field-measured vegetation density will be validated.

Activities and Milestones:	Develop study plan/design: May–September 2013 Procurement (contracts, equipment, supplies): October–December 2013 Historical data analysis: September 2013–March 2014 Boardwalk build-up and plot set-up: September–December 2013 Data collection/sampling of the in-situ study: January 2014–December 2015 Data collection/sampling of test-cell study: January 2015–December 2016 Data analysis and reporting: January–June 2017

Initial Study Plan Overview

File 8_RSSP_STA-Water&P-Budget-Improvements_Jun13.docx

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: STA Water and Phosphorus Budget Improvements

Principal Investigator: Tracey Piccone

Study Question:

Can improvements be made to STA water and phosphorus budgets published in recent editions of the SFER?

Study Sub-question(s):

- What are the sources of error(s) in STA water budgets?
- How can errors in water budget components be reduced?

Background: Water budget analysis is an important tool used to understand the treatment performance of STAs. STA water budgets are comprised of structure flows (inflows and outflows), rainfall, ET, seepage, change in storage and residual (error). Developing a closed water budget is not a simple task due to the physical characteristics of wetland systems and errors associated with the measurement and estimation of each of the water budget components. Water control structure flows are generally the largest component of STA water budgets, accounting, on an average year, for about 70-80 percent of the annual water budget, while rainfall and ET are roughly 10-12 percent. In dry years, especially during drought, when inflow and outflow structures are mostly closed, seepage, ET and rainfall account for larger percentages of the water budget. To improve STA water and phosphorus budgets, errors in all water budget components should be reduced to the maximum extent practicable. This study includes efforts to evaluate sources of error in the STA water budgets and develop recommendations for reducing such errors and improving water budget accuracy. Once the water budget improvements are made, this study will also include developing revised phosphorus budgets using the improved water budgets. A phased implementation approach is proposed as described in the sections below.

Study Hypotheses and Objectives:

Hypotheses:

N/A

Study Objectives:

Phase I: Develop improved water budget for STA-3/4 Cells 3A and 3B as a test case, then develop a summary report including recommendations and cost estimates for Phase II based on the results of the initial effort. (Go/Stop decision point)

Phase II: Develop improved flow estimates for all STA cells using one or more of the simplified methods investigated during Phase I, then develop improved water budgets for all STA cells using the improved flow estimates. Next, develop revised phosphorus budgets, loading rates and settling rates for all STA cells using the improved flow estimates and water budgets.

Phase III: If the results of Phase II indicate the need for further improvements to flow estimates or other water budget components, other items such as structural improvements, enhanced monitoring, seepage studies, or operational refinements may be considered.

Proposed Methodology:

Location

Phase I: STA-3/4 Cells 3A and 3B.
Phase II: All STA treatment cells.
Phase III: TBD

Scope

The STA Water and Phosphorus Budget Team is evaluating STA-3/4 Cells 3A and 3B as a test case for improving STA water budgets. Once complete, the results can be applied to improve other STA water budgets. Phase I efforts consist of SFWMD technical staff completing office work only; Phase I includes no field work or contract costs. Phases II and III, if approved, could potentially include contract costs (labor, materials and equipment). For example, further improvements in water budgets may require development and maintenance of additional DBKEYs, field investigation (e.g., surveying, seepage measurements), enhanced monitoring, equipment installation, as well as structural retrofits and operational changes. Phase II is proposed to include ongoing maintenance of additional DBKEYS, as well as annual development of STA water and phosphorus budgets.

Duration

Phase I began in February 2013 and is estimated to last approximately 5 months (approximate end date June 30, 2013).
Phase II, if approved, is estimated to last approximately 7 years (approximate end date September 30, 2020.)
Phase III, if approved, could begin any time after FY2014, and depending on the overall scope could last for an additional 2-3 years or more.

Detailed Activities

A team of SFWMD staff has been assembled to evaluate the sources of error in the STA water budgets, and to develop recommendations for reducing the errors in and improving the accuracy of the STA water and phosphorus budgets. The initial phase consists of an evaluation of the STA-3/4 Cell 3A and 3B water budgets. Improvements to previously published water budgets will be made where feasible, and recommendations for additional improvements provided as appropriate. A summary report will be prepared at the conclusion of Phase I and will be used to determine whether or not to proceed with Phase II. Phase II will proceed only if approved by the Restoration Strategies Steering Committee. Similarly, Phase III will proceed only with approval of the Restoration Strategies Steering Group.

Activities and Milestones:	Initiate Phase I: February 2013 Complete Phase I including summary report: approximately June 2013 Initiate Phase II: October 2013 Complete Phase II: approximately September 2020 Initiate Phase III: To be determined, as needed

Initial Study Plan Overview

File 9_RSSP_Evaluation-TP-Sampling-Methods_Jun13.docx

RESTORATION STRATEGIES SCIENCE PLAN

Study Name: Evaluation of Sampling Methods for TP

Principal Investigator: Pete Rawlik

Study Question:

- What sampling regime provides the most accurate representation of TP?

Study Sub-question(s):

- What are the pros and cons of various sampling methods for SFWMD programs and projects? [Note: Evaluation sampling regimes will include inherent assumptions, required resources, sources of unexplained variation, costs, cost-benefits, and potential contamination routes.]

Background: In general, the SFWMD uses three methods to collect water quality samples for total phosphorus, coded as TPO4 in the SFWMD's data base: Grab sampling, collection by auto-samplers, both of which use a central laboratory to conduct analysis, and sampling by remote analyzers, which have built in micro-laboratories. In all of these methods, sample collection may be initiated in response to flow at the sampling site, a specified span of time, or a combination of the two, such as a weekly grab if flow is observed, or a weekly grab sample regardless of flow conditions. Historically, a significant difference in TP concentrations has often been observed between results from auto-samplers and those from grab samples. While some of this has been shown to be the result of differences in the collection period, other data suggests large masses of solids, such as mats of vegetation and other organic material, may have significant impacts on sampling results. The ephemeral and sometimes submerged nature of such events may serve to explain some of the short-term elevations observed in data collected using auto-samplers and remote analyzers. Additionally, the flow criteria for triggering an auto-sampler and their relation to structure operation and measured concentrations must be examined. Other issues that must be evaluated for each method are the costs of installation and maintenance, the cost-benefit, and the potential for contamination and sampling failure.

Study Hypotheses and Objectives:

Hypotheses:

1) Minor variations in sampling location and depth (up to several meters) associated with grab sample collection and equipment deployment has no impact on analytical results
2) Auto-sampler trigger volumes may not be sufficiently sensitive to allow collection of first-flush events, or during periods of low flow
3) The presence of biofouling organisms on sampling equipment and ephemeral masses of solids in the water column, influence TP concentrations collected using auto-samplers and remote analyzers
4) The frequency of sampling for TP and the ability to relate those values to specific flow events may impact flow-weighted means

Objectives: Overall: Provide information to select sampling method that provides representative data for the diversity of sampling needs of SFWMD programs and projects

1) Determine congruency between methods and characteristics of water being sampled
2) Using high frequency remote analyzer data as a standard, examine the impact of sampling frequency on weekly flow-weighted means using both actual samples and mathematically composited results
3) Document the occurrence and impact of ephemeral events and evaluate possible management strategies of minimize events
4) Develop management recommendations to improve sampling for both operations and compliance

Proposed Methodology:

Location

Evaluation of sampling methods will be carried out at the discharge from STA-1W (G-310). The proximity of this location to SFWMD headquarters along with the existing facilities minimizes logistical issues. Once significant progress has been made toward establishing methodologies and recommendations the project could be repeated in other areas.

Scope

This study consists of several components:

1) Review literature on strengths and weaknesses of sampling methods

2) Evaluate existing SFWMD data on previous comparisons and prepare publications on remote analyzer, grab sampling and auto-sampling comparison.
3) Conduct a study on the comparability of the three sampling methods over a short period of time (day).
4) Evaluate the impact of long-term deployment of equipment on the comparability of the results from the sampling methods.
5) Investigate data quality, data comparability, cost benefits for all methods, and development of a strategy for optimizing or improving monitoring.

Duration

The entire project is expected to last for 18 months.

Detailed Activities

1) Published literature and existing data will be gathered, reviewed and analyzed to provide guidance on experimental design and focus.
2) In order to establish that the methods are without fundamental bias, it will be established that the methods show no differences upon initial deployment, or that slight variations in location have no appreciable impact on results. Thus, comparisons between multiple grab samples which vary in location and depth, and samples collected using the auto-sampler pump, will be compared to simultaneous results from the remote analyzer. Blanks confirming the status of bottles and tubing will be performed, as well as all other relevant QC.

   Samples for this analysis will be collected in the following manner: Intakes for the auto-sampler and the remote analyzer will be co-located as much as possible, and this will be considered the base point for sampling. The remote analyzer will then be set to trigger hourly, on the hour. Once this is complete, staff will wait for the remote analyzer to begin sampling, and then manually trigger the auto-sampler pump and collect a discrete pumped-grab. This pumped-grab sample will then be removed and preserved for analysis. At the same time, a set of three grab samples will be collected. These grabs will be taken at the base point (0), one meter away (1), and two meters away (2). These measurements will be made in rapid succession and perpendicular to stream flow. These grab samples will then be preserved for analysis. This process will be repeated hourly for 10 events, providing 30 grab samples and 10 pumped-grab samples, as well as 10 remote analyzer events. Under this design, each hourly event should present 5 results (3 grabs, 1 pumped grab, and 1 remote analyzer) that function as pairs. These samples can be used in a paired analysis to show variability between the methodologies. If more data are needed, the entire experiment can be repeated multiple times.

3) In order to establish the impact of long-term deployment of equipment on auto-samplers and remote analyzers, sampling via several methods will be co-located and carried out for an entire year. The study assumes that breakpoint flow data will be available at the structure(s). The study will be initiated following quarterly maintenance on the existing deployed flow proportional composite auto-sampler (ACF). As these units are used for compliance, no modifications to procedures will be implemented for these units, however under normal operations, only the date and time of the first flow trigger is recorded. For this study, all flow triggers will be recorded. A second auto-sampler set to collect samples on an hourly basis and producing daily discrete samples (ADT) will be co-located with the ACF. To minimize flow data discrepancies the ADT 24 hour period will run from noon on one day to noon on the next and weekly sampling will be timed to this period as well. Single grab samples will be collected weekly. Additionally, weekly pumped-grab samples will be pulled through the auto-sampler pump of the ADT.

   In order to measure the heterogeneity of the water column, turbidity and conductivity probes will be co-located with the sampling intakes, and set to collect a measurement on every half-hour. In addition to the probes, it may be helpful to visually document the movement of floating vegetation as it passes monitoring stations, and then relate these to changes in turbidity and TP. In order to accomplish this, video cameras may be deployed to document such events. These may be limited to diurnal deployments during high flow events.

This set of samples will provide a high number of results that can be looked at using a variety of durations, and in conjunction with flow data. Such data can be used to look at the impact of short-term events, long term changes in water quality, and the impact of flow on the measurement of water quality. The ability to pair data from grabs, pumped-grabs, calculated weekly composites from the ADT, and the ACF should be valuable in determining the representativeness of each method. The comparison of the pumped-grab to the routine grab sample should identify the impact of long-term deployment on the representativeness of in situ equipment.

4) Analysis of collected data using paired tests and ANOVAs will allow for the identification of significant differences in sampling methods and possible sources of issues including periodicity, contamination, ephemeral events, and responsiveness of monitoring to flow events. Data analysis
    a. Summary statistics for each of the variables tested (FWM TP and TP): number of samples, mean, standard deviations, standard error, median, IQR, minimum, maximum, normality.
    b. Initial data analyses will be performed to compare Grab$_0$, Grab$_1$, Grab$_2$, and AA (auto analyzer data) to determine if differences exist between distances.
        i. Wilcoxon signed-rank test
        ii. Paired t-Test
    c. A paired data analysis will be performed based on the proposed data collection presented in sampling matrices shown in Tables 1 and 2 and distributional assumptions. Methods of collecting TP data will be evaluated as well as potential bio-fouling in intake tubing.
        i. Wilcoxon signed-rank test
        ii. Paired t-Test
        iii. Kolmogorov-Smirnov, two-sample test
        iv. A significance level (α) of 0.05 to determine statistical differences.
5) Interpretation of data and statistics could potentially lead to modifications and improvements in maintenance strategies, flow triggers, and even frequencies. Such data in combination with breakpoint flow data may be useful in developing hybrid sampling frequencies such as flow triggered timed composites. Data may also be used to help validate the remote analyzer methodology.
6) Concurrent with these studies, initiate development of Phase II which uses observations, data and ongoing analyses to design potential solutions including changes to sampling method and design, equipment maintenance, equipment design, and site design and maintenance.

Activities and Milestones:	Develop study plan/design: June 2013 Procurement (equipment, supplies): August 2013 Set-up equipment: September 2013 Data collection/sampling: October 2013–September 2014 Data analysis and reporting: August 2013–June 2015

Table 1. Matrix for comparing auto analyzer, auto-sampler (flow and time composited) and grab data.

Sample Type	ACF	ACT	AA	$Grab_0$
ACF				
ACT	**Compare weekly, monthly, quarterly and annual time steps. (FWM from daily ACT with flow compare ACF)**			
AA	**Compare weekly, monthly, quarterly and annual time steps. (FWM from hourly ACT with flow compare ACF)**	**Daily composite ACT data compared to mean daily concentration from hourly AA data**		
$Grab_0$	**Compare same day Grab with ACF. Compare monthly FWM from Grab and ACF**	**Compare Grab to same day bottle from ACT**	**Compare grab to same or nearest hour AA**	

ACF (auto-sampler flow composite) – Potentially 52 samples per year could be collected depending on flow.

ACT (auto-sampler time composite) –hourly water samples collected and composited in one container for 24-hour period. Potentially 365 samples per year.

AA (Auto Analyzer) –samples collected on an hourly basis and analyzed. Potentially 8,760 measurements per year.

$Grab_0$ (Grab sample at intakes) – initially 10 samples collected in one day with one sample collected each week. Potentially 52 samples per year.

Table 2. Matrix for comparing auto analyzer and various grab sample data.

Sample Type	AA	$Grab_0$	$Grab_{ACF}$	$Grab_1$
AA				
$Grab_0$	Compare grab to same or nearest hour AA			
$Grab_1$	One day study, compare grab to same or nearest hour AA	One day study, compare grabs for subtle variations in distance		
$Grab_2$	One day study, compare grab to same or nearest hour AA	One day study, compare grabs for subtle variations in distance		One day study, compare grabs for subtle variations in distance
$Grab_{ACF}$	Compare grab to same or nearest hour AA	Compare grabs for biofouling through low use pump over a quarter		
$Grab_{ACT}$	Compare grab to same or nearest hour AA	Compare grabs for biofouling through low use pump over a quarter	Compare grabs for biofouling through low use pump over a quarter	

AA (Auto Analyzer) –samples collected on an hourly basis and analyzed. Potentially 8760 measurements per year.

$Grab_0$ (Grab sample at intakes) – initially 10 samples collected in one day with one sample collected each week. Potentially 52 samples per year.

$Grab_{ACF}$ (Grab taken through pump of ACF) – Check bio-fouling of tubing. Potentially 52 samples per year.

$Grab_{ACT}$ (Grab taken through pump of ACT) – Check bio-fouling of tubing. Potentially 52 samples per year.

$Grab_1$ (Grab taken 1 meter from intakes) – Check for variations with distance from auto-sampler intakes. 10 samples collected on initial sampling date.

$Grab_1$ (Grab taken 2 meters from intakes) – Check for variations with distance from auto-sampler intakes. 10 samples collected on initial sampling date.

Appendix D:
STA Water Quality Monitoring Plans

Operational Project Monitoring Plan

For

Eastern Flow-Way
Stormwater Treatment Area 1 East

(Project Code: STA1E)

01/08/2013

This monitoring plan is adaptive and therefore subject to change based on operational needs. It will be reviewed and/or modified at a minimum, on an annual basis.

Water Quality Monitoring Section
Water Quality Bureau, Water Resources Division
South Florida Water Management District

SFWMD-FIELD-MP-046-03

Table of Contents

Figures

Tables

Appendices

1.0 Glossary

ACF	Autosampler collection based upon flow trigger
CLQM	Clinical Laboratory Quality Manual
DBHYDRO	South Florida Water Management District Environmental Database
DQOs	Data Quality Objectives
ECP	Everglades Construction Project
EFA	Everglades Forever Act
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FSQM	Field Sampling Quality Manual
GPS	Global Positioning System
LIMS	Laboratory Information Management System
NPDES	National Pollutant Discharge Elimination System
PSTA	Periphyton-based Stormwater Treatment Area
SFWMD	South Florida Water Management District
STA1E	Stormwater Treatment Area 1 East
USACE	United States Army Corps of Engineers
WCA-1	Water Conservation Area 1

2.0 Project Organization

Overall project organization and responsibilities are detailed in the South Florida Water Management District (SFWMD or District) Applied Sciences (ASB) and Water Quality Bureau (WQB) Quality Management Plan (QMP). Field activity responsibilities are detailed in the District's Field Sampling Quality Manual (FSQM). Laboratory analysis and data validation responsibilities are detailed in the District's Chemistry Laboratory Quality Manual (CLQM). These documents define the procedures used by SFWMD personnel to meet the Florida Department of Environmental Protection's (FDEP) Quality Assurance (QA) Rule, Florida Administrative Code (F.A.C.) 62-160. Refer to these documents for details on key personnel and relevant responsibilities.

3.0 Project Description

3.1 Introduction and Background

This document serves as a reference for surface water quality monitoring for Stormwater Treatment Area 1 East (STA1E). The operational plan for this project contains detailed structure specifications including brief descriptions of the mandate and/or permit required monitoring at each station. Current project status, schematics and the project operational plan can be viewed at the District's STA status page.

Surface water monitoring at STA1E began in 2004, as part of the Everglades Construction Project (ECP). STA1E's mandated stations consist of the STA1E inflows at G-311, S-319 and S-361; STA1E outflow station S-362 and diversion stations G-300. The construction, operation and maintenance of this Everglades Construction Project are required by the Everglades Forever Act (EFA) to restore the Everglades ecosystem. The guidance contained in this document will assist in maintaining consistency in sampling locations, parameter lists, and frequencies as well as providing documentation of the project scope and an ongoing historical perspective.

3.2 Mandates and Permits

Station locations, sampling frequencies, and parameters to be sampled are dictated by the mandate and/or permits governing this project (see Appendix 1 for details). In addition, a mercury and toxicants monitoring program required by Everglades Forever Act Permit (0311207) is included as Appendix 2.

As part of the Eastern Flow-way for the Everglades Construction Project, STA1E is subject to both the Everglades Forever Act Permit #0311207 and the National Pollutant Discharge Elimination System Industrial Wastewater Facility (NPDES) Permit FL0778451, both issued on September 10, 2012 and expiring on September 09, 2017. These permits dictate the types and frequencies of monitoring to be done, and the parameters to be analyzed, and can be viewed at:

- Everglades Forever Act Permit
  http://www.dep.state.fl.us/water/wqssp/everglades/docs/ecp-sta/draft-watershed-efa-permit.pdf
- NPDES Permit

http://www.dep.state.fl.us/secretary/news/2012/06/npdes_watershed_permit_consent_order.pdf

Additional stations, parameters and frequencies are required as part of operational monitoring are detailed in Appendix 1.

3.3 Project Objectives

The primary objectives of this monitoring project are:

1. Assess compliance with applicable water quality standards and phosphorus discharge limits;
2. Aid in determining the nutrient concentrations to quantify the tons of nutrients removed by the STA annually;
3. Guide mid and long term resource management decisions for nutrient removal capabilities of the STA.

3.4 Duration

3.4.1 Initiation Conditions

The monitoring for this project was initiated at S-319 on September 30, 2004, in response to start-up phase of this project.

3.4.2 Modification or Termination Conditions

The mandated monitoring described in this document will be ongoing as required by the EFA 0311207 and NPDES FL0778451 permits, which are renewed once every 5 years. Conditions for modification or termination of the project are detailed in the permit(s) that specify the conditions of the project. Monitoring for operations will continue indefinitely in support of the project goals and objectives. Monitoring may increase or decrease over time, depending upon individual cell operations, data results, end user needs and permit requirements. Short-term changes to collection events may be made as a result of an extreme weather conditions (i.e., droughts and tropical storms/hurricanes), other safety concerns, or construction activities.

4.0 Geographic Location

4.1 Regional Area

The locations of all monitoring stations are depicted on the map in Figure 1.

4.2 Sampling Locations

The locations of all monitoring stations are depicted in Figure 1 with exact locations described in Table 1.

4.3 Access and Authority

The gates on roadways into STA1E are secured with a District Palm Beach County “W” lock. The lock requires a “W” key which can be obtained through a request made through the FPM and/or Field Supervisor. Access to STA1E is from either SR80 just east of the

1st entrance to S5A pump station; the two main access points are along the eastern STA1E border (off Flying Cow Road) and along the western border. Samples are collected on the upstream side of structures/culverts.

Table 1: Surface Water Sites, GPS Coordinates and Descriptions

Station Name	Latitude	Longitude	Description
G300	264038.3	802146.99	Gated structure on western edge of ST1E receiving water from S5A Inflow & Distribution Basin and diverting it to the L-40 Canal.
G311	264045.921	802148.812	Inflow gated structure into western distribution cell from I & D basin
S319	264054.935	801934.035	Primary inflow pump station – C51 canal into eastern distribution cell
S361	263854.913	801857.858	Seepage return flow pump station into cell 4S.
S362	263733.001	801903.378	Primary outflow pump station into L-40 canal
S363C	264036.357	801816.797	Cell 1 East inflow (start)
S364A	263948.334	801844.934	Cell 1 west outflow/cell 2 inflow (interior)
S364C	263948.235	801808.547	Cell 1 west outflow/cell 2 inflow (interior)
S365A	263901.257	801841.894	Cell 2 west outflow (end)
S365B	263901.268	801814.611	PSTA/cell 2 east outflow (end)
S366B	264035.799	801934.561	Cell 3 west inflow (start)
S366D	264035.736	801913.657	Cell 3 east inflow (start)
S367B	263948.481	801935.814	Cell 3 west outflow/cell 4N inflow (interior)
S367D	263948.434	801912.64	Cell 3 east outflow/cell 4N inflow (interior)
S368B	263856.055	801938.781	Cell 4N west outflow/cell 4S inflow (interior)
S368D	263856.009	801917.364	Cell 4N east outflow/cell 4S inflow (interior)
S369B	263752.508	801933.491	Cell 4S west outflow (end)
S369C	263744.6	801920.132	Cell 4S east outflow (end)
S370A	264035.95	802039.098	Cell 5 west inflow (start)
S370C	264035.861	802001.915	Cell 5 east inflow (start)
S371A	263948.787	802042.717	Cell 5 west outflow/cell 6 inflow (interior)
S371C	263948.689	802004.159	Cell 5 east outflow/cell 6 inflow (interior)
S372B	263835.157	802025.762	Cell 6 west outflow (end)
S372D	263814.51	802005.169	Cell 6 east outflow (end)
S373A	264037.348	802133.86	Cell 7 west inflow (start)
S373B	264036	802102.77	Cell 7 east inflow (start)
S374A	263948.67	802113.836	Cell 7 west outflow/cell 6 inflow (interior)
S374C	263948.641	802056.292	Cell 7 east outflow/cell 6 inflow (interior)

The standard positional goal for site coordinates is ±1 meter. This standard can be obtained with a professional grade DGPS system. The coordinates are relative to NAD83 HARN horizontal datum.

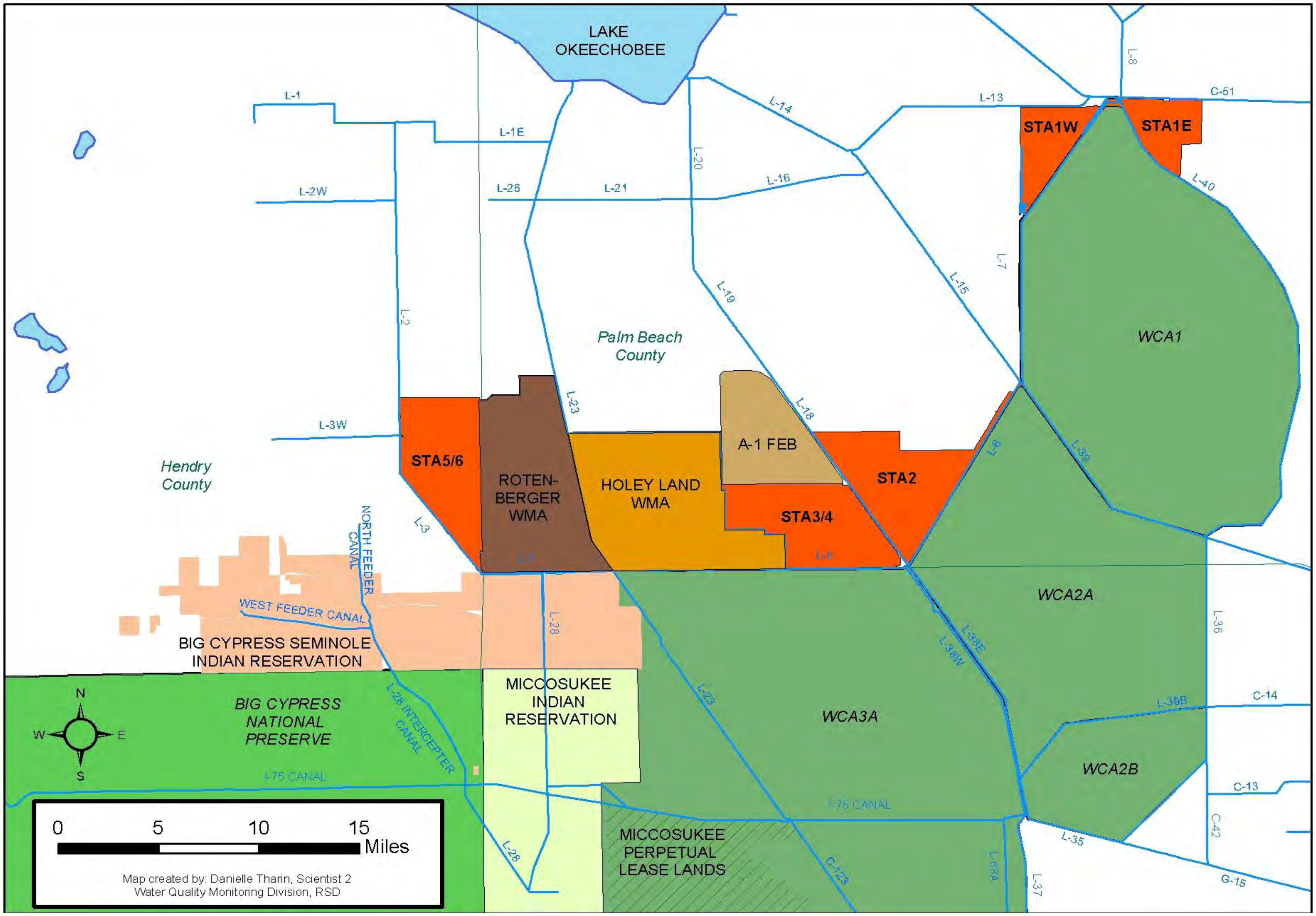
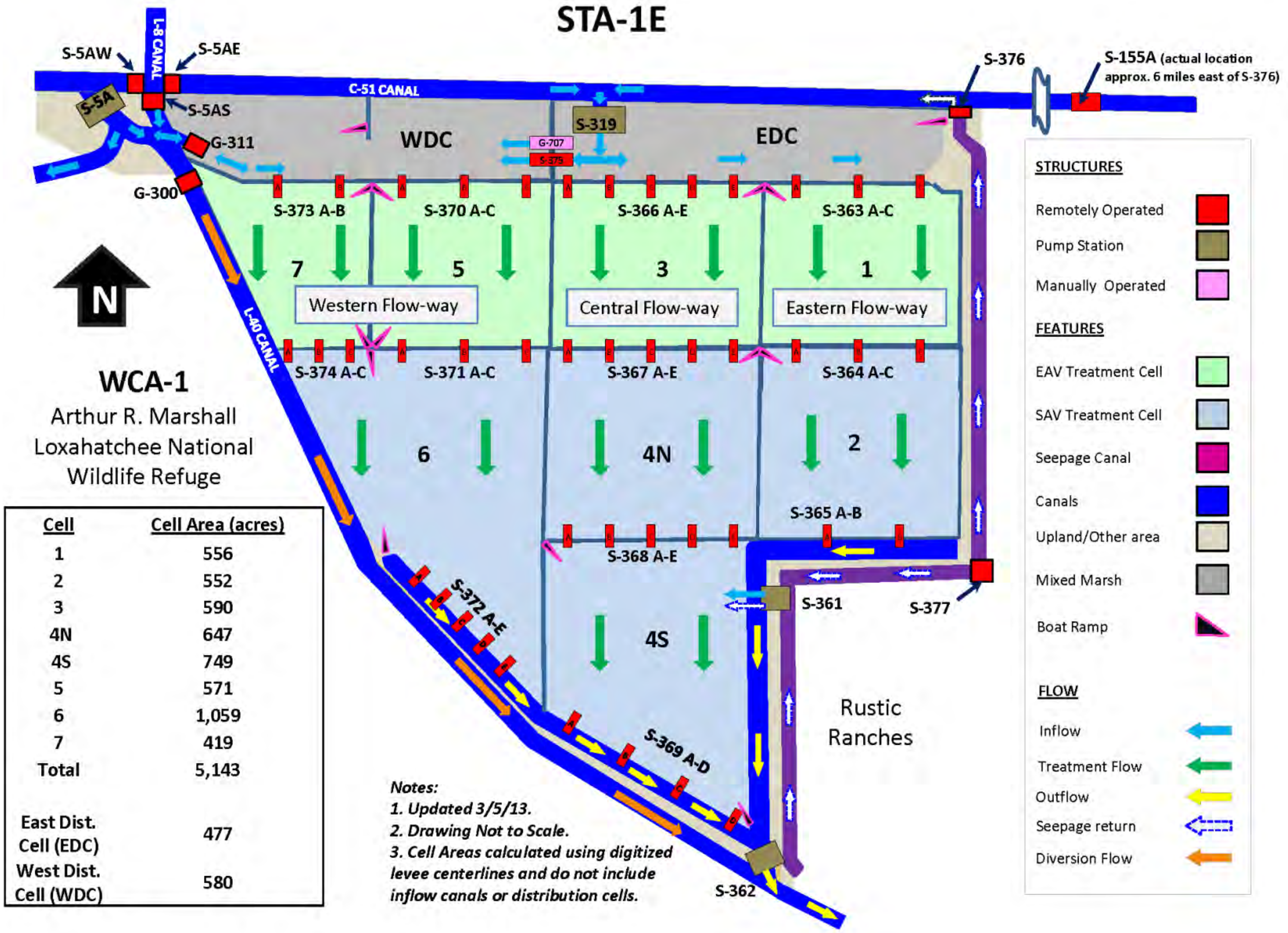


Figure 1: Stormwater Treatment Areas



Cell	Cell Area (acres)
1	556
2	552
3	590
4N	647
4S	749
5	571
6	1,059
7	419
Total	5,143
East Dist. Cell (EDC)	477
West Dist. Cell (WDC)	580

Notes:
1. Updated 3/5/13.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals or distribution cells.

Figure 2: STA1E Layout Map

5.0 Field Activities

5.1 Monitoring Frequencies by Site and Parameters

All samples required for collection are depicted in Table 2. As of August 1, 2011, the STA Operation sites will be monitored according to weekly, biweekly or monthly recorded flow with autosamplers disabled at these sites as of September 2011. Some stations within the monitoring network are collected based on whether flow has been recorded. Specifically, structure operation activity is determined within a specified timeframe through the review of electronic data. If no flow (i.e., no operations) has been recorded, the sample is considered a No Bottle sample (NOB) and the structure is not visited. Conversely, if flow has been recorded during the specified timeframe, a sample is collected.

5.2 Project Specific Guidelines

All surface water samples shall be collected on the upstream side of any structure at a depth of 0.5 m unless vegetation and/or other conditions inhibit the collection of a representative sample upstream. Prior to sampling an alternative site, a consultation with a Field Technician Supervisor and/or the FPM must take place; this action must be documented in the field notes.

Backup grab samples will accompany the autosampler collection based upon flow trigger (ACF) samples collected on a weekly basis. In addition, in situ readings (i.e., Temperature, pH, DO and Specific Conductance) are measured as the grab samples are being collected. Samples are collected are on the upstream side of structures or culverts.

5.3 Grab Sampling Procedures

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District's FSQM.

Table 2: STA1E Grab/Autosampler Sample Frequency and Parameters

Station	Collection Method	Frequency	Parameter ACODES
Outflow Station			
S362	Grab	Weekly	OPO_4, TPO_4, DO, pH, Scond, Temp
		Biweekly	ALKA, Ca, Cl, NH_4, NOx, SO_4, $TDPO_4$, TKN, TSS
	ACF	Weekly	TPO_4
Inflow Stations			
G311 **S319** **S361**	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
		Weekly Recorded Flow	ALKA, Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
		Quarterly	DOC
	ACF	Weekly	TPO_4
Diversion Station			
G300	Grab	Weekly	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
		Biweekly	ALKA, NOx, SO_4, TKN

Station	Collection Method	Frequency	Parameter ACODES
Flow Way Start Stations			
S363C **S366B** **S366D** **S370A** **S370C** **S373A** **S373B**	Grab	Biweekly Recorded Flow	Ca, TPO_4, DO, pH, Scond, Temp
Flow Way Interior Stations			
S364A **S364C** **S367B** **S367D** **S368B** **S368D** **S371A** **S371C** **S374A** **S374C**	Grab	Monthly Recorded Flow	Ca, OPO_4, $TDPO_4$,TPO_4, DO, pH, Scond, Temp
Flow Way End Stations			
S365A **S365B** **S369B** **S369C** **S372B** **S372D**	Grab	Weekly Recorded Flow	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
		Quarterly	DOC

5.4 Field Testing Procedures

Field testing procedures shall follow the procedures and requirements found in the District's FSQM. Table 3 below describes the field parameters collected for this project. The table shows only the most commonly used parameters.

Table 3: Field Analytical Parameters Collected

Parameter	Resolution	Accuracy
Dissolved Oxygen	0.01 mg/L	0-20 mg/L, ± 0.2 mg/L
Specific Conductance	0.001 mS/cm	± 0.5% of reading ±0.001 mS/cm
Temperature	0.01° C	± 0.2°C
pH	0.01 unit	± 0.2 unit

5.5 Field Quality Control Requirements

Field quality control requirements shall follow the procedures found in the Quality Control Section of the District's FSQM.

5.6 Autosamplers

Samples are collected under flow-proportional (ACF) conditions at the stations identified in Table 2. Frequency for ACF collections is determined by a "trigger volume" established through the protocols established by Abtew and Powell (2004). Discrete bottles within each autosampler are pre-acidified and composited on a weekly basis and analyzed for total phosphorus (TPO_4).

5.7 Sample Submission

Following completion of sample collection for each day, the samples are transported in coolers with wet ice at $\leq 6^{o}C$ to the laboratory for analysis. Samples are submitted to the laboratory on the same day as collection or via courier the following day. Samples are submitted according to the requirements outlined in the District's FSQM. If samples are submitted to other than the District's in house laboratory, the laboratory must be a District approved laboratory.

6.0 Data Quality Objectives

6.1 Data Uses

The data from STA1E are compiled and reported in accordance with the conditions outlined in the permit or mandate specified in Section 3.2. Typically the data are reported in the District's Annual South Florida Environmental Report (SFER), or in some cases is reported in a standalone mandated report, such as the quarterly Everglades Settlement Agreement Report. The SFER can be found at www.sfwmd.gov/sfer/.

6.2 Data Quality

All monitoring described herein shall meet the indicators conveyed in the FDEP's Quality Assurance Rule, 62-160 F.A.C. The District has adopted a uniform set of Data Quality Objectives (DQOs) following criteria detailed within the "Analytical Methods and Default QA/QC Targets" table of the CLQM.

The DQOs of the field testing parameters for this project are covered by the table entitled Field Quality Assurance Objectives found in the field testing section of the FSQM. This manual is updated regularly, and therefore, the most recent version of the District's FSQM details the specific field testing DQOs for this project at the time of sample collection.

Samples are analyzed according to the provisions within the FDEP Rule 62-160 F.A.C. and the District's CLQM. This manual is updated regularly, and therefore, the most recent version of the District's CLQM details DQOs for this project at the time of sample collection for each specific laboratory analysis. Data are qualified in accordance with the FSQM, CLQM and applicable data validation SOPs.

6.3 Completeness Targets

The completeness target (i.e., the number of samples successfully collected and analyzed) shall be set at 95% annually for this project. Sampling attempts shall be included in the completeness target. At times samples will not be able to be collected on an attempt due to no flow or low water conditions, unsafe station conditions, equipment malfunction, site maintenance, or other unforeseen problems that might affect sample collection and/or quality. If samples cannot be collected on an attempt, collectors shall document "no bottle" (NOB) to indicate and attempt was made and/or the sample could not be collected for the documented reasons. Attempted collection (NOB) of samples will be considered a collected sample when calculating completeness targets.

7.0 Data and Records Management

The laboratory shall evaluate the data in accordance with the data quality objectives stated in the FSQM and CLQM. All data submittals shall conform to existing District guidelines.

7.1 Contract Deliverables

There are no contract deliverables for this project.

7.2 Data and Record Storage

After the data validation process, all data and records are maintained so that end users can retrieve and review all information relative to a sampling event. Field records are maintained in NuGenesis by scanning actual field note pages records directly into NuGenesis (See SFWMD-FIELD-SOP-022). All analytical data and specified metadata are sent to a database (DBHYDRO) for long-term storage and retrieval.

The District shall maintain master copies of field and laboratory generated records. It is the responsibility of the District to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. At least quarterly, any contractor performing work for the project shall provide all original field records to the District's WQB for permanent archival.

Records shall be maintained for the life of the project and a minimum of five years thereafter, in a manner that will protect the physical condition and/or integrity of the records. Storage shall follow the SOP for Archive Records Storage and Retention (SFWMD-FIELD-SOP-022). Corrections of data or records shall follow the applicable District SOPs and FSQM.

8.0 Revisions and Modifications

Date	Section	Page(s)	Change From	Change To	Reason
01/01/2013	All	All			Monitoring plan modified to conform to requirements of EFA Permit # 0311207, NPDES Permit # FL0778451, and their associated Consent Orders as well as STA Operational considerations.

References:

Abtew, Wossenu & Powell, B. Water Quality Sampling Schemes for Variable Flow Canals at Remote Sites. Journal of the American Water Resources Association. October, 2007. Pp 1197 – 1204.

FDEP (Florida Department of Environmental Protection). Quality Assurance Rule, 62-160 Florida Administrative Code (F.A.C.).

South Florida Water Management District, Chemistry Laboratory Quality Manual (CLQM), Version 1.0, October 2011 or a newer version if available. http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/analytical%20services/tab2/tab5/2011%20quality%20manual.pdf

South Florida Water Management District, Field Sampling Quality Manual (FSQM), Version 7.0, December 2011 or a newer version if available. http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/water%20quality%20monitoring%20division/subtab%20-%20wqm%20-%20qa/tab24442257/fsqm_sfwmd-field-qm-001-07.pdf

South Florida Water Management District, Field Sampling Quality Management Plan (QMP), Version 3.0, June 2011 or a newer version if available.
http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/subtab%20-%20qaqc/tab21630104/rsd_qmp_v3_0.pdf

Signature Page

Monitoring Plan

For

Eastern Flow-Way
Stormwater Treatment Area One East
(STA1E)

Linda Crean, Water Quality Monitoring Section Administrator — **Date**

David Struve, Analytical Services Section Administrator — **Date**

Julianne LaRock, Compliance Assessment and Reporting Section Administrator — **Date**

Ming Chen, Quality Assurance Administrator — **Date**

Appendix 1: Site Requirements by Mandate

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
Outflow Station				
S362	National Pollution Discharge Elimination System [NPDES]	Grab	Weekly Recorded Flow (WRF)	Total Phosphorus (TPO_4), pH
		ACF	Weekly (W)	TPO_4
	Everglades Forever Act [EFA]	Grab	See Specific Condition 21	Turbidity (TURB)
			WRF	TPO_4, Dissolved Oxygen (DO), pH, Specific conductance (Scond), Temperature (Temp)
			Biweekly Recorded Flow (BWRF)	Alkalinity (ALKA), Nitrite-Nitrate (NOx), Sulfate (SO_4), Total Nitrogen (TN[1])
		ACF	W	TPO_4
	Settlement Agreement	Grab	W	Orthophosphorus (OPO_4), TPO_4
			Biweekly (BW)	ALKA, Calcium (Ca), Chloride (Cl), NOx, Sulfate (SO_4), Total Dissolved Phosphorus ($TDPO_4$), Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS)
		ACF	W	TPO_4
	STA Operations	Grab	W	TPO_4, DO, pH, Scond, Temp
			BW	ALKA, Ca, Cl, NOx, NH_4, OPO_4, SO_4, $TDPO_4$, TKN, TSS
		ACF	W	TPO_4
Inflow Stations				
G311 **S319** **S361**	NPDES	Grab	WRF	TPO_4
		ACF	W	TPO_4
	EFA	Grab	WRF	TPO_4, pH, Scond, Temp
			BWRF	ALKA, NOx, SO_4, TN[1]
		ACF	W	TPO_4
	STA Operations	Grab	W	TPO_4, DO, pH, Scond, Temp
			WRF	ALKA, Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_{4,}$ TKN, TSS
			Quarterly (Q)	DOC
		ACF	W	TPO_4
Diversion Station				
G300	EFA	Grab	WRF	TPO_4
	Settlement Agreement	Grab	W	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
			BW	ALKA, NOx, SO_4, TKN
		ACF	W	TPO_4
	STA Operations	Grab	WRF	TPO_4
Flow Way Start Stations				
S363C **S366B** **S366D** **S370A** **S370C**	STA Operations	Grab	BWRF	Ca, TPO_4, DO, pH, Scond, Temp

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
S373A **S373B**				
Flow Way Interior Stations				
S364A **S364C** **S367B** **S367D** **S368B** **S368D** **S371A** **S371C** **S374A** **S374C**	STA Operations	Grab	Monthly recorded flow (MRF)	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
Flow Way End Stations				
S365A **S365B** **S369B** **S369C** **S372B** **S372D**	STA Operations	Grab	WRF	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
			Q	DOC

[1] TN is calculated as the sum of TKN and NOx

Appendix 2: Mercury and Other Toxicants Monitoring Plan

Flow-Path: Eastern
Stormwater Treatment Area 1E
EFA Permit No. 0311207

Monitoring of water-column concentrations of total mercury (THg) and methylmercury (MeHg) began in January 2005 at STA1E. Both the central flow-way (Cells 3-4N-4S) and the western flow-way (Cells 5-6-7) met the mercury startup criteria, as specified in Exhibit "C" of EFA Permit No. 0195030-001-GL, in August 2005 (see data summary provided in correspondence from R. Bearzotti, SFWMD dated September 9, 2005). The U.S. Army Corps of Engineers completed construction of a PSTA Demonstration Project in the eastern flow-way (Cells 1 and 2) of STA1E in February 2007. The eastern flow-way met mercury startup criteria, as specified in Exhibit "F" of EFA permit 0279449-001-EM, in August 2007. February 29, 2012 the Florida Department of Environmental Protection (Department) approved transfer of STA1E mercury monitoring from Phase 2 – Tier 1: Routine Monitoring during Stabilization Period to Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9 for all flow ways (Western, Central and Eastern) which include cells 1, 2, 3, 4N, 4S, 5, 6 and 7 of STA1E.

Based on the, initial performance of the three flow-ways and the guidance contained in "*A Protocol for Monitoring Mercury and Other Toxicants"* (dated April 2011; hereafter referred to as the *Protocol*), the District shall conduct Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9 as follows:

3.0 Phase 3 - Operational Monitoring

3.1 Phase 3 - Tier 1: Routine Operational Monitoring from Year 4 to Year 9

3.1.1 Fish Tissues

Semiannually, mosquitofish will be collected from multiple locations within each flow-way and physically composited into one spatially-averaged sample (to total at least 100 fish) per flow-way (i.e., eastern flow-way comprised of Cells 1 and 2; central flow-way comprised of Cells 3, 4N, and 4S; and the western flow-way comprised of Cells 5, 6, and 7) for THg analysis (note, a single aliquot will be analyzed per composite). Additionally, mosquitofish (to total at least 100 fish) will be collected from a single site located in the receiving waters immediately downstream from the project (site STA1ELX) and analyzed for THg.

As reported in previous annual reports (see 2010 South Florida Environmental Report and references therein), mercury levels tend to be statistically higher in resident fish from Cell 2A as compared to the other cells. Accordingly, to assess "worst case" conditions, large-bodied fish will be collected only from Cell 2A and the downstream station STA1ELX once every three years beginning in 2011. This limited spatial sampling of large-bodied fish within the STA is to revert back to include formerly sampled stations in Cells 4 and 6 (i.e., STA1EC4SA and STA1EC6A), if Tier 2 is triggered or if mosquitofish demonstrate significantly altered spatial patterns in mercury biomagnification.

Specifically, sunfish (n should be greater than or equal to 5) should be collected from each station and individually analyzed as whole-fish. At the same time, largemouth bass (*Micropterus salmoides*; n should be greater than or equal to 5) should be collected from each station and individually analyzed (fillets) for THg. To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections will target bluegill (*Lepomis microchirus*) ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches); however, other lepomids (due to similar trophic status, first priority being given to spotted sunfish (*L. punctatus*) or sizes will be collected if efforts fail to locate targeted fish.

These data will then be used to track the following:

- THg levels in individual mosquitofish composite;
- Annual average THg levels in mosquitofish;
- THg levels in large-bodied fish

Table 1: Phase 3 - Tier 1: Routine Operational Monitoring from Year 4 to Year 9

Matrix	Location	Collection Method	Frequency	Parameter
Mosquitofish	Each Flow-way & STA1ELX	Net or Trap	Semiannually	THg
Sunfish and Bass (n=5 each)	Cell 2A & STA1ELX	Electrofish or Hook & Line	Triennially	THg

3.2 Phase 3 - Tier 2: Expanded Monitoring and Risk Assessment

Tier 2 monitoring and assessment is triggered if one of the following action levels is exceeded during operation:

- If annual average THg levels in mosquitofish progressively increased over time (i.e., two or more years) or any (semi-annual) mosquitofish composite exceeds the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeds the 75th percentile concentration for the period of record for all basins; or
- If triennial monitoring of large-bodied fish reveal tissue Hg levels in fishes have statistically increased progressively over time or have become elevated to the point of exceeding the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeded the 75th percentile concentration for the period of record for all basins.

The following steps will be taken if any action level in Tier 2 is triggered:

Step 1: Notify the Department;

Step 2: Resample fish species that triggered Tier 2;

If results of Step 2 (i.e., re-sampling) demonstrate that the anomalous condition was an isolated event, the Department will be notified that the project will revert back and continue with Tier 1 monitoring. Alternatively, if results of Step 2 reveal the anomalous condition was not an isolated event, proceed to Step 3.

Step 3: Expanding monitoring program as follows:

- Increase frequency of mosquitofish collection from semiannually to monthly.
- If Tier 2 was triggered by THg levels in fish at the downstream site, possibly due to excessive loading from the STA outflow, then quarterly water-column sampling at the outflow station will begin. If necessary (i.e., if loading uncertainty is high), increase frequency of surface water collection to monthly (reducing temporal interpolation), or as appropriate for hydraulic retention time (HRT).
- If Tier 2 was triggered by THg levels in fish within only one of the treatment trains, further define spatial extent of problem by collecting multiple mosquitofish composites from within the treatment train exhibiting anomalous conditions.
- If Tier 2 was triggered by tissue THg levels in large-bodied fish, increase sample size of large-bodied fish to n = 20, i.e., 20 each of sunfish (collect various species and sizes) and/or bass (collect various sizes and extract otolith from bass for age determination).
- To evaluate possible trends in methylation rates in sediments (i.e., to determine if methylation rates are increasing or decreasing), replicate sediment cores (0-4 cm) can be collected from the suspected methylation "hot spot" and reference locations within the component (for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe)) over a given period of time (i.e., 2 to 4 months). At these same locations and collection times, collect pore water samples and analyze for THg, MeHg, and sulfides, or if no acceptable pore water protocol has been developed, then acid-volatile sulfide (AVS) on solids shall be completed.

Projects shown to have (spatially) large or multiple MeHg "hotspots" should consider use of the Everglades Mercury Cycling Model (E-MCM) or comparable model as an assessment tool (i.e., to synthesize results of expanded monitoring).

Step 3 will also include the notification of the Department that anomalous conditions are continuing. The Department and the District may then develop an adaptive management plan using the data generated from the expanded monitoring program. This plan will evaluate the potential risks from continued operation under existing conditions (i.e., through a risk assessment for appropriate ecological receptors). If risk under existing operational conditions is deemed acceptable, then project monitoring would continue under a modified Tier 2 scheme to monitor exposure. On the other hand, if risk under existing operational conditions is deemed unacceptable, then the adaptive management plan would then proceed to determine potential remedial actions to (1) reduce exposure and risk (e.g., signage for human health concerns[1], reduce fish populations, reduce forage habitat suitability)) and (2) affect mercury biogeochemistry to reduce net methylation (e.g., modify hydroperiod or stage, water quality).

In developing this adaptive management plan, the Department may conduct a publicly noticed workshop to solicit comments from the District, the U.S. Army Corps of Engineers, the U.S.

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[1] Note that assessment of potential human health impacts and corrective actions (i.e., signage) will require the involvement of the Florida Department of Health.

Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Park Service, the Florida Fish and Wildlife Conservation Commission, and other interested persons.

The next step would then be to carry out such remedial or corrective action. If the remedial or corrective action is demonstrated to be successful, then the project would revert back to Tier 1 monitoring. Alternatively, if monitoring data indicate that the remedial action was unsuccessful in reducing fish tissue concentrations or downstream loading, the Department and the District would then initiate a peer-reviewed, scientific assessment of the benefits and risks of the project.

3.3 Phase 3 - Tier 3: Termination of Monitoring After Year 9

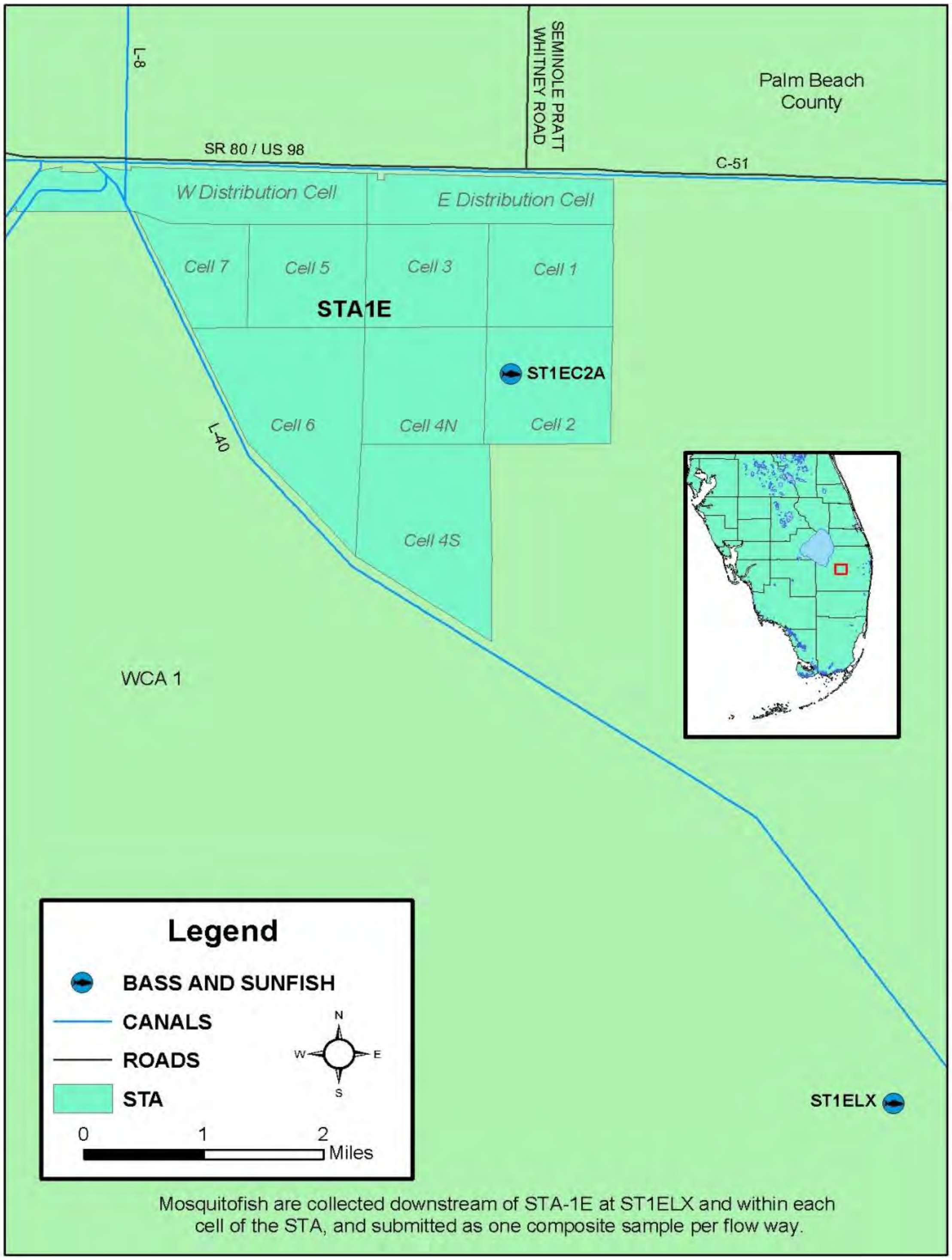
If fish collected under Tier 1 have not exceeded action levels by year 9, project-specific monitoring would be discontinued; future assessments would be based on regional monitoring.

4.0 Annual Mercury Monitoring Report

The District shall notify the Department immediately if monitoring data indicate that any of the action levels are exceeded. In addition, the District shall submit an annual report to be incorporated into the South Florida Environmental Report (SFER) and submitted to the Department no later than March 1st of each year. The annual report shall summarize the most recent results of the monitoring as defined above and compares them with the cumulative results from previous years. This report shall also evaluate assessment performance measures (i.e., action levels) outlined above.

5.0 Adaptive Management Strategy

It is the intent that this monitoring plan will be carried out within the context of an adaptive management strategy that will allow for appropriate changes based on new, better understanding of mercury cycling, fate and transport as conveyed in the guidance contained in the *Protocol*.



Mosquitofish are collected downstream of STA-1E at ST1ELX and within each cell of the STA, and submitted as one composite sample per flow way.

STA1E Mercury and other Toxicants Monitoring Locations

Operational Project Monitoring Plan

For

Eastern Flow-Way
Stormwater Treatment Area 1 West

(Project Code: STA1W)

01/07/2013

This monitoring plan is adaptive and therefore subject to change based on operational needs. It will be reviewed and/or modified at a minimum, on an annual basis.

Water Quality Monitoring Section
Water Quality Bureau, Water Resources Division
South Florida Water Management District

SFWMD-FIELD-MP-047-03

Table of Contents

Figures

Tables

Appendices

1.0 Glossary

ACF	Autosampler collection based upon flow trigger
CLQM	Clinical Laboratory Quality Manual
DBHYDRO	South Florida Water Management District Environmental Database
District	South Florida Water Management District
DO	Dissolved Oxygen
DQOs	Data Quality Objectives
EAA	Everglades Agricultural Area
ECP	Everglades Construction Project
EFA	Everglades Forever Act
ENR	Everglades Nutrient Removal
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FSQM	Field Sampling Quality Manual
GPS	Global Positioning System
LIMS	Laboratory Information Management System
NPDES	National Pollutant Discharge Elimination System
SFER	South Florida Environmental Report
SFWMD	South Florida Water Management District
STA1W	Stormwater Treatment Area 1 West
WCA-1	Water Conservation Area 1

2.0 Project Organization

Overall project organization and responsibilities are detailed in the South Florida Water Management District (SFWMD or District) Applied Sciences (ASB) and Water Quality Bureau (WQB) Quality Management Plan (QMP). Field activity responsibilities are detailed in the District's Field Sampling Quality Manual (FSQM). Laboratory analysis and data validation responsibilities are detailed in the District's Chemistry Laboratory Quality Manual (CLQM). These documents define the procedures used by SFWMD personnel to meet the Florida Department of Environmental Protection's (FDEP) Quality Assurance (QA) Rule, Florida Administrative Code (F.A.C.) 62-160. Refer to these documents for details on key personnel and relevant responsibilities.

3.0 Project Description

3.1 Introduction and Background

This document serves as a reference for surface water quality monitoring for STA1W. The operational plan for this project contains detailed structure specifications including brief descriptions of the mandate and/or permit required monitoring at each station. Current project status, schematics and the project operational plan can be viewed at the District's STA status page.

Surface water monitoring at STA1W began in June 2000, as part of the Everglades Construction Project (ECP). STA1W's mandated stations consist of the inflows at G-302; outflow station S-310 and G-251and diversion stations G-301. The construction, operation and maintenance of this Everglades Construction Project are required by the Everglades Forever Act (EFA) to restore the Everglades ecosystem. The guidance contained in this document will assist in maintaining consistency in sampling locations, parameter lists, and frequencies as well as providing documentation of the project scope and an ongoing historical perspective.

3.2 Mandates and Permits

Station locations, sampling frequencies, and parameters to be sampled are dictated by the mandate and/or permits governing this project (see Appendix 1 for details). In addition, a mercury and toxicants monitoring program required by Everglades Forever Act Permit (0311207) is included as Appendix 2.

As part of the Eastern Flow-way for the Everglades Construction Project, STA1W is subject to both the Everglades Forever Act Permit #0311207 and the National Pollutant Discharge Elimination System Industrial Wastewater Facility (NPDES) Permit FL0778451, both issued on September 10, 2012 and expiring on September 09, 2017. These permits dictate the types and frequencies of monitoring to be done, and the parameters to be analyzed, and can be viewed at:

- Everglades Forever Act Permit
  http://www.dep.state.fl.us/water/wqssp/everglades/docs/ecp-sta/draft-watershed-efa-permit.pdf
- NPDES Permit

http://www.dep.state.fl.us/secretary/news/2012/06/npdes_watershed_permit_consent_order.pdf

Additional stations, parameters and frequencies are required as part of operational monitoring are detailed in Appendix 1.

3.3 Project Objectives

The primary objective of this monitoring project is to:

1. Assess compliance with applicable water quality standards and phosphorus discharge limits;
2. Aid in determining the nutrient concentrations to quantify the tons of nutrients removed by the STA annually;
3. Guide mid and long term resource management decisions for nutrient removal capabilities of the STA.

3.4 Duration

3.4.1 Initiation Conditions

The monitoring for this project was initiated during June, 2000. Prior monitoring for Cells 1 through 4 was conducted as part of the Everglades Nutrient Removal (ENR) Project.

3.4.2 Modification or Termination Conditions

The mandated monitoring described in this document will be ongoing as required by the EFA 0311207 and NPDES FL0778451 permits, which are renewed once every 5 years. Conditions for modification or termination of the project are detailed in the permit(s) that specify the conditions of the project. Monitoring for operations will continue indefinitely in support of the project goals and objectives. Monitoring may increase or decrease over time, depending upon individual cell operations, data results, end user needs and permit requirements. Short-term changes to collection events may be made as a result of an extreme weather conditions (i.e., droughts and tropical storms/hurricanes), other safety concerns, or construction activities.

4.0 Geographic Location

4.1 Regional Area

The STA1W project consists of 19 monitoring stations in Palm Beach County (Figure 1). Table 1 provides the station names, global positioning system (GPS) coordinates, and a description of each monitoring station. The locations of all monitoring stations are depicted on the map in Figure 1.

4.2 Sampling Locations

The locations of all monitoring stations are depicted in Figure 1 with exact locations described in Table 1.

4.3 Access and Authority

The gates on roadways into STA1W are secured with a District Palm Beach County "W" lock. The lock requires a "W" key which can be obtained through a request made through the FPM and/or Field Supervisor. Samples are collected on the upstream side of structures/culverts.

Table 1: STA1W Surface Water Monitoring Sites, GPS Coordinates and Descriptions

Station Name	Latitude	Longitude	Description
G251 (ENR012)	263552.244	802633.18	Immediately upstream (west) of G251. Cell 3 outflow pump station (seepage)
G250S (ENR002)	263552.244	802633.18	Immediately upstream (north) of G250. Cell 1A inflow pump station
G310	263553.57	802644	Primary outflow pump station
G301	264032.33	802248.99	Gated structure in NE corner on L-7 canal (diversion)
G302	264035.213	802250.99	Primary inflow gated structure - NE corner
G327B	264037.448	802635.695	Pump structure on SW corner of cell 5B in STA1W (seepage)
G309	263739.122	802640	North cell 4 outflow gated structure (end)
G308	263645.943	802641.5	North cell 3 outflow gated structure (end)
G307	263712.301	802642.247	South cell 4 outflow gated structure (end)
G306G	263932.69	802639.9	7th outflow gated structure (from north) for cell 5B (end)
G306C	264011.732	802639.911	3rd outflow gated structure (from north) for cell 5B (end)
G305N	264000.942	802420.3	14th inflow open culvert (from north) for cell 5B (interior)
G305G	264019.811	802405.8	7th inflow open culvert (from north) for cell 5B (interior)
G259	263556.243	802646.18	South cell 3 outflow culvert (end)
G255	263929.234	802445.177	Inflow gated structure for cell 2A (start)
G254D	263805.238	802604.179	7th inflow culvert (from west) for cell 4 (interior)
G254B	263805.238	802625.18	3rd inflow culvert (from west) for cell 4 (interior)
G249D	263831.012	802609.408	4th inflow culvert (from west) for cell 2B (interior)
G248B	263830.708	802509.540	2nd inflow culvert (from west) for cell 1B (interior)

*The standard positional goal for site coordinates is ±1 meter. This standard can be obtained with a professional grade DGPS system. The coordinates are relative to NAD83 HARN horizontal datum.

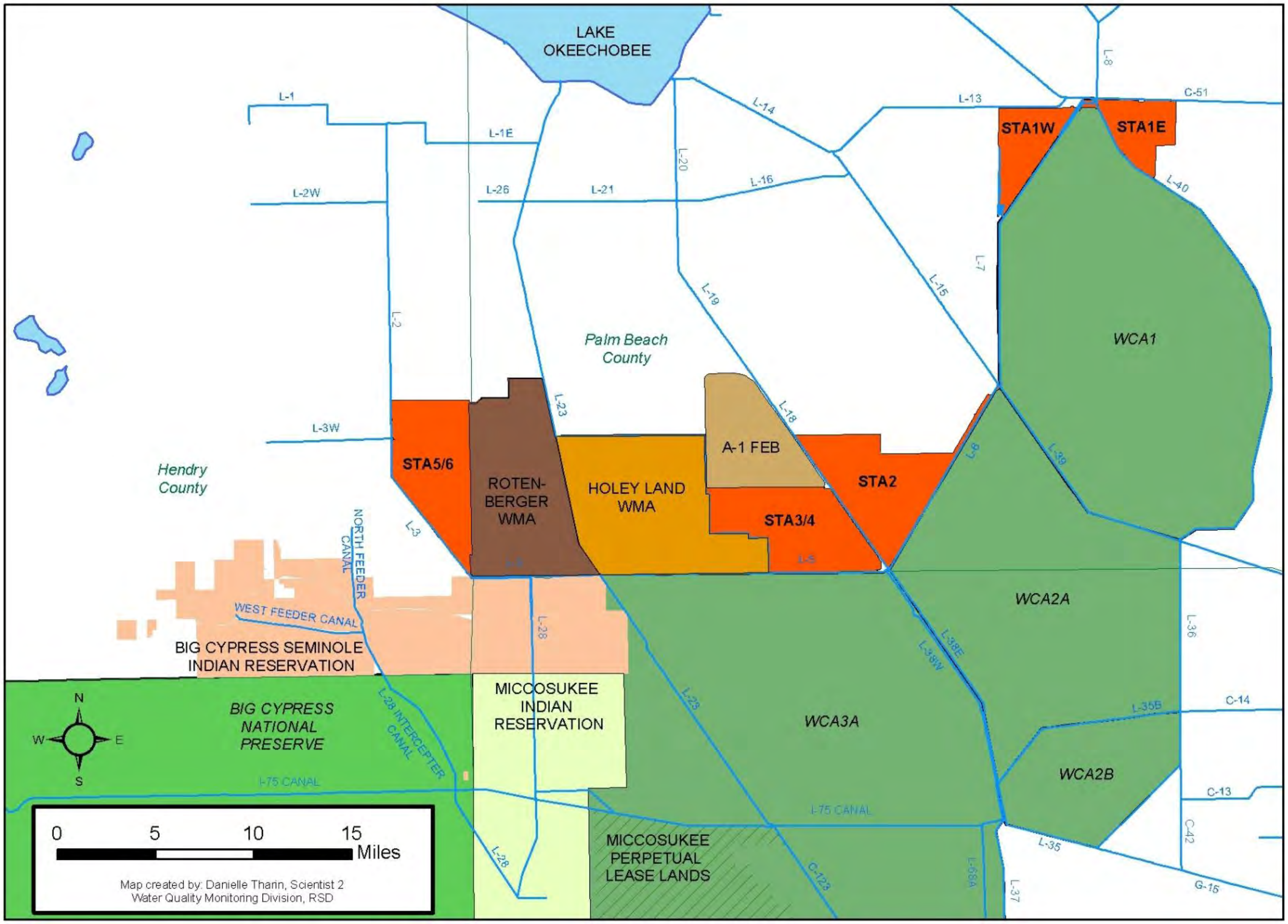
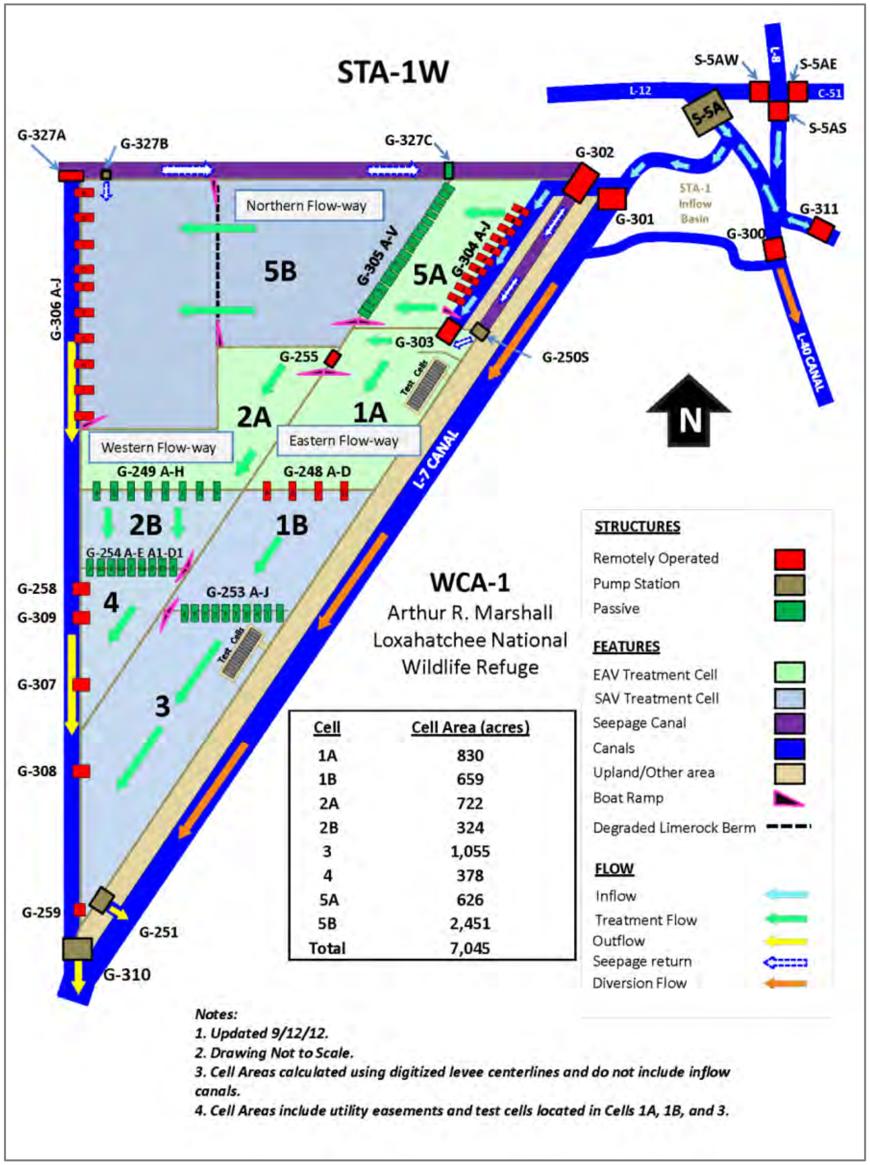


Figure 1: Regional Area Map



Cell	Cell Area (acres)
1A	830
1B	659
2A	722
2B	324
3	1,055
4	378
5A	626
5B	2,451
Total	7,045

Notes:
1. Updated 9/12/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.
4. Cell Areas include utility easements and test cells located in Cells 1A, 1B, and 3.

Figure 2: STA1W Layout

5.0 Field Activities

5.1 Monitoring Frequencies by Site and Parameters (ACODES)

All samples required for collection are depicted in Table 2. Some stations within the monitoring network are collected based on whether flow has been recorded. Specifically, structure operation activity is determined within a specified timeframe through the review of electronic data. If no flow (i.e., no operations) has been recorded, the sample is considered a No Bottle sample (NOB) and the structure is not visited. Conversely, if flow has been recorded during the specified timeframe, a sample is collected.

5.2 Project Specific Guidelines

All surface water samples shall be collected on the upstream side of any structure at a depth of 0.5 m unless vegetation and/or other conditions inhibit the collection of a representative sample upstream. Prior to sampling an alternative site, a consultation with a Field Technician Supervisor and/or the FPM must take place; this action must be documented in the field notes.

Backup grab samples will accompany the autosampler collection based upon flow trigger (ACF) samples collected on a weekly basis. In addition, in situ readings (i.e., Temperature, pH, DO and Specific Conductance) are measured as the grab samples are being collected. Samples collected are on the upstream side of structures/culverts.

5.3 Grab Sampling Guidelines

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District's FSQM.

Table 2: STA1W Grab/Autosampler Collection Frequency and Parameters

Station Name	Collection Method	Frequency	Parameter ACODES
Outflow Station			
G310	Grab	Weekly	OPO_4, TPO_4, DO, pH, Scond, Temp
		Biweekly	ALKA, Ca, Cl, NH_4, NOx, SO_4, $TDPO_4$, TKN, TSS
	ACF	Weekly	TPO_4
Outflow and End Station			
G251 (ENR012)	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
		Weekly Recorded Flow else Biweekly	ALKA, Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
	ACF	Weekly	TPO_4
Inflow Station			
G302	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
		Weekly Recorded Flow	ALKA, Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
		Quarterly	DOC
	ACF	Weekly	TPO_4
Diversion Station			
G301	Grab	Weekly	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
		Biweekly	ALKA, NOx, SO_4, TKN
Flow Way Start Station			

Station Name	Collection Method	Frequency	Parameter ACODES
G255	Grab	Biweekly Recorded Flow	Ca, TPO_4, DO, pH, Scond, Temp
Flow Way Interior Stations			
G248B **G249D** **G254B** **G254D** **G305G** **G305N**	Grab	Monthly Recorded Flow	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
Flow Way End Stations			
G259 **G306C** **G306G** **G307** **G308** **G309**	Grab	Weekly Recorded Flow	Ca, OPO_4, TDPO4, TPO_4, DO, pH, Scond, Temp
		Quarterly	DOC
Divides and Seepage Structures			
G250S **(ENR002)** **G327B**	Grab	Monthly Recorded Flow	TPO_4, DO, pH, Scond, Temp

5.4 Field Testing Procedures

Field testing procedures shall follow the procedures and requirements found in the District's FSQM. Table 3 below describes the field parameters collected for this project. The table shows only the most commonly used parameters.

Table 3: Field Analytical Parameters Collected

Parameter	Resolution	Accuracy
Dissolved Oxygen	0.01 mg/L	0-20 mg/L, ± 0.2 mg/L
Specific Conductance	0.001 mS/cm	± 0.5% of reading +0.001 mS/cm
Temperature	0.01° C	± 0.15°C
pH	0.01 unit	± 0.2 unit

5.5 Field Quality Control Requirements

Field quality control requirements shall follow the procedures found in the Field Quality Control Section of the District's FSQM.

5.6 Autosampler Collection

Samples are collected with flow-proportional (ACF) at the stations identified in Table 2. Frequency for ACF collections is determined by a "trigger volume" established through the protocols established by Abtew and Powell (2004). The frequency of ADT collection is set by the FPM following discussions with the data end user(s). Discrete bottles within each autosampler are pre-acidified and composited on a weekly basis and analyzed for total phosphorus (TPO_4).

5.7 Sample Submission

Following completion of sample collection for each day, the samples are placed in ice and transported in coolers at $\leq 6^{o}$C to the laboratory for analysis. Samples are submitted to the laboratory on the same day as collection or via courier the following day. Samples are submitted according to the requirements outlined in the District's FSQM. If samples are submitted to other than the District's laboratory, the laboratory must be a District approved laboratory.

6.0 Data Quality Objectives

6.1 Data Uses

The data from STA1W are compiled and reported in accordance with the conditions outlined in the permit or mandate specified in Section 3.2. Typically the data are reported in the District's annual South Florida Environmental Report (SFER), or in some cases is reported in a standalone mandated report, such as the quarterly Everglades Settlement Agreement Report. The SFER can be found at www.sfwmd.gov/sfer/.

6.2 Data Quality

All monitoring described herein shall meet the indicators conveyed in the FDEP's Quality Assurance Rule, 62-160 F.A.C. The District has adopted a uniform set of Data Quality Objectives (DQOs) following criteria detailed within the "Analytical Methods and Default QA/QC Targets" table of the CLQM.

The DQOs of the field testing parameters for this project are covered by the table entitled Field Quality Assurance Objectives found in the field testing section of the FSQM. This manual is updated regularly, and therefore, the most recent version of the District's FSQM details the specific field testing DQOs for this project at the time of sample collection.

Samples are analyzed according to the provisions within the FDEP Rule 62-160 F.A.C. and the District's CLQM. This manual is updated regularly, and therefore, the most recent version of the District's CLQM details DQOs for this project at the time of sample collection for each specific laboratory analysis. Data are qualified in accordance with the FSQM, CLQM and applicable data validation SOPs.

6.3 Completeness Targets

The completeness target (i.e., the number of samples successfully collected and analyzed) shall be set at 95% annually for this project. Sampling attempts shall be included in the completeness target. At times samples will not be able to be collected on an attempt due to no flow or low water conditions, unsafe station conditions, equipment malfunction, site maintenance, or other unforeseen problems that might affect sample collection and/or quality. If samples cannot be collected on an attempt, collectors shall document "no bottle" (NOB) to indicate and attempt was made and/or the sample could not be collected for the documented reasons. Attempted collection (NOB) of samples will be considered a collected sample when calculating completeness targets.

7.0 Data and Records Management

The laboratory shall evaluate the data in accordance with the data quality objectives stated in the FSQM and CLQM. All data submittals shall conform to existing District guidelines.

7.1 Contract Deliverables

There are no contract deliverables for this project.

7.2 Data and Record Storage

After the data validation process, all data and records are maintained so that end users can retrieve and review all information relative to a sampling event. Field records are maintained in NuGenesis by scanning actual field note pages records directly into NuGenesis (See SFWMD-FIELD-SOP-022). All analytical data and specified metadata are sent to a database (DBHYDRO) for long-term storage and retrieval.

The District shall maintain master copies of field and laboratory generated records. It is the responsibility of the District to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. At least quarterly, any contractor performing work for the project shall provide all original field records to the District's WQB for permanent archival.

Records shall be maintained for the life of the project and a minimum of five years thereafter, in a manner that will protect the physical condition and/or integrity of the records. Storage shall follow the SOP for Archive Records Storage and Retention (SFWMD-FIELD-SOP-022). Corrections of data or records shall follow the applicable District SOPs and FSQM.

8.0 Revisions and Modifications

Date	Section	Page Number(s)	Change From	Change To	Reason
01/01/2013	All	All			Monitoring plan modified to conform to requirements of EFA Permit # 0311207, NPDES Permit # FL0778451, and their associated Consent Orders as well as STA Operational considerations.

References

Abtew, Wossenu & Powell, B. Water Quality Sampling Schemes for Variable Flow Canals at Remote Sites. Journal of the American Water Resources Association. October, 2007. Pp 1197 – 1204.

FDEP (Florida Department of Environmental Protection). Quality Assurance Rule, 62-160 Florida Administrative Code (F.A.C.).

South Florida Water Management District, Chemistry Laboratory Quality Manual (CLQM), Version 1.0, October 2011 or a newer version if available.

http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/analytical%20services/tab2/tab5/2011%20quality%20manual.pdf

South Florida Water Management District, Field Sampling Quality Manual (FSQM), Version 7.0, December 2011 or a newer version if available.

http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/water%20quality%20monitoring%20division/subtab%20-%20wqm%20-%20qa/tab24442257/fsqm_sfwmd-field-qm-001-07.pdf

South Florida Water Management District, Field Sampling Quality Management Plan (QMP), Version 3.0, June 2011 or a newer version if available.

http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/subtab%20-%20qaqc/tab21630104/rsd_qmp_v3_0.pdf

Signature Page

Operational Monitoring Plan

For

Eastern Flow-Way
Stormwater Treatment Area One West
(STA1W)

Linda Crean, Water Quality Monitoring Section Administrator **Date**

David Struve, Analytical Services Section Administrator **Date**

Julianne LaRock, Compliance Assessment and Reporting Section Administrator **Date**

Ming Chen, Quality Assurance Administrator **Date**

Appendix 1: Site Requirements by Mandate

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
Outflow Station				
G310	National Pollution Discharge Elimination System [NPDES]	Grab	Weekly Recorded Flow (WRF)	Total Phosphorus (TPO$_4$), pH
		ACF	Weekly (W)	TPO$_4$
	Everglades Forever Act [EFA]	Grab	See Specific Condition 21	Turbidity (TURB)
			WRF	TPO$_4$, Dissolved Oxygen (DO), pH, Specific conductance (Scond), Temperature (Temp)
			Biweekly Recorded Flow (BWRF)	Alkalinity (ALKA), Nitrite-Nitrate (NOx), Sulfate (SO$_4$), Total Nitrogen (TN[1])
		ACF	W	TPO$_4$
	Settlement Agreement	Grab	W	Orthophosphorus (OPO$_4$), TPO$_4$
			Biweekly (BW)	ALKA, Calcium (Ca), Chloride (Cl), NOx, Sulfate (SO$_4$), Total Dissolved Phosphorus (TDPO$_4$), Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS)
		ACF	W	TPO$_4$
	STA Operations	Grab	W	TPO$_4$, DO, pH, Scond, Temp
			BW	ALKA, Ca, Cl, NOx, Ammonia (NH$_4$), SO$_4$, OPO$_4$, TDPO$_4$, TKN, TSS
		ACF	W	TPO$_4$
Outflow and Flow Way End Station				
G-251 (ENR012)	National Pollution Discharge Elimination System [NPDES]	Grab	WRF	TPO$_4$, pH
		ACF	W	TPO$_4$
	Everglades Forever Act [EFA]	Grab	See Specific Condition 21	TURB
			WRF	TPO$_4$, DO, pH, Scond, Temp
			BWRF	ALKA, NOx, SO$_4$, TN[1]
		ACF	W	TPO$_4$
	Settlement Agreement	Grab	W	TPO$_4$
			BW	ALKA, Ca, Cl, NOx, SO$_4$, TDPO$_4$, TKN, TSS
		ACF	W	TPO$_4$
	STA Operations	Grab	W	TPO$_4$, DO, pH, Scond, Temp
			WRF	ALKA, Ca, Cl, NOx, NH$_4$, OPO$_4$, SO$_4$,

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
				$TDPO_4$, TKN, TSS
		ACF	W	TPO_4
Inflow Stations				
G302	NPDES	Grab	WRF	TPO_4
		ACF	W	TPO_4
	EFA	Grab	WRF	TPO_4, pH, Scond, Temp
			BWRF	ALKA, NOx, SO_4, TN[1]
		ACF	W	TPO_4
	STA Operations	Grab	W	TPO_4, DO, pH, Scond, Temp
			WRF	ALKA, Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
			Quarterly (Q)	DOC
		ACF	W	TPO_4
Seepage and Diversion Stations				
G-250S (ENR002) **G327B**	STA Operations	Grab	Monthly Recorded Flow (MRF)	TPO_4, DO, Scond, pH, Temp
G301	EFA	Grab	WRF	TPO_4
	Settlement Agreement	Grab	W	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
			BW	ALKA, NOx, SO_4, TKN
		ACF	W	TPO_4
	STA Operations	Grab	WRF	TPO_4
Flow Way Start Station				
G255	STA Operations	Grab	BWRF	Ca, TPO_4, DO, pH, Scond, Temp
Flow Way Interior Stations				
G248B **G249D** **G254B** **G254D** **G305G** **G305N**	STA Operations	Grab	MRF	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
Flow Way End Stations				
G259 **G306C** **G306G** **G307** **G308** **G309**	STA Operations	Grab	WRF	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
			Q	DOC

[1] TN is calculated as the sum of TKN and NOx

Appendix 2: Project STA1W Mercury and other Toxicants Monitoring Plan

Eastern Flow-Way
Stormwater Treatment Area 1W
EFA Permit No. 0311207

The Florida Department of Environmental Protection (Department) issued minor permit modification 0279449-009 August 21, 2009, approving transfer of STA-1W mercury monitoring from Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9 to Phase 3 – Tier 3: Routine Operational Monitoring After Year 9. This implemented the termination of all site specific mercury monitoring at STA-1W.

Operational Project Monitoring Plan

For

Central Flow-Way

Stormwater Treatment Area 2

(Project Code: STA2)

01/07/2013

This monitoring plan is adaptive and therefore subject to change based on operational needs. It will be reviewed and/or modified at a minimum, on an annual basis.

Water Quality Monitoring Section
Water Quality Bureau, Water Resources Division
South Florida Water Management District

SFWMD-FIELD-MP-073-02

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Figures

Tables

Appendices

1.0 Glossary

ACF	Autosampler collection based upon flow trigger
ADaPT	Automated Data Processing Tool (a software application that processes data validation based on the Florida DEP QA Rule).
CAMB	Conservation Area Mass Balance Project
CLQM	District's Chemistry Laboratory Quality Manual
DBHYDRO	SFWMD hydrometeorologic, water quality and hydrogeologic data storage and retrieval system
DGPS	Differential Global Positioning System
DQOs	Data Quality Objectives
EAA	Everglades Agricultural Area
EFA	Everglades Forever Act
ESA	Environmental Site Assessment
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FSQM	Field Sampling Quality Manual
GPS	Global Positioning System
NAD83 HARN	North American Datum of 1983 High Accuracy Reference Network
NPDES	National Pollutant Discharge Elimination System
NCB	North Compartment B Flow Way
NPDES	National Pollutant Discharge Elimination System
QA/QC	Quality Assurance/Quality Control
SFER	South Florida Environmental Report
SFWMD	South Florida Water Management District
SCB	South Compartment B Flow Way
SQAG	Sediment Quality Assessment Guidelines
STA2	Stormwater Treatment Area 2
WCA	Water Conservation Area
WQB	Water Quality Bureau

2.0 Project Organization

Overall project organization and responsibilities are detailed in the South Florida Water Management District (SFWMD or District) Water Quality Bureau (WQB) Quality Management Plan (QMP). Field activity responsibilities are detailed in the District's Field Sampling Quality Manual (FSQM). Laboratory analysis and data validation responsibilities are detailed in the District's Chemistry Laboratory Quality Manual (CLQM). These documents define the procedures used by SFWMD personnel to meet the Florida Department of Environmental Protection's (FDEP) Quality Assurance Rule, Florida Administrative Code (F.A.C.) 62-160. Refer to these documents for details on key personnel and relevant responsibilities.

3.0 Project Description

3.1 Project Introduction and Background

The Central Flow Way consists of Stormwater Treatment Area Two (STA2) and Stormwater Treatment Area 3/4 (ST34). This document serves as a reference for surface water quality monitoring for Stormwater Treatment Area Two (STA2) and the Compartment B Build-out Project (Compartment B). This integrated operational plan for this project contains detailed structure specifications including brief descriptions of the mandate and/or permit required monitoring at each station. Current project status, schematics and the project operations plan can be viewed at the District's STA status web page.

There are three main flow ways in the STA2 and Compartment B Project. These are: 1) the original STA2, 2) the North Compartment B (NCB) and 3) the South Compartment B (SCB). The total effective treatment area for all three flow ways is 14,919 acres and is divided as detailed in Table 1.

- The original STA2 began operations in 1997 and accepts inflow from the Hillsboro canal through S6 or from privately owned lands through G328. Water is directed into three cells through gated culverts. Cell 1 has four inflow culverts G329A-D, Cell 2 has seven inflow culverts G331A-G, and Cell 3 has five inflow culverts G333A-E. Water flows out of the Cell 1 through five gated culverts G330A-E, from Cells 2 and Cell 3 through gated spillways (G332 and G334, respectively) to a common discharge canal. The G337 seepage pump station directs perimeter seepage back into the STA2 supply canal.
- North Compartment B began operations in November 2012 and accepts water from the North New River Canal through G434 and flows into gated culverts for Cells 5 (G438A-E) and 6 (G438F-J). Cell 5 has three outflow culverts G367D-F and Cell 6 has three outflow culverts G367A-C which flow into Cell 4. Cell 4 discharges to the common discharge canal through a gated spillway G368. There is a seepage pump at the G434 pump station to redirect seepage back into the NCB inflow.
- G337A now acts a divide structure allowing inflow from S6 or G328 to enter North Compartment B or allows water from G434 to enter the original STA2.

- South Compartment B began startup testing in November 2012 and accepts water from the North New River canal through G435; this water flows into Cell 7 through six gated culverts G440A-F. The water then flows out of Cell 7 and into Cell 8 through three gated culverts G442A-C. Water leaves Cell 8 through two gated culverts G441A-B to a common discharge canal. G445 is a seepage pump station located near the inflow of Cell 8, and pulls seepage from the FPL right of way located between Cell 8 and the L6 canal. Currently, this flow way is offline for regular monitoring.
- Water for all three flow ways is collected into a common discharge canal and is discharged to the L6 canal to Western WCA2A through either G335 or G436.

This document serves as a reference for surface water quality monitoring for STA2. The operational plan for this project contains detailed structure specifications including brief descriptions of the mandate and/or permit required monitoring at each station. Current project status, schematics and the project operational plan can be viewed at the District's STA status page.

3.2 Mandates and Permits

Station locations, sampling frequencies, and parameters to be sampled are dictated by the mandate and/or permits governing this project (see below). In addition, the mercury and toxicants monitoring program required by the Everglades Forever Act is included as Appendix 2.

As part of the Central Flow-way for the Everglades Construction Project, STA2 and Compartment B are subject to both the Everglades Forever Act Permit #0311207 and the National Pollutant Discharge Elimination System Industrial Wastewater Facility (NPDES) Permit FL0778451, both issued on September 10, 2012 and expiring on September 09, 2017. Adherence to these permits is paramount to the success of this project. These permits dictate the types and frequencies of monitoring to be done, and the parameters to be analyzed, and can be viewed at:

- Everglades Forever Act Permit
  http://www.dep.state.fl.us/water/wqssp/everglades/docs/ecp-sta/draft-watershed-efa-permit.pdf
- NPDES Permit
  http://www.dep.state.fl.us/secretary/news/2012/06/npdes_watershed_permit_consent_order.pdf

Additional stations, parameters and frequencies are required as part of operational monitoring are detailed in Appendix 1.

3.3 Project Objectives

The primary objectives of this monitoring project are to evaluate water quality status and trends within the STA. The water quality data obtained under this program will be used to;

1. Assess compliance with applicable water quality standards and phosphorus discharge limits;
2. Aid in determining the nutrient concentrations to quantify the tons of nutrients removed by the STA annually;
3. Guide mid and long term resource management decisions for nutrient removal capabilities of the STA

3.4 Duration

3.4.1 Initiation Conditions

The monitoring for this project was initiated on 04/07/1997 with monitoring of Compartment B initiated on 11/01/2012 for the purpose of evaluating water quality status and trends within the STA.

One station, S6, is being monitored as part of two projects (i.e., STA2 and Compartment B and the Conservation Area Mass Balance (CAMB) Project) for supplementary mandates. These mandates are the Settlement Agreement and the Everglades Agricultural Area (EAA Rule) Chapter 40E-63 (Appendix 1).

3.4.2 Modification or Termination Conditions

The mandated monitoring described in this document will be ongoing as required by the EFA 0311207 and NPDES FL0778451 permits, which are renewed once every 5 years. Conditions for modification or termination of the project are detailed in the permit(s) that specify the conditions of the project. Monitoring for operations will continue indefinitely in support of the project goals and objectives. Monitoring may increase or decrease over time, depending upon individual cell operations, data results, end user needs and permit requirements. Short-term changes to collection events may be made as a result of an extreme weather conditions (i.e., droughts and tropical storms/hurricanes), other safety concerns, or construction activities.

4.0 Geographic Location

4.1 Regional Area

The STA2 project consists of twenty four (24) monitoring stations in western Palm Beach County (Figure 1). Table 1 provides the station names, global positioning system (GPS) coordinates, and a description of each monitoring station. The locations of all monitoring stations are depicted on the map in Figure 1.

4.2 Sampling Locations

The locations of all monitoring stations are depicted on the map in Figure 2 with exact locations described in Table 1.

4.3 Access and Authority

The gates on roadways into STA 2 are secured with a District “1W” lock. The lock requires a “1MK” key which can be obtained through a request made through the FPM and/or Field Supervisor. Samples are collected on the upstream side of structures/culverts.

Table 1: STA2 Surface Water Monitoring Sites and GPS Coordinates

Station	Latitude	Longitude	Description
S6	262820.263	802644.181	STA2 primary inflow pump station located on the Hillsboro Canal.
G328	262702.535	802757.727	Pump station discharging EAA water into the Supply Canal for inflow into STA2; approximately 2 miles southwest of S6. Also can pump water from STA2 for irrigation.
G335	262244.772	803045.658	Outflow pump station discharging into the L-6 canal from STA2 and Comp B
G436	262237.378	803054.244	Outflow pump station discharging into the L-6 canal from STA2 and Comp B
G330D	262246.04	803123.691	Five gated culverts labeled G330A to G330E discharge water from Cell 1. G330D is an outflow culvert from Cell 1 of STA2.
G332	262248.031	803138.478	Outflow spillway from Cell 2 STA2
G334	262245.632	803141.361	Outflow spillway from Cell 3 STA2
G329B	262514.421	802923.765	Four gated culverts labeled G329A to G329D accept inflow to Cell 1 of STA2. G329B is the monitored inflow culvert to Cell 1.
G331D	262514.353	803103.218	Seven gated culverts labeled G331A to G331G accept inflow to Cell 2 of STA2. G331D is the monitored inflow culvert to Cell 2.
G333C	262513.999	803242.359	Five gated culverts labeled G333A to G333E accept inflow to Cell 3 of STA2. G333C is the monitored inflow culvert to Cell 3.
G337	262522.902	802900.109	Seepage return pump station for STA2
G337A	262514.703	803317.112	Optional North Build Out Inflow from the Hillsboro Canal through S6 and G328. This structure can also supply STA2 with inflow water from the North New River Canal.
G434	262605.757	803640.031	North Build Out primary inflow pump station located on the North New River Canal.
G438D	262605.924	803502.679	Five gated culverts labeled G438A to G438E accept inflow to Cell 5 of Compartment B North Build Out. G438D is the monitored inflow culvert to Cell 5.
G438I	262606.592	803310.458	Five gated culverts labeled G438F to G438J accept inflow to Cell 6 Compartment B North Build Out. G438I is the monitored inflow culvert to Cell 6.
G367C	262422.664	803413.581	Three gated culverts labeled G367A to G367C accept inflow to Cell 5 Compartment B North Build Out. G367C is the monitored culvert from Cell 6 to Cell 4.
G367E	262422.512	803455.374	Three gated culverts labeled G367D to G367E accept inflow to Cell 5 of Compartment B North Build Out. G367E is the monitored culvert from Cell 5 to Cell 4.
G368	262241.105	803320.409	Compartment B North Build Out outflow from Cell 4 to G335 or G436.
G-435	262237.684	803400.175	Compartment B South Build Out Inflow Pump Station located on the North New River Canal
G440D	262238.448	803243.556	Six gated culverts labeled G440A to G440F accept inflow to Cell 7 of Compartment B South Build Out. G440D is the monitored inflow culvert to Cell 8.
G442	262105.271	804752.416	Gated culvert passing water from Compartment B South Build Out cell 7 to cell 8.

Station	Latitude	Longitude	Description
G-441	262239.339	803113.462	Compartment B South Build Out outflow gated culvert from Cell 8 to G335 or G436
G338	262812.147	802643.261	Gated spillway structure located in the Hillsboro Canal downstream of the S6 pump station. This structure can divert water to and from WCA1 through S6.
G339	262750.946	802707.353	Gated spillway structure located at the confluence of the STA2 inflow canal and the L6 borrow canal. This structure is intended to move water from the S6 and G328 pump stations to the L6 borrow canal.

*The standard positional goal for site coordinates is ±1 meter. This standard can be obtained with a professional grade DGPS system. The coordinates are relative to NAD83 HARN horizontal datum.

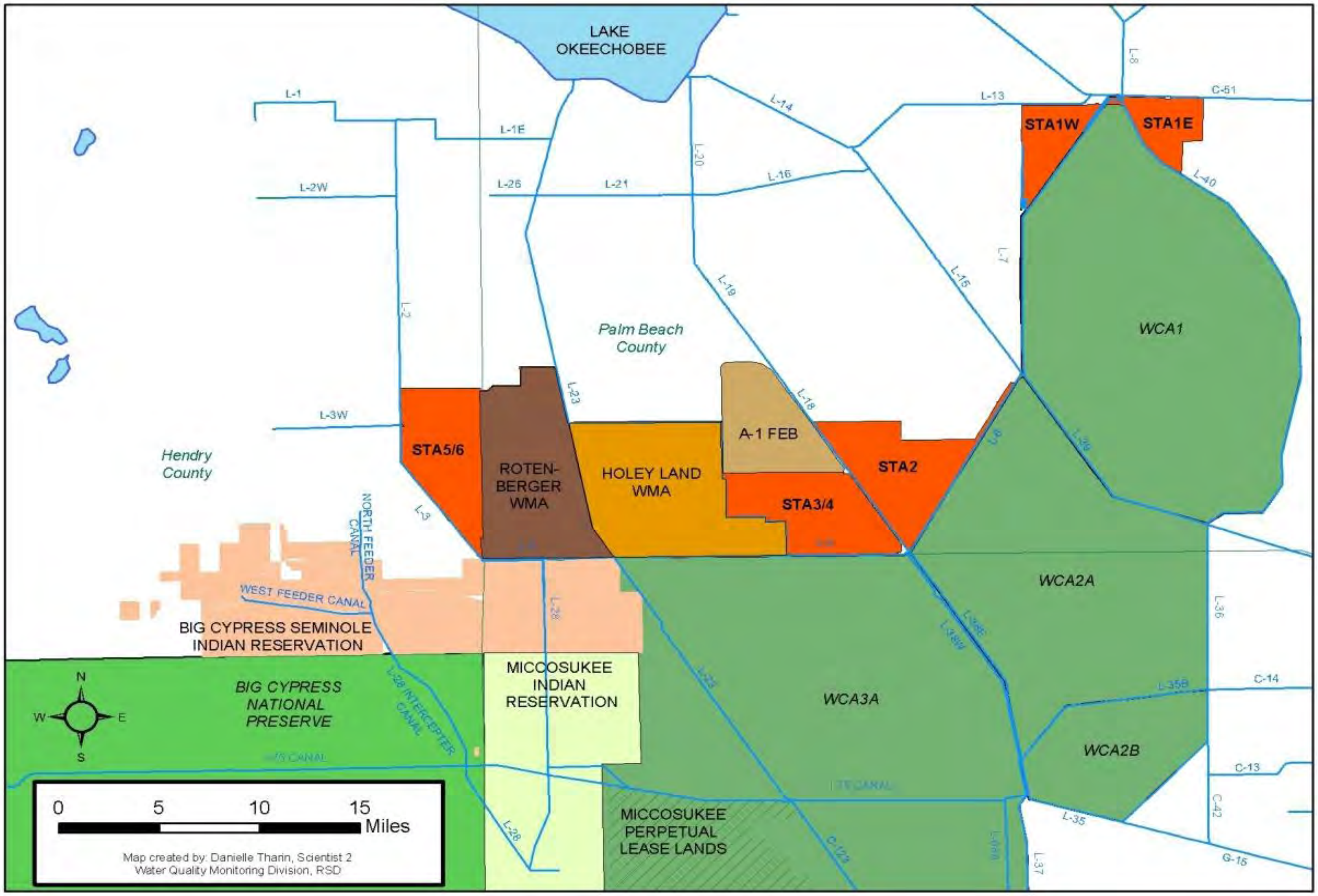
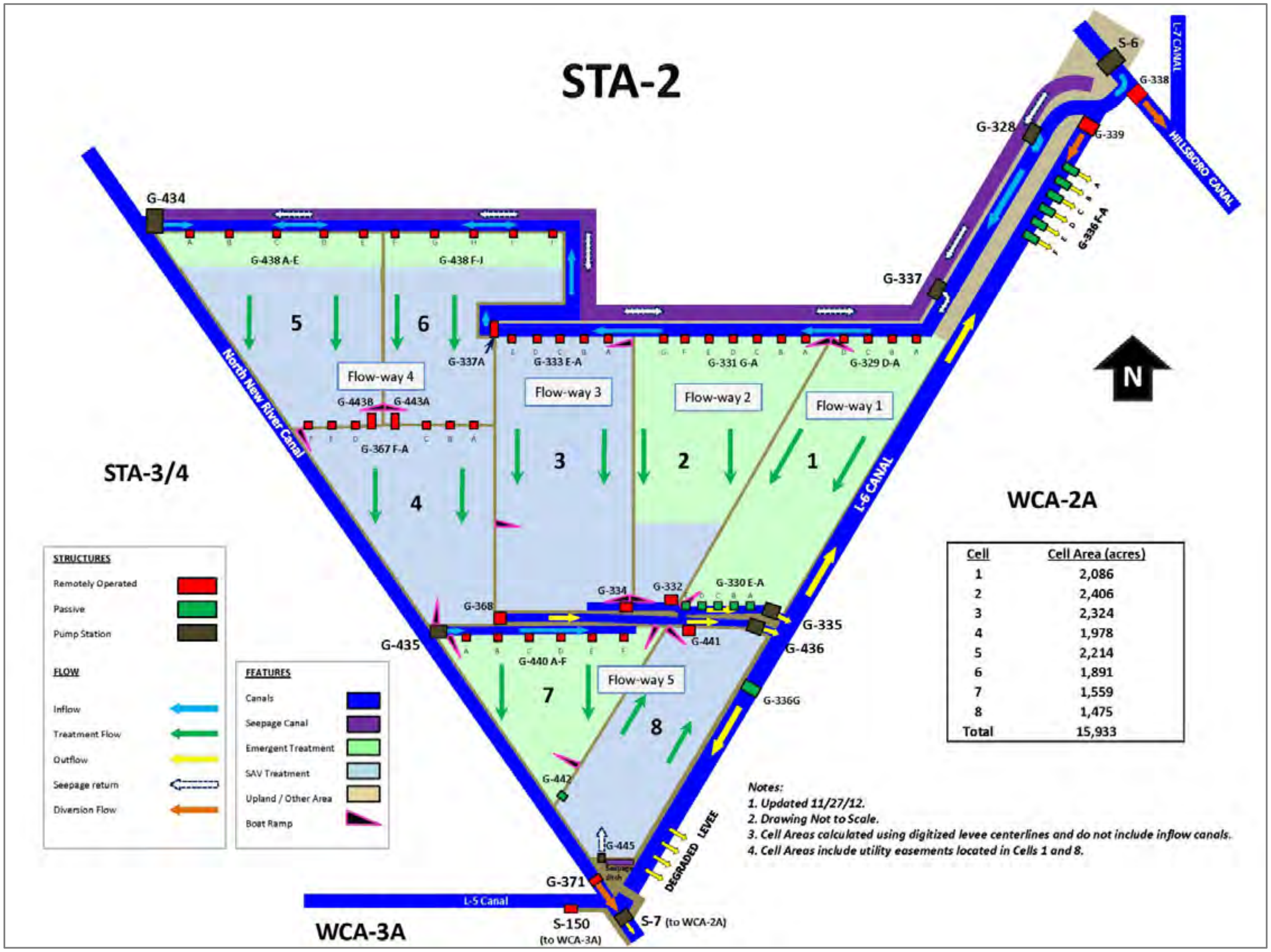


Figure 1: Regional Map including STA2



Cell	Cell Area (acres)
1	2,086
2	2,406
3	2,324
4	1,978
5	2,214
6	1,891
7	1,559
8	1,475
Total	15,933

Notes:
1. Updated 11/27/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.
4. Cell Areas include utility easements located in Cells 1 and 8.

Figure 2: STA2 Site Location Map

Table 2: STA-2 Grab/Autosampler Station, Frequency and Parameter ACODES

Station Name	Method	Frequency	Parameter ACODES
Outflow Stations			
G335, G436	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
		Biweekly Recorded Flow	$TDPO_4$, OPO_4, TKN, NOx, NH_4, SO_4, Cl, Ca, TSS
		Quarterly	DOC
	ACF	Weekly	TPO_4
Inflow Stations			
S6	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
		Weekly Recorded Flow	ALKA, Ca, Cl, DOC, K, Mg, Na, NH_4, NOx, OPO_4, SiO_2, SO_4, TDKN, $TDPO_4$, TKN, TOC, TSS
		Quarterly	Fe
	ACF	Weekly	NOx, TKN, TPO_4
G328, G434, G435*	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
		Weekly Recorded Flow	Ca, Cl, OPO_4, NH_4, NOx, SO_4, $TDPO_4$, TKN, TSS
		Quarterly	DOC
	ACF	Weekly	TPO_4
Diversion Stations			
G338, G339	Grab	Weekly Recorded Flow	TPO_4, DO, pH, Scond, Temp
Flow Way Starts, Ends and Interior Stations			
G329B, G331D, G333C, G438D, G438I, G440D*	Grab	Biweekly Recorded Flow	Ca, TPO_4, DO, pH, Scond, Temp
G330D, G332, G334, G368, G441*	Grab	Weekly Recorded Flow	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
		Quarterly	DOC
G367C, G367E, G442*	Grab	Monthly Recorded Flow	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
Divides and Seepage Structures			
G337A	Grab	Monthly Recorded Flow	TPO_4 DO, pH, Scond, Temp
G337	Grab	Monthly Recorded Flow	TPO_4 DO, pH, Scond, Temp

*Site currently in startup and not being monitored according to this plan.

5.0 Field Activities

5.1 Monitoring Frequencies by Station and Parameters (ACODES)

All samples required for collection by grab sampling are depicted in Table 2. Some stations within the monitoring network are collected based on whether flow has been recorded. Specifically, structure operation activity is determined within a specified timeframe through the review of electronic data. If no flow (i.e., no operations) has been recorded, the sample is considered a No Bottle sample (NOB) and the structure is not visited. Conversely, if flow has been recorded during the specified timeframe, a sample is collected.

5.2 Project Specific Guidelines

All surface water samples shall be collected on the upstream side of any structure at a depth of 0.5 m unless vegetation and/or other conditions inhibit the collection of a representative sample upstream. Prior to sampling an alternative site, a consultation with a Field Technician Supervisor and/or the FPM must take place; this action must be documented in the field notes.

Backup grab samples will accompany the autosampler collection based upon flow trigger (ACF) samples collected on a weekly basis. In addition, in situ readings (i.e., Temperature, pH, DO and Specific Conductance) are measured as the grab samples are being collected. Samples collected on upstream side of structures/culverts. G337A is a divide structure and flow may occur in both directions. Flow originating from S6 shall be considered the upstream location for the purposes of this monitoring plan and flows originating from G434 will be considered as reverse flow for this structure.

5.3 Grab Sampling Procedures

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District's FSQM.

5.4 Field Testing Procedures

Field testing procedures shall follow the procedures and requirements found in the District's FSQM. Table 3 below describes the field parameters collected for this project. The table shows only the most commonly used parameters. Refer to the FSQM for guidance on other parameters that may be measured by field testing, (i.e. Salinity, Turbidity, PAR, ORP, depth, Secchi).

Table 3: Field Analytical Parameters Collected

Parameter	Resolution	Accuracy
DO	0.01 mg/l	0-20 mg/l, ± 0.2 mg/l
Specific conductance	0.001 mS/cm	± 0.5% of reading ± 0.001 mS/cm
Temp	0.01^{o} C	± 0.15^{o}C
pH	0.01 unit	± 0.2 unit

5.5 Field Quality Control Requirements

Field quality control requirements shall follow the procedures found in the Quality Control Section of the District's FSQM.

5.6 Autosampler Collection

Samples are collected with flow-proportional (ACF) at the inflow pump stations (S6, G328, G434 and G435) and the outflow pump stations (G335 and G436) as identified in Table 2. Frequency for ACF collections is determined by a "trigger volume" established through the protocols established by Abtew and Powell (2004). Discrete bottles within each autosampler are pre-acidified and composited on a weekly basis and analyzed for total phosphorus (TPO_4).

In addition, flow proportional samples for TKN and NOx are collected at S6 for the CAMB Project. This autosampler is refrigerated; therefore, it collects samples in a composite format. On January 8, 2013, the following autosamplers were decommissioned and these sites are now sampled by grab only: G332, G334, G330D, G337A, G368, G329B, G331D, G333C, and G337. Until startup is complete, the autosampler at G441 remains on flow to capture discharges related to seepage and rainfall.

5.7 Sample Submission

Following completion of sample collection for each day, the samples are placed in ice and transported in coolers at $\leq 6^{o}$C to the laboratory for analysis. Samples are submitted to the laboratory on the same day as collection or via courier the following day. Samples are submitted according to the requirements outlined in the District's FSQM. If samples are submitted to other than the District's laboratory, the laboratory must be a District approved laboratory.

6.0 Data Quality Objectives

6.1 Data Usage

The data from STA2 are compiled and reported in accordance with the conditions outlined in the permit or mandate specified in Section 3.2. Typically the data are reported in the District's Annual South Florida Environmental Report (SFER), or for S6, data are reported in a standalone mandated report and the quarterly Everglades Settlement Agreement Report. The SFER can be found at www.sfwmd.gov/sfer/.

6.2 Data Quality

All monitoring described herein shall meet the indicators conveyed in the FDEP's Quality Assurance Rule, 62-160 F.A.C. The District has adopted a uniform set of Data Quality Objectives (DQOs) following criteria detailed within the "Analytical Methods and Default QA/QC Targets" table of the CLQM.

The DQOs of the field testing parameters for this project are covered by the table entitled Field Quality Assurance Objectives found in the field testing section of the FSQM. This manual is updated regularly, and therefore, the most recent version of the District's FSQM details the specific field testing DQOs for this project at the time of sample collection.

Samples are analyzed according to the provisions within the FDEP Rule 62-160 F.A.C. and the District's CLQM. This manual is updated regularly, and therefore, the most recent version of the District's CLQM details DQOs for this project at the time of sample collection for each specific laboratory analysis. Data are qualified in accordance with the FSQM, CLQM and applicable data validation SOPs.

6.3 Completeness Targets

The completeness target (i.e., the number of samples successfully collected and analyzed) shall be set at 95% annually for this project. Sampling attempts shall be included in the completeness target. At times samples will not be able to be collected on an attempt due to no flow or low water conditions, unsafe station conditions, equipment malfunction, site maintenance, or other unforeseen problems that might affect sample collection and/or quality. If samples cannot be collected on an attempt, collectors shall document "no bottle" (NOB) to indicate and attempt was made and/or the sample could not be collected for the documented reasons. Attempted collection (NOB) of samples will be considered a collected sample when calculating completeness targets.

7.0 Data and Records Management

The laboratory shall evaluate the data in accordance with the data quality objectives stated in the FSQM and CLQM. All data submittals shall conform to existing District guidelines. Contract laboratory data for mercury or pesticide analysis shall be submitted to the District in the ADaPT format or other format as requested by the District.

7.1 Data Deliverables

There are no contract deliverables for this project.

7.2 Data Storage

After the data validation process, all data and records are maintained so that end users can retrieve and review all information relative to a sampling event. Field records are maintained in NuGenesis by scanning actual field note pages records directly into NuGenesis (See SFWMD-FIELD-SOP-022). All analytical data and specified metadata are sent to a database (DBHYDRO) for long-term storage and retrieval.

The District shall maintain master copies of field and laboratory generated records. It is the responsibility of the District to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. At least quarterly, any contractor performing work for the project shall provide all original field records to the District's WQB for permanent archival.

Records shall be maintained for the life of the project and a minimum of five years thereafter, in a manner that will protect the physical condition and/or integrity of the records. Storage shall follow the SOP for Archive Records Storage and Retention (SFWMD-FIELD-SOP-022). Corrections of data or records shall follow the applicable District SOPs and FSQM.

8.0 Revisions and Modifications

[This section is left for future changes as they are made and should be referenced throughout the document as revisions occur. Sections should be added chronologically. As revisions are made a note should be made in the corresponding section of the plan.]

Date	Section	Page Number(s)	Change From	Change To	Reason
01/01/2013	All	All			Monitoring plan modified to conform to requirements of EFA Permit # 0311207, NPDES Permit # FL0778451, and their associated Consent Orders as well as STA Operational considerations.

References:

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Signature Page

Monitoring Plan

For

Central Flow-Way

Stormwater Treatment Area 2
(STA2)

Linda Crean, Water Quality Monitoring Section Administrator — Date

David Struve, Analytical Services Section Administrator — Date

Julianne LaRock, Compliance Assessment and Reporting Section Administrator — Date

Ming Chen, Quality Assurance Administrator — Date

Appendix 1: Site Requirements by Mandate

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
Outflow Stations				
G335 **G436**	National Pollution Discharge Elimination System (NPDES)	Grab	Weekly Recorded Flow (WRF)	Total Phosphorus (TPO$_4$), pH
		ACF	Weekly (W)	TPO$_4$
	Everglades Forever Act (EFA)	Grab	See Specific Condition 21	Turbidity (TURB)
		Grab	WRF	TPO$_4$, Dissolved Oxygen (DO), pH, Specific Conductance (SCond) Temperature (Temp)
		Grab	Biweekly Recorded Flow (BWRF)	Total Nitrogen (TN^1), Nitrate-Nitrite (NOx), Sulfate (SO$_4$)
		ACF	W	TPO$_4$
	STA Operations	Grab	W	TPO$_4$, DO, pH, SCond, Temp
		Grab	BWRF	Calcium (Ca), Chloride (Cl), Ammonia (NH$_4$), NOx, Ortho-Phosphorus (OPO$_4$), SO$_4$, Total Dissolved Phosphorus (TDPO$_4$), Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS)
		Grab	Quarterly (Q)	DOC
		ACF	W	TPO$_4$
Inflow Stations				
S6	NPDES	Grab	WRF	TPO$_4$
		ACF	W	TPO$_4$
	EFA	Grab	WRF	TPO$_4$, pH SCond, Temp
		Grab	BWRF	TN, NOx, SO$_4$
		ACF	W	TPO$_4$
	EAA Rule	Grab	W	TPO$_4$
		ACF	W	TPO$_4$
	Settlement Agreement	Grab	WRF	Alkalinity, Ca, Cl, Dissolved Organic Carbon (DOC), Magnesium (MG), NH$_4$, NOx, OPO$_4$, Potassium (K), Silica (SiO$_2$), Sodium (Na), SO$_4$,TDKN, TDPO$_4$, TKN, Total Organic Carbon (TOC), TPO$_4$, TSS, DO, pH, SCond, Temp
		Grab	Q	Total Iron (FE)
		ACF	W	NOx, TKN, TPO$_4$
	STA Operations	Grab	W	TPO$_4$, DO, pH, SCond, Temp
		Grab	WRF	Ca, Cl, NH$_4$, NOx, OPO$_4$, SO$_4$, TDPO$_4$, TKN, TSS
		Grab	Q	DOC
		ACF	W	TPO$_4$

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
Inflow Stations				
G328	NPDES	Grab	WRF	TPO$_4$
		ACF	W	TPO$_4$
	EFA	Grab	WRF	TPO$_4$, pH, SCond, Temp
		Grab	BWRF	TN, NOx, SO$_4$
		ACF	W	TPO$_4$
	Everglades Agricultural Area Chapter Rule 40E-63 (EAA Rule)	Grab	W	TPO$_4$
		ACF	W	TPO$_4$
	STA Operations	Grab	W	TPO$_4$, DO, pH, SCond, Temp
		Grab	WRF	Ca, Cl, NH$_4$, NOx, OPO$_4$, SO$_4$, TDPO$_4$, TKN, TSS
		Grab	Q	DOC
		ACF	W	TPO$_4$
G434 **G435**	NPDES	Grab	WRF	TPO$_4$
		ACF	W	TPO$_4$
	EFA	Grab	WRF	TPO$_4$, pH, SCond, Temp
		Grab	BWRF	TN, NOx, SO$_4$
		ACF	W	TPO$_4$
	EAA Rule	Grab	W	TPO$_4$
		ACF	W	TPO$_4$
	STA Operations	Grab	W	TPO$_4$, DO, pH, SCond, Temp
		Grab	WRF	Ca, Cl, NH$_4$, NOx, OPO$_4$, SO$_4$, TDPO$_4$, TKN, TSS
		Grab	Q	DOC
		ACF	W	TPO$_4$
Seepage, Divide, and Diversion Stations				
G337 **G337A**	STA Operations	Grab	Monthly Recorded Flow (MRF)	TPO$_4$, DO, pH, SCond, Temp
G338 **G339**	EFA	Grab	WRF	TPO$_4$
	STA Operations	Grab	WRF	TPO$_4$, DO, pH, SCond, Temp
Flow Way Start Stations				
G329B **G331D** **G333C** **G438D** **G438I** **G440D**	STA Operations	Grab	BWRF	Ca, TPO$_4$, DO, pH, SCond, Temp,
Flow Way Interior Stations				
G367C **G367E** **G442**	STA Operations	Grab	MRF	Ca, OPO$_4$, TDPO$_4$, TPO$_4$, DO, pH, SCond, Temp

Station Name	**Mandate**	**Collection Method**	**Frequency**	**Analytical Parameters**
Flow Way End Stations				
G334 **G330D** **G332** **G368** **G441**	STA Operations	Grab	WRF	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, SCond, Temp
			Q	DOC

[1] TN is calculated as the sum of TKN and NOx

Appendix 2: STA-2 and Comp. B Mercury and Other Toxicants Monitoring Plan

Central Flow-Way
Stormwater Treatment Area 2
EFA Permit No. 0311207

Monitoring of water-column concentrations of total mercury (THg) and methylmercury (MeHg) began in the summer of 2000 at STA-2. STA-2 Cells 2 and 3 met mercury (Hg) startup criteria, as specified in Exhibit "D" of EFA Permit No.0126704, in September 2000 and November 2000, respectively. In August 2001, flow-though operation of Cell 1 was authorized under an EFA permit modification; Cell 1 met startup criteria in November 2002 (for review, see 2003 and 2004 Everglades Consolidated Reports and the 2005 South Florida Environmental Report [SFER]).

In January 2007, the District completed construction of a new flow-way in STA-2, known as Cell 4. STA-2 Cell 4 met the mercury start up criteria as specified in Exhibit "D" of EFA Permit No. 0126704-005-EM in September 2007. Routine monitoring of mercury in Cell 4 was initiated October 2007. In addition, Cell 4 met conditions contained in "*A Protocol for Monitoring Mercury and Other Toxicants*" (dated April 2011; hereafter referred to as the *Protocol*) to terminate atrazine monitoring in June 2008 (see data summary provided in correspondence from H. Andreotta, SFWMD dated January 6, 2012). The Florida Department of Environmental Protection (Department) approved termination of atrazine monitoring January 30, 2012. February 29, 2012, the Department approved transfer of STA-2 mercury monitoring from Phase 2 - Tier 1: Routine Monitoring during Stabilization Period for Cells 1, 2 and 3 of STA-2 to Phase 3 – Tier 3: Routine Operational Monitoring After Year 9 and Phase 3 – Tier 1: Routine Operational Monitoring From Year 4 to Year 9 for Cell 4 of STA-2. Phase 3 – Tier 3 implemented the termination of all site specific mercury monitoring at STA-2 Cells 1, 2, and 3.

As of the date of this updated monitoring plan, the District has constructed two new flow-ways in STA-2, known as EAA Compartment B Buildout Project (Compartment B). These new flow-ways consist of the North Buildout (NBO), which includes Cells 4, 5, and 6 and the South Build-out (SBO), which includes Cells 7 and 8. Compartment B incorporates the existing Cell 4.

Based on the current status of Compartment B, initial performance of Cells 1, 2, and 3, and the guidance contained in the *Protocol*, the District shall initiate Phase 1 – Tier 2: Field Sampling for Initial Startup Monitoring Prior to Discharge for Compartment B (Cells 4, 5, 6, 7 and 8) and implement Phase 3 – Tier 3: Routine Operational Monitoring After Year 9, which terminates mercury monitoring, for Cells 1, 2, and 3 and as follows:

1.0 Phase 1: Baseline Collection and Assessment

1.2 Phase 1 - Tier 2: Field Sampling for Initial Startup Monitoring Prior to Discharge

1.2.1 Mosquitofish

i) When construction of the Compartment B is completed, the District shall notify the Department and within one month of initial flooding collect mosquitofish from multiple locations within the two new flow-ways known as NBO and SBO (to total at least 100 fish; see Figure 2 for map). Samples shall be physically composited into one (spatially-averaged) sample per flow-way and analyzed for total mercury (THg), cis-chlordane, trans-chlordane, o,p'-DDD, p,p-DDD, o,p'DDE, p,p'-DDE, o,p'-DDT, p,p'-DDT, cis-nonachlor, trans-nonchlor, and toxaphene analysis (note, a single aliquot should be analyzed per composite).

ii) The District shall provide the Department with the results of the first collection of mosquitofish as well as the appropriate action levels for comparison (90% upper confidence level of the basin-wide average or the 75th percentile concentration for the period of record for all basins). If tissue concentrations from Compartment B are below the 90% upper confidence level of the basin-wide average or below the 75th percentile concentration for the period of record for all basins (if basin-specific data are lacking) after concurrence from the Department, the District may initiate flow-through operation and routine monitoring for the Compartment B.

However, if Hg or other toxicant concentrations in the mosquitofish composite exceed one of the above-referenced action levels, the District shall immediately (within 14 days of receiving quality-assured data from the laboratory) collect a sample(s) to confirm the exceedance(s). In addition, the District shall consult with the Department to determine the most appropriate course of action and obtain authorization to initiate flow-through operation. At a minimum, the course of action will include implementation of Tier 2 Expanded Monitoring and Risk Assessment by the District during initial flow-through operations (e.g., collection of monthly mosquitofish within the STA and at one station downstream of the STA at a minimum), additional details on expanded monitoring are provided in the *Protocol*). The recommended course of action may also include additional measures as determined to be appropriate. When results of expanded monitoring demonstrate concentration of Hg in mosquitofish from the Compartment B has decreased to acceptable levels (below action levels referenced above) and the concentrations at the downstream site are not significantly elevated above baseline levels, the District shall notify the Department and request that the monitoring revert back to Tier 1 routine monitoring.

1.2.2 Soil

After the soils have been flooded and saturated for some period of time (i.e., in excess of a month) and prior to discharge, sediment cores will be collected from five representative locations within both the NBO and SBO. Downstream startup sediment was already collected for Cell 4 startup in December 2007. Efforts will be made to co-locate sediment sites with mosquitofish collection sites.

At each location or site, a minimum of three cores (number of cores in excess of three will be determined by amount of sediment required for analysis) from the 0 to 4 cm horizon are to be collected and composited as a single sediment sample.

To serve as baseline for future comparison, if future conditions warrant follow-up sampling of sediments (i.e., if Tier 2 were triggered), sediment samples will be analyzed for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe). Additionally, these sediment samples will be analyzed and assessed for toxicants other than mercury as discussed below.

1.3 Water

Although mercury will be monitored and assessed prior to discharge based on tissue concentrations, because of the concern for potential acute toxicity, water will be collected from immediately upstream of the STA-2 and Compartment B inflow pump stations (G-328, S-6, G434, and G-435) and outflow pump stations (G-335 and G-436) and analyzed for toxicants other than mercury as discussed below.

Selection of Toxicants Other Than Mercury

The following information sources have been reviewed for data regarding this project: URS Corporation, Environmental Site Assessment (ESA) for Acceler8 Projects (Woerner South Farm and Okeelanta Property). Based on this review, samples will be collected and analyzed for the parameters identified in Table 1 for each of the specified matrices.

Table 1: Parameter list of toxicants other than mercury that will be analyzed in specified matrix.

Analyte	Surface Water	Sediment	Fish Tissues
chlordane	X	X	
cis-chlordane			X
trans-chlordane			X
o,p’-DDD			X
p,p’-DDD	X	X	X
o,p’-DDE			X
p,p’-DDE	X	X	X
o,p’-DDT			X
p,p’-DDT	X	X	X
cis-nonachlor			X
trans-nonachlor			X
toxaphene	X	X	X

Table 2: Initial Startup Monitoring Prior to Discharge

Matrix	Location	Collection Method	Frequency	Parameter
Mosquitofish	Within each flow-way of NBO & SBO	Net or Trap	One-time	THg cis-chlordane, trans-chlordane, o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'-DDT, p,p'-DDT, cis-nonachlor, trans-nonachlor, toxaphene
Sediment	5 locations each within NBO & SBO	Sediment Core	One-time	THg, MeHg, Moisture Content, TOC, TS, and TFe Chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, toxaphene
Surface Water	G-328, S-6, G434, G-435, G-335, and G-436	Grab	One-time	Chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, toxaphene

The District shall provide the Department with the results of these analyses as well as the appropriate action levels for comparison. If the following criterion is met for NBO and SBO, the District may initiate flow-through operational and routine compliance monitoring (for details on routine monitoring, see below).

- If ambient mosquitofish do not demonstrate excessive bioaccumulation that exceeds a critical tissue benchmark used to establish SQAGs or in site-specific risk assessments;
- If concentrations in sediments do not exceed an effects-based, numerical sediment quality assessment guideline (SQAGs for sediment dwelling organisms, MacDonald Environmental Sciences Ltd. and USGS, 2003);
- If concentrations in sediments do not exceed an established bio-accumulative based SQAG, if available (MacDonald Environmental Sciences Ltd. and USGS, 2003), a action level reported in the ESA or a level that was determined to be critical in a site-specific risk assessment;
- If water-column concentrations do not exceeded the state water quality standard (WQS) in Chapter 62-302, Florida Administrative Code (F.A.C.)

However, if the above referenced action level is exceeded, the District shall immediately (within 14 days of receiving quality assured data from the laboratory) collect a sample(s) to confirm the exceedance(s). In addition, the District shall consult with the Department to determine the most appropriate course of action and obtain authorization to initiate flow-through operation from Compartment B. At a minimum, the course of action will include implementation of Tier 2 Expanded Monitoring and Risk Assessment by the District during initial flow-through operations. The recommended course of action may also include additional measures as determined to be appropriate. When results of expanded monitoring demonstrate concentrations in each flow-way has decreased to acceptable levels (below action levels referenced above), and the concentrations at the downstream site are not significantly elevated above baseline levels, the District shall notify the Department and request that the monitoring revert back to Tier 1 routine monitoring.

2.0 Monitoring During Three-Year Stabilization Period

2.1 Phase 2 - Tier 1: Routine Monitoring During Stabilization Period

2.1.1. Water

An unfiltered surface water sample (n = 1) shall be collected in accordance with Chapter 62-160, F.A.C. at the G-328, S-6, G-434 and G-435 inflow pump stations and immediately upstream of the G-335 and G-436 outflow pump stations (Figure 1) on a quarterly basis and analyzed for THg and methylmercury (MeHg) (sulfate is being monitored under the EFA permit required routine WQ monitoring program). In addition, flow shall be monitored at the inflow and outflow to allow for load estimation to and from the project (it should be recognized that quarterly sampling would allow for only rough estimation of loads).

Based on the discussion above regarding toxicants other than mercury, a surface water sample will be collected quarterly at G-328, S-6, G-434 and G-435 and immediately upstream of G-335 and G-436 and analyzed for the parameters listed in Table 1 under surface water.

This data set will be assessed to determine if outflow concentrations exceed state water quality standards (WQS), and whether annual outflow loads of analytes are significantly greater than inflow loads, including atmospheric loading; load estimates will include confidence intervals that describe uncertainty in measures of flow and concentration (e.g., field and analytical precision) and resulting from interpolation (note: assessment protocol to be negotiated with permitting authority). Failure to satisfy these assessment measures would trigger Tier 2 Expanded Monitoring and Risk Assessment (see below).

Because of differences in the anticipated time frames under which sedimentary release are thought to occur (i.e., relative to MeHg that may have time lag associated with changes in biogeochemistry and microbial methylation driven by water quality, especially in sandy soils), monitoring for other toxicants would cease after one year if action levels are not exceeded within that time.

2.1.2. Fish Tissues

Samples of fish from multiple trophic levels will be collected from each independently operated flow-way (NBO and SBO) and from a single downstream site in the receiving water of the project (Figure 1). Specifically, mosquitofish will be collected quarterly from multiple locations within each NBO and SBO, physically composited into one (spatially-averaged) sample (to total at least 100 fish) per flow-way, and analyzed for THg and other toxicants listed in Table 1 under fish (note, a single aliquot will be analyzed per composite). Additionally, mosquitofish (to total at least 100 fish) will be collected quarterly from a single site located in the receiving waters immediately downstream from the project (i.e., station CA2NF downstream of G-336 A-F within WCA-2) and analyzed for THg and other toxicants.

In addition, sunfish (n should be greater than or equal to 5) and largemouth bass (*Micropterus salmoides);* (n should be greater than or equal to 5) shall be collected annually from NBO and SBO and from station CA2NF located in the receiving waters and individually analyzed for THg and other toxicants listed in Table 1 under fish (i.e., whole sunfish and fillets from the bass). To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections should target *Lepomis macrochirus (*bluegill) ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches). However, other Lepomids or sizes are to be collected if efforts fail to locate targeted fish. Owing to similar trophic status, if bluegill cannot be collected, first priority will be given to spotted sunfish, *Lepomis punctatus*. If neither sunfish nor bass are present, consideration should be given to sampling other species.

Table 3: Phase 2 – Tier 1: Routine Monitoring During Stabilization Period

Matrix	Location	Collection Method	Frequency	Parameter
Surface Water	G-328, S-6, G-434 G-435, G-335 and G-436	Grab	Quarterly	THg, MeHg Chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, toxaphene*
Mosquitofish	NBO, SBO, and one downstream station (CA2NF)	Net or Trap	Quarterly	cis-chlordane, trans-chlordane, o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'-DDT, p,p'-DDT, cis-nonachlor, trans-nonachlor, toxaphene*
Bass & Sunfish (n=5 each)	NBO, SBO, and one downstream station (CA2NF)	Electrofish or Hook & Line	Annually	THg cis-chlordane, trans-chlordane, o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'-DDT, p,p'-DDT, cis-nonachlor, trans-nonachlor, toxaphene*

* Monitoring for toxicants other than mercury will cease after one year if action levels are not exceeded.

Assessment

To detect and minimize any adverse effects as early as possible (and to provide a basis for identifying adaptive management options, if deemed necessary), the results of this monitoring will be assessed based on the criteria and time table described under Phase 2 – Tier 1 in the *Protocol*. Monitoring results will be provided to the Department in accordance with the reporting requirements described below.

2.2 Phase 2 - Tier 2: Expanded Monitoring and Risk Assessment

In accordance with the *Protocol*, if Tier 1 data exceed the action levels identified under Phase 2 – Tier 2: Expanded Monitoring and Risk Assessment, the District shall notify the Department and after obtaining the Department's concurrence, shall expand monitoring and undertake all necessary steps consistent with the *Protocol*.

3.0 Operational Monitoring

The monitoring plan and associated data will be re-evaluated on regular basis beginning after year 1 for other toxicants and after year 3 for mercury species to determine if criteria specified in the *Protocol* are being satisfied (following startup of Compartment B). Based on that assessment, and with the concurrency of the Department, monitoring and assessment efforts may be reduced (as identified in Phase 3 – Tier 1: Operational Monitoring from Year 4 to Year 9 of the *Protocol*) or eliminated altogether at the project level to be subsumed by regional monitoring (as identified in Phase 3 – Tier 3: Routine Operational Monitoring After Year 9 of the *Protocol*). However, if monitoring reveals anomalous conditions as described under Phase 3 – Tier 2: Expanded Monitoring and Risk Assessment, the District shall expand monitoring and undertake all necessary steps identified under Phase 3 – Tier 2 the *Protocol*.

3.1 Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9

3.1.1 Fish Tissues

Semiannually, mosquitofish will be collected from multiple locations within independently operated flow-way (NBO and SBO) and from a single downstream site in the receiving water of the project (Figure 1). Specifically, mosquitofish will be collected semiannually from multiple locations within each NBO and SBO, physically composited into one (spatially-averaged) sample (to total at least 100 fish) per flow-way, and analyzed for THg (note, a single aliquot will be analyzed per composite). Additionally, mosquitofish (to total at least 100 fish) will be collected semiannually from a single site located in the receiving waters immediately downstream from the project (i.e., station CA2NF downstream of G-336 A-F within WCA-2) and analyzed for THg.

To assess "worst case" conditions, large-bodied fish will be collected only from the flow-way with the highest observed concentration and the downstream station identified above once every three years. This limited spatial sampling of large-bodied fish within the STA is to revert back to include formerly sampled stations, if Tier 2 is triggered or if mosquitofish demonstrate significantly altered spatial patterns in mercury biomagnification.

Specifically, sunfish (n should be greater than or equal to 5) should be collected from each station and individually analyzed as whole-fish. At the same time, largemouth bass (*Micropterus salmoides*; n should be greater than or equal to 5) should be collected from each station and individually analyzed (fillets) for THg. To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections will target bluegill (*Lepomis microchirus*) ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches); however, other lepomis (due to similar trophic status, first priority being given to spotted sunfish (*L. punctatus*) or sizes will be collected if efforts fail to locate targeted fish.

This data will then be used to track the following:

- THg levels in individual mosquitofish composite;
- Annual average THg levels in mosquitofish;
- THg levels in large-bodied fish

Table 4: Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9

Matrix	Location	Collection Method	Frequency	Parameter
Mosquitofish	NBO, SBO, and one downstream station (CA2NF)	Net or Trap	Semiannually	THg
Bass & Sunfish (n=5 each)	Flow-way with historically highest [THg] (To Be Determined) and one downstream station (CA2NF)	Electrofish or Hook & Line	Triennially	THg

3.2 Phase 3 - Tier 2: Expanded Monitoring and Risk Assessment

Tier 2 monitoring and assessment is triggered if one of the following action levels is exceeded during operation:

- If annual average THg levels in mosquitofish progressively increased over time (i.e., two or more years) or any (semi-annual) mosquitofish composite exceeds the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeds the 75th percentile concentration for the period of record for all basins; or
- If triennial monitoring of large-bodied fish reveal tissue Hg levels in fishes have statistically increased progressively over time or have become elevated to the point of exceeding the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeded the 75th percentile concentration for the period of record for all basins.

The following steps will be taken if any action level in Tier 2 is triggered:

Step 1: Notify the Department;

Step 2: Resample fish species that triggered Tier 2;

If results of Step 2 (i.e., re-sampling) demonstrate that the anomalous condition was an isolated event, the Department will be notified that the project will revert back and continue with Tier 1 monitoring. Alternatively, if results of Step 2 reveal the anomalous condition was not an isolated event, proceed to Step 3.

Step 3: Expanding monitoring program as follows:

- Increase frequency of mosquitofish collection from semiannually to monthly.
- If Tier 2 was triggered by THg levels in fish at the downstream site, possibly due to excessive loading from the STA outflow, then quarterly water-column sampling the outflow station will begin. If necessary (i.e., if loading uncertainty is high), increase frequency of surface water collection to monthly (reducing temporal interpolation), or as appropriate for hydraulic retention time (HRT).
- If Tier 2 was triggered by THg levels in fish within only one of the treatment trains, further define spatial extent of problem by collecting multiple mosquitofish composites from within the treatment train exhibiting anomalous conditions.
- If Tier 2 was triggered by tissue THg levels in large-bodied fish, increase sample size of large-bodied fish to n = 20, i.e., 20 each of sunfish (collect various species and sizes) and/or bass (collect various sizes and extract otolith from bass for age determination).
- To evaluate possible trends in methylation rates in sediments (i.e., to determine if methylation rates are increasing or decreasing), replicate sediment cores (0-4 cm) can be collected from the suspected methylation "hot spot" and reference locations within the component (for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe)) over a given period of time (i.e., 2 to 4 months). At these same locations and collection times, collect pore water samples and analyze for THg, MeHg, and sulfides, or if no acceptable pore water protocol has been developed, then acid-volatile sulfide (AVS) on solids shall be completed.

Projects shown to have (spatially) large or multiple MeHg "hotspots" should consider use of the Everglades Mercury Cycling Model (E-MCM) or comparable model as an assessment tool (i.e., to synthesize results of expanded monitoring).

Step 3 will also include the notification of the Department that anomalous conditions are continuing. The Department and the District may then develop an adaptive management plan using the data generated from the expanded monitoring program. This plan will evaluate the potential risks from continued operation under existing conditions (i.e., through a risk assessment for appropriate ecological receptors). If risk under existing operational conditions is deemed acceptable, then project monitoring would continue under a modified Tier 2 scheme to monitor exposure. On the other hand, if risk under existing operational conditions is deemed unacceptable, then the adaptive management plan would then proceed to determine potential remedial actions to (1) reduce exposure and risk (e.g., signage for human health concerns[1], reduce fish populations, reduce forage habitat suitability) and (2) affect mercury biogeochemistry to reduce net methylation (e.g., modify hydroperiod or stage, water quality).

In developing this adaptive management plan, the Department may conduct a publicly noticed workshop to solicit comments from the District, the U.S. Army Corps of Engineers, the U.S.

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[1] Note that assessment of potential human health impacts and corrective actions (i.e., signage) will require the involvement of the Florida Department of Health)

Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Park Service, the Florida Fish and Wildlife Conservation Commission, and other interested persons.

The next step would then be to carry out such remedial or corrective action. If the remedial or corrective action is demonstrated to be successful, then the project would revert back to Tier 1 monitoring. Alternatively, if monitoring data indicate that the remedial action was unsuccessful in reducing fish tissue concentrations or downstream loading, the Department and the District would then initiate a peer-reviewed, scientific assessment of the benefits and risks of the project.

3.3 Phase 3 - Tier 3: Termination of Monitoring After Year 9

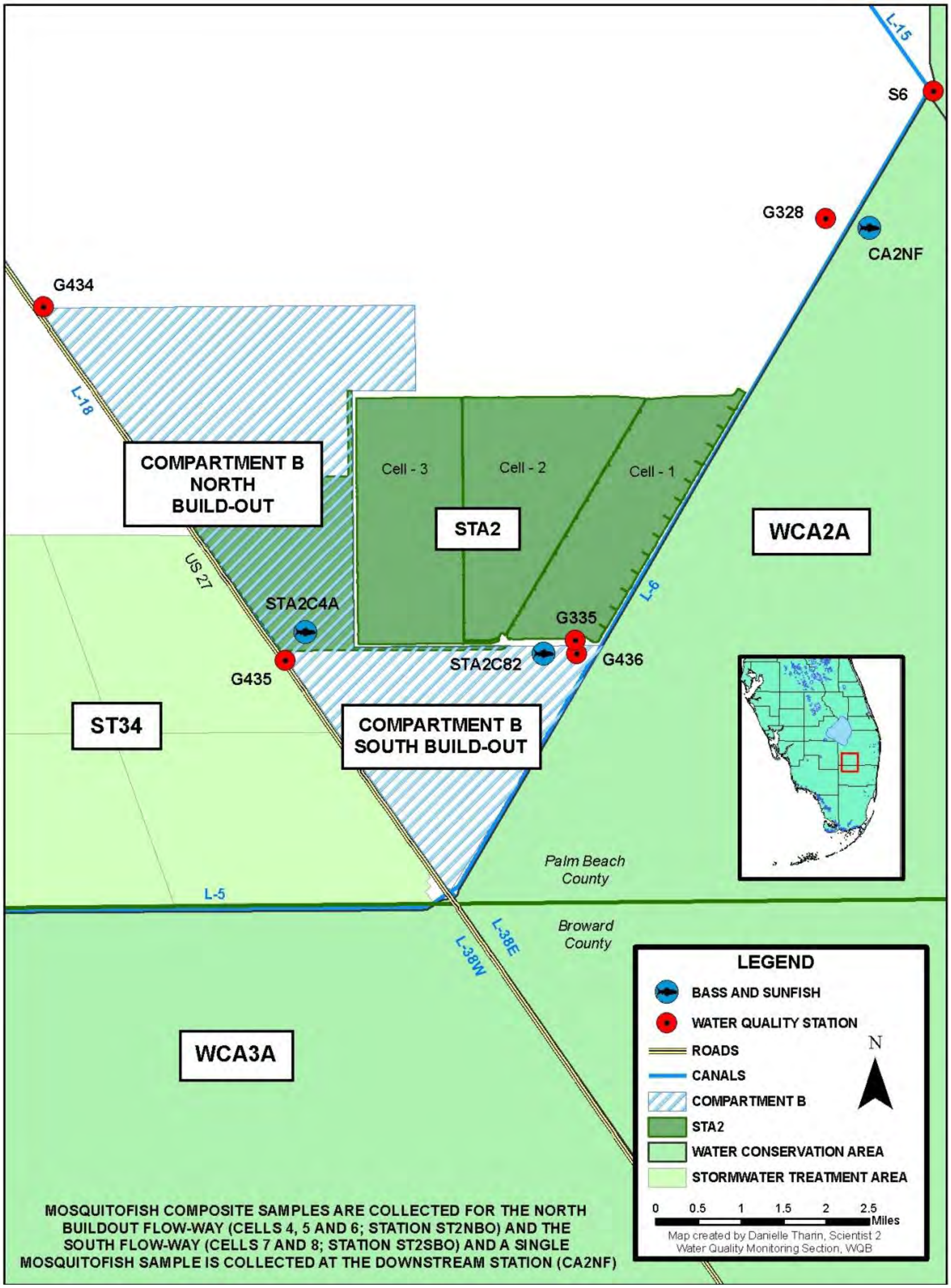
If fishes collected under Phase 3 - Tier 1 have not exceeded action levels by year 9, project-specific monitoring would be discontinued; future assessments would be based on regional monitoring.

4.0 Annual Mercury Monitoring Report

The District shall notify the Department immediately if monitoring data indicate that any of the action levels are exceeded. In addition, the District shall submit an annual report to be incorporated into the SFER and submitted to the Department no later than March 1st of each year. The annual report shall summarize the most recent results of the monitoring as defined above and compares them with the cumulative results from previous years. This report shall also evaluate assessment performance measures (i.e., action levels) outlined above.

5.0 Adaptive Management Strategy

It is the intent that this monitoring plan will be carried out within the context of an adaptive management strategy that will allow for appropriate changes based on new, better understanding of mercury cycling, fate and transport as conveyed in the guidance contained in the *Protocol*.



MOSQUITOFISH COMPOSITE SAMPLES ARE COLLECTED FOR THE NORTH BUILDOUT FLOW-WAY (CELLS 4, 5 AND 6; STATION ST2NBO) AND THE SOUTH FLOW-WAY (CELLS 7 AND 8; STATION ST2SBO) AND A SINGLE MOSQUITOFISH SAMPLE IS COLLECTED AT THE DOWNSTREAM STATION (CA2NF)

Figure 1: STA-2 Mercury and Other Toxicants Monitoring Stations

Operational Project Monitoring Plan

For

Central Flow-Way
Stormwater Treatment Area 3/4

(Project Code: STA3/4)

01/07/2013

This monitoring plan is adaptive and therefore subject to change based on operational needs. It will be reviewed and/or modified at a minimum, on an annual basis.

Water Quality Monitoring Section
Water Quality Bureau, Water Resources Division
South Florida Water Management District

SFWMD-FIELD-MP-045-04

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Figures

Tables

Appendices

1.0 Glossary

ACF	Autosampler Composite Flow
CLQM	Clinical Laboratory Quality Manual
COC	Chain of Custody
DBHYDRO	South Florida Water Management District Environmental Database
DQOs	Data Quality Objectives
EAA	Everglades Agricultural Area
EFA	Everglades Forever Act
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FSQM	Field Sampling Quality Manual
F.S.	Florida Statutes
LIMS	Laboratory Information Management System
LTP	Long Term Plan
NPDES	National Pollutant Discharge Elimination System
PSTA	Periphyton-based Stormwater Treatment Area
QA/QC	Quality Assurance/Quality Control
QMP	Quality Management Plan
STA	Stormwater Treatment Area
SFER	South Florida Environmental Report
SFWMD	South Florida Water Management District
WQS	Water Quality Standard
WQM	Water Quality Monitoring Section

2.0 Project Organization

Overall project organization and responsibilities are detailed in the South Florida Water Management District (SFWMD or District) Water Quality Bureau (WQB) Quality Management Plan (QMP). Field activity responsibilities are detailed in the District's Field Sampling Quality Manual (FSQM). Laboratory analysis and data validation responsibilities are detailed in the District's Chemistry Laboratory Quality Manual (CLQM). These documents define the procedures used by SFWMD personnel to meet the Florida Department of Environmental Protection's (FDEP) Quality Assurance Rule, Florida Administrative Code (F.A.C.) 62-160. Refer to these documents for details on key personnel and relevant responsibilities.

3.0 Project Description

3.1 Project Introduction and Background

This document serves as a reference for surface water quality monitoring in Stormwater Treatment Area (STA) 3/4. The guidance contained herein is intended to assist in maintaining consistency in sampling locations, parameter lists, and frequencies as well as providing documentation of the project scope and an ongoing historical perspective.

The operational plan for STA3/4 contains detailed structure specifications including brief descriptions of permit required water quality monitoring at each structure.

3.2 Active Mandates and Permits

Station locations, sampling frequencies, and parameters to be sampled are dictated by the mandate and/or permits governing this project (see below). In addition, a mercury and toxicants monitoring program required by Everglades Forever Act (EFA) is included as Appendix 2.

As part of the Central Flow-way for the Everglades Construction Project, STA3/4 is subject to both the Everglades Forever Act Permit #0311207 and the National Pollutant Discharge Elimination System Industrial Wastewater Facility (NPDES) Permit FL0778451, both issued on September 10, 2012 and expiring on September 09, 2017. These permits dictate the types and frequencies of monitoring to be done, and the parameters to be analyzed, and can be viewed at:

- Everglades Forever Act Permit
  http://www.dep.state.fl.us/water/wqssp/everglades/docs/ecp-sta/draft-watershed-efa-permit.pdf
- NPDES Permit
  http://www.dep.state.fl.us/secretary/news/2012/06/npdes_watershed_permit_consent_order.pdf

Additional stations, parameters and frequencies are required as part of operational monitoring are detailed in Appendix 1.

3.3 Project Objectives

The primary objective of this monitoring project is to:

1. Assess compliance with applicable water quality standards and phosphorus discharge limits;
2. Aid in determining the nutrient concentrations to quantify the tons of nutrients removed by the STA annually;
3. Guide mid and long term resource management decisions for nutrient removal capabilities of the STA.

3.4 Duration

3.4.1 Initiation Conditions

The monitoring for this project was initiated in 2003 with twelve (12) stations sampled. Eighteen (18) project operation/mission driven stations were added through 2006 as illustrated in Table 1.

3.4.2 Modification or Termination Conditions

The mandated monitoring described in this document will be ongoing as required by the EFA 0311207 and NPDES FL0778451 permits, which are renewed once every 5 years. Conditions for modification or termination of the project are detailed in the permit(s) that specify the conditions of the project. Monitoring for operations will continue indefinitely in support of the project goals and objectives. Monitoring may increase or decrease over time, depending upon individual cell operations, data results, end user needs and permit requirements. Short-term changes to collection events may be made as a result of an extreme weather conditions (i.e., droughts and tropical storms/hurricanes), other safety concerns, or construction activities.

4.0 Geographic Location

4.1 Regional Area

This project is located within the south-central portion of the Everglades Agricultural Area (EAA) and includes wetlands and Class III freshwaters within the southernmost portion of Palm Beach County, Florida. The STA is located on 16,544 acres of lands located just north of the L-5 canal, directly north of the Palm Beach County line, extending from the Holey Land Wildlife Management Area eastward to U.S. Highway 27 (North New River Canal), and includes: Sections 31-36, Township 46 South, Range 37 East, Sections 1-16 and 22-24, Township 47 South, Range 37 East, Sections 6-8 and 16-21, Township 47 South, Range 38 East, and Section 31, Township 46 South, Range 38 East (Figure 1).

4.2 Sampling Locations

The locations of all monitoring stations are depicted in Figure 1 with exact locations described in Table 1.

4.3 Access and Authority

The gates on roadways into STA 3/4 are secured with a District “Clewiston” lock. The lock requires a “C” key which can be obtained through a District key permit. Samples are collected on the upstream side of structures/culverts.

Table 1: STA3/4 Surface Water Monitoring Sites, GPS Coordinates and Descriptions

Station	Latitude	Longitude	Description
G370	262346.672	83523.478	Inflow pump station
G370S	262346.673	803523.477	Seepage pump autosampler near inflow pump station G370
G371*	262013.31	803218.901	Diversion structure located north of the S7 structure
G372	262608.505	804828.09	Inflow pump station
G372S	262604.627	804836.937	Seepage pump autosampler near inflow pump station G372
G373*	262606.965	804841.241	Diversion located in the Miami Canal south of G372 Structure
G374B	262346.166	803541.879	Cell 1A inflow gate structure
G374E	262346.023	803624.747	Cell 1A inflow gate structure
G375B	262149.350	803417.953	Cell 1A to cell 1B
G375E	262148.731	803530.464	Cell 1A to cell 1B
G376B	262007.606	803320.636	Cell 1B outflow structure
G376E	262007.241	803441.973	Cell 1B outflow structure
G377B	262345.849	803715.344	Cell 2A inflow gate structure
G377D	262345.736	803747.237	Cell 2A inflow gate structure
G378B	262148.494	803644.126	Cell 2A to 2B
G378D	262148.329	803733.601	Cell 2A to 2B
G378 E	262148.218	803757.842	PSTA inflow cell 2A to 2B
G379B	262006.754	803626.394	Cell 2B outflow gated structure
G379D	262021.565	803727.797	Cell 2B outflow gated structure
G379E	262030.839	803755.033	Cell 2B outflow gated structure
G380B	262345.490	803855.421	Cell 3 inflow gate structure
G380E	262345.079	804023.401	Cell 3 inflow gate structure
G381B	262135.102	803855.680	Cell 3 outflow gated structure
G381E	262147.536	804023.581	Cell 3 outflow gated structure
G383	262347.025	803650.926	Inflow pump station
G384B	262240.700	804024.200	Cell 3A to Cell 3B – west of G384A
G384E	262240.700	804024.399	Cell 3A to Cell 3B – west of G384D
G388	262031.737	803800.628	Cell 2B, outflow pump station for PSTA project
G389A	262109.994	803745.370	Inflow to cell 2B_1_4
G389B	262110.020	803753.310	Inflow to cell 2B_1_4
G390A	262109.943	803759.459	Inflow to cell 2B_1_2
G390B	262109.994	803806.279	Inflow to cell 2B_1_2

The standard positional goal for site coordinates is ±1 meter. This standard can be obtained with a professional grade DGPS system. The coordinates are relative to NAD83 HARN horizontal datum.

*Sites collected as a part of the EAA Monitoring Plan

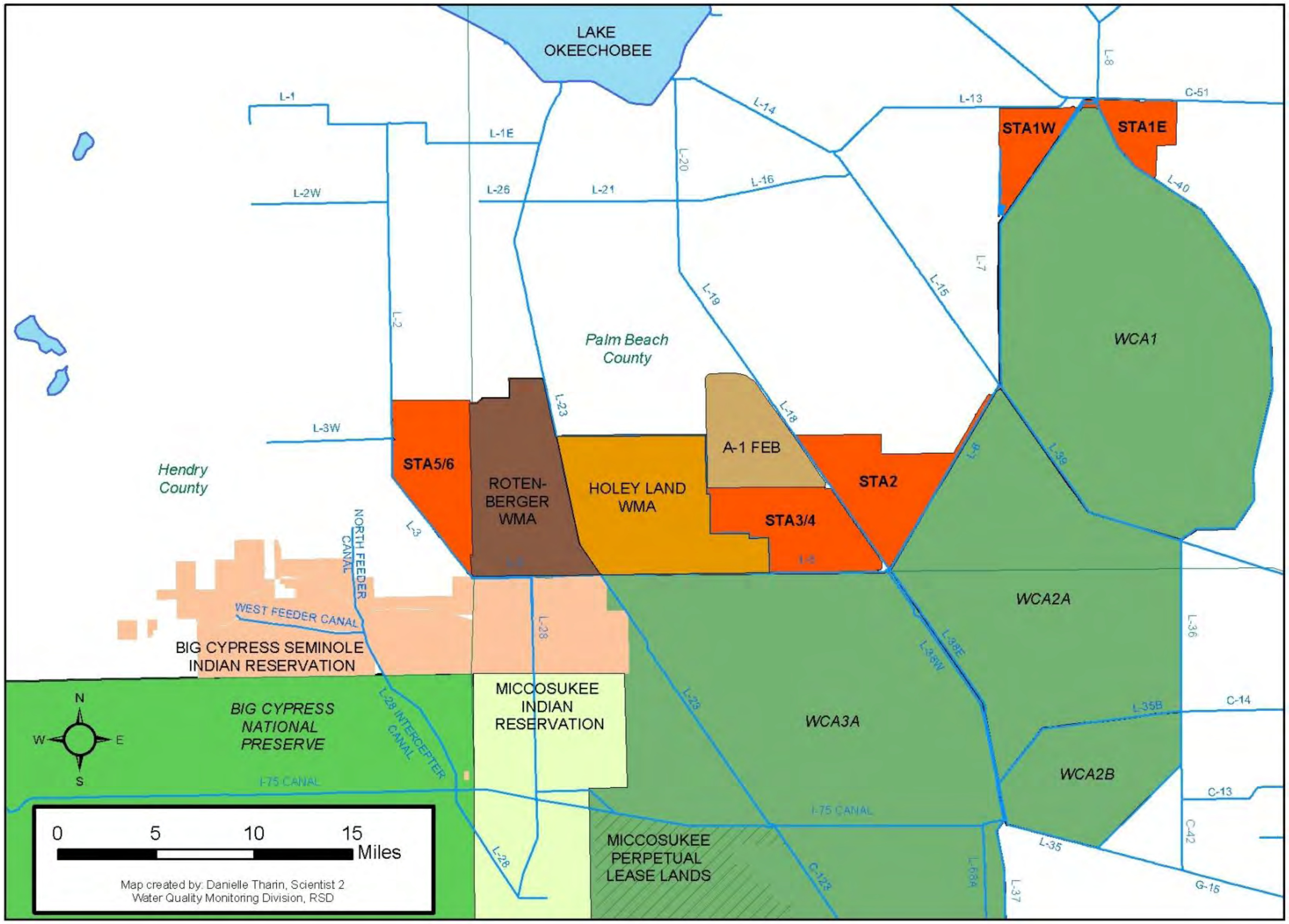
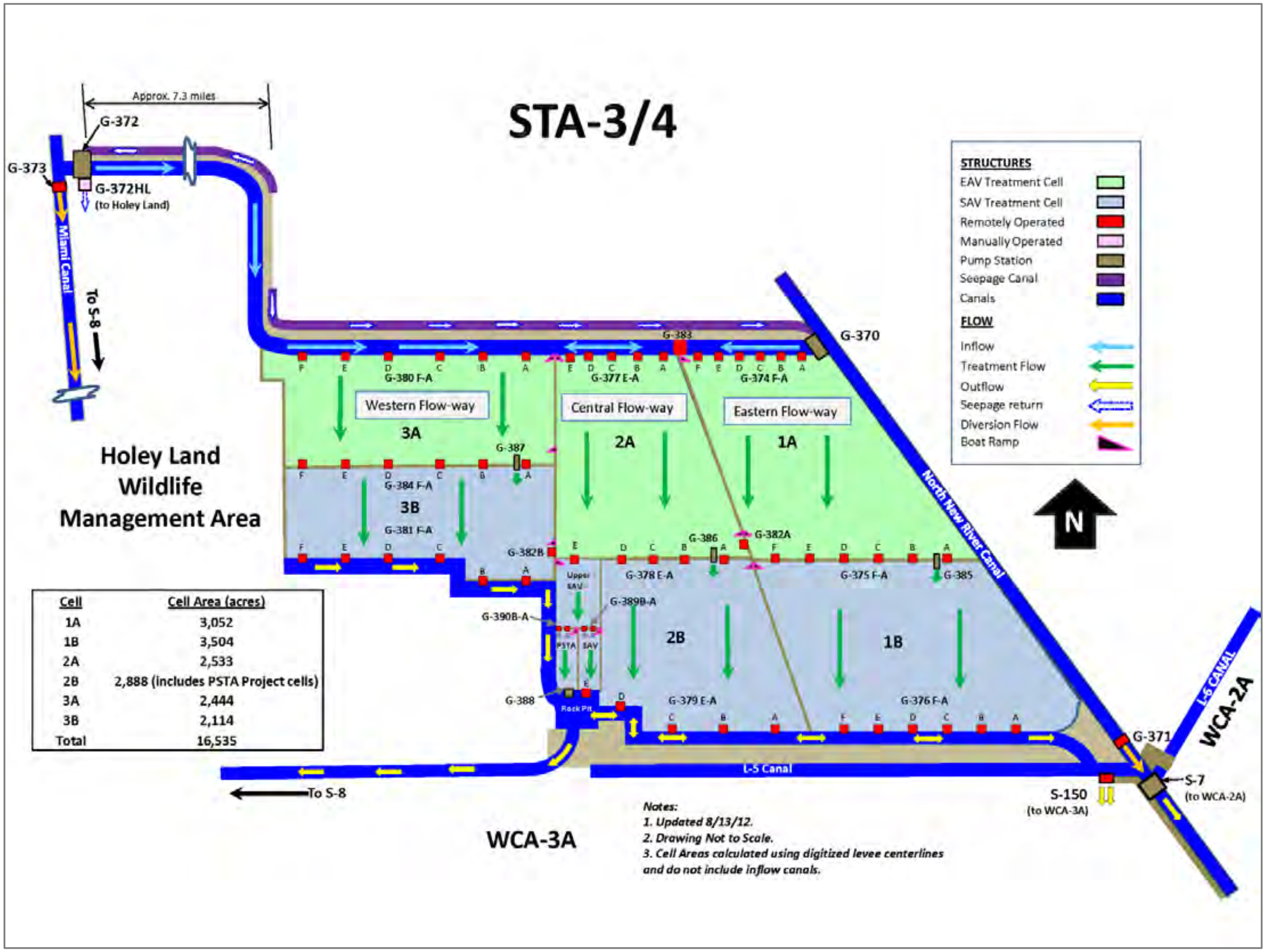


Figure 1: Regional Area of STA3/4



Cell	Cell Area (acres)
1A	3,052
1B	3,504
2A	2,533
2B	2,888 (includes PSTA Project cells)
3A	2,444
3B	2,114
Total	16,535

Notes:
1. Updated 8/13/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.

Figure 2: Project STA3/4 Station Map

Table 2: STA3/4 Sample Frequencies and Parameters

Station Name	Collection Method	Frequency	Parameter ACODES
Outflow and Flow Way End Stations			
G376B G376E G379B G379D G381B G381E	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
	Grab	Weekly Recorded Flow	Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS,
	Grab	Quarterly	DOC
	ACF	Weekly	TPO4
Inflow Stations			
G370 G372	Grab	Weekly	TPO_4, DO, pH, Scond, Temp
	Grab	Weekly Recorded Flow	Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
	ACF	Weekly	TPO_4
	Grab	Quarterly	DOC
Diversion Stations			
G371† G373	ACF	Weekly	TPO_4
	Grab	Weekly	TPO_4
Flow-Way Starts and Interior Stations			
G374B G374E G377B G377D G380B G380E	Grab	Biweekly Recorded Flow	Ca, TPO_4, DO, pH, Scond, Temp
G375B G375E G378B G378D G384B G384E	Grab	Monthly Recorded Flow	Ca, OPO_4, TDP, TPO_4, DO, pH, Scond, Temp
Divides and Seepage Stations			
G383 G370S G372S	Grab	Monthly Recorded Flow	TPO_4, DO, pH, Scond, Temp
PSTA Stations			
G388 G379E G378E G389A G389B G390A G390B	Grab	Weekly	OPO_4, TPO_4, $TDPO_4$, DO, pH, Scond, Temp
	ACF	Weekly	TPO_4
	Grab	Biweekly	ALKA, Ca, Cl, DOC, Mg, Na, NH_4, NOx, K, SO_4, TDS, TKN, TSS, TURB

† Site collected as a part of EAA monitoring plan

5.0 Field Activities

5.1 Monitoring Frequencies by Station and Parameters

All samples required for collection are depicted in Table 2. Some stations within the monitoring network are collected based on whether flow has been recorded. Specifically, structure operation activity is determined within a specified timeframe through the review of electronic data. If no flow (i.e., no operations) has been recorded, the sample is considered a No Bottle sample (NOB) and the structure is not visited. Conversely, if flow has been recorded during the specified timeframe, a sample is collected.

5.2 Project Specific Guidelines

All surface water samples shall be collected on the upstream side of any structure at a depth of 0.5 m unless vegetation and/or other conditions inhibit the collection of a representative sample upstream. Prior to sampling an alternative site, a consultation with a Field Technician Supervisor and/or the FPM must take place; this action must be documented in the field notes.

Backup grab samples will accompany the autosampler collection based upon flow trigger (ACF) samples collected on a weekly basis. In addition, in situ readings (i.e., Temperature, pH, DO and Specific Conductance) are measured as the grab samples are being collected. Samples are collected on upstream side of structures/culverts.

5.3 Grab Sampling Procedures

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District’s FSQM.

5.4 Field Testing Procedures

Field testing procedures shall follow the procedures and requirements found in the Field Testing Section of the District’s FSQM. The field parameters for this project are described below.

Table 3: Field Analytical Parameter Collection

Parameter	Resolution	Accuracy
Dissolved Oxygen	0.01 mg/l	0-20 mg/l, ± 0.2 mg/l
Specific conductance	0.001 mS/cm	± 0.5% of reading ± 0.001 mS/cm
Temperature	0.01° C	± 0.15°C
pH	0.01 unit	± 0.2 unit

5.5 Field Quality Control Requirements

Field quality control requirements shall follow the procedures found in the Quality Control Section of the District’s FSQM.

5.6 Autosampler Collection

Samples are collected with flow-proportional (ACF) at the stations identified in Table 2. Frequency for ACF collections is determined by a “trigger volume” established through the protocols established by Abtew and Powell (2004). The frequency of ADT collection is set by the FPM following discussions with the data end user(s). Discrete bottles within each autosampler are pre-acidified and composited on a weekly basis and analyzed for total phosphorus (TPO_4).

5.7 Sample Submission

Following completion of sample collection for each day, the samples are placed in ice and transported in coolers less than or equal to ≤ 6° Celsius to the laboratory for analysis. Samples are submitted to the laboratory on the same day as collection or via courier the following day. Samples are submitted according to the requirements outlined in the District's FSQM. If samples are submitted to other than the District's laboratory, the laboratory must be a District approved laboratory.

6.0 Data Quality Objectives

6.1 Data Usage

The data from STA3/4 are compiled and reported in accordance with the conditions outlined in the permit or mandate specified in Section 3.2. Typically the data are reported in the District's Annual South Florida Environmental Report (SFER), or in some cases is reported in a standalone mandated report, such as the quarterly Everglades Settlement Agreement Report. The SFER can be found at www.sfwmd.gov/sfer/.

6.2 Data Quality

All monitoring required by the attached permit shall meet the indicators conveyed in the FDEP's Quality Assurance Rule, 62-160 F.A.C. The District has adopted a uniform set of Data Quality Objectives (DQOs) following criteria detailed within the "Analytical Methods and Default QA/QC Targets" table of the CLQM.

The DQOs of the field testing parameters for this project are covered by the table entitled *Field Quality Assurance Objectives* found in the field testing section of the FSQM. This manual is updated annually, and therefore, the most recent version of the District's FSQM details the specific field testing DQOs for this project at the time of sample collection.

Samples are analyzed according to the provisions within the FDEP Rule 62-160 F.A.C. and the District's CLQM. This manual is annually updated, and therefore, the most recent version of the District's CLQM details DQOs for this project at the time of sample collection for each specific laboratory analysis. Data are qualified in accordance with the FSQM and CLQM data validation and reporting sections.

6.3 Completeness Targets

Completeness targets (i.e., the number of samples successfully collected and analyzed) shall be set at 95% annually for this project. Sampling attempts shall be included in the completeness target. At times samples will not be able to be collected on an attempt due to no flow or low water conditions, unsafe station conditions, equipment malfunction, site maintenance, or other unforeseen problems that might affect sample collection and/or quality. If samples cannot be collected on an attempt, collectors shall document “no bottle” (NOB in DBHYDRO) to indicate and attempt was made. Attempted collection (NOB) of samples will be considered a collected sample when calculating completeness targets.

7.0 Data and Records Management

The laboratory shall evaluate the data in accordance with the data quality objectives stated in the FSQM and CLQM. All data submittals shall conform to existing District guidelines.

7.1 Data Deliverables

There are no contract deliverables for this project.

7.2 Data and Record Storage

After the data validation process, all data and records are maintained so that end users can retrieve and review all information relative to a sampling event. Field records are maintained in NuGenesis by scanning actual field note pages records directly into NuGenesis (See SFWMD-FIELD-SOP-022). All analytical data and specified metadata are sent to a database (DBHYDRO) for long-term storage and retrieval.

The District shall maintain master copies of field and laboratory generated records. It is the responsibility of the District to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. At least quarterly, any contractor performing work for the project shall provide all original field records to the District’s WQB for permanent archival.

Records shall be maintained for the life of the project and a minimum of five years thereafter, in a manner that will protect the physical condition and/or integrity of the records. Storage shall follow the SOP for Archive Records Storage and Retention (SFWMD-FIELD-SOP-022). Corrections of data or records shall follow the applicable District SOPs and FSQM.

8.0 Revisions and Modifications

Date	Section	Page Number(s)	Change From	Change To	Reason
01/01/2013	All	All			Monitoring plan modified to conform to requirements of EFA Permit # 0311207, NPDES Permit # FL0778451, and their associated Consent Orders as well as STA Operational considerations.

References:

Abtew, Wossenu & Powell, B. Water Quality Sampling Schemes for Variable Flow Canals at Remote Sites. Journal of the American Water Resources Association. October, 2007. Pp 1197 – 1204.

FDEP (Florida Department of Environmental Protection). Quality Assurance Rule, 62-160 Florida Administrative Code (F.A.C.)

South Florida Water Management District, Chemistry Laboratory Quality Manual (CLQM), Version 1.0, October 2011 or a newer version if available.

http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/analytical%20services/tab2/tab5/2011%20quality%20manual.pdf

South Florida Water Management District, Field Sampling Quality Manual (FSQM), Version 7.0, December 2011 or a newer version if available.

http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/water%20quality%20monitoring%20division/subtab%20-%20wqm%20-%20qa/tab24442257/fsqm_sfwmd-field-qm-001-07.pdf

South Florida Water Management District, Field Sampling Quality Management Plan (QMP), Version 3.0, June 2011 or a newer version if available.

http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/subtab%20-%20qaqc/tab21630104/rsd_qmp_v3_0.pdf

Signature Page

Monitoring Plan

For

Central Flow-Way
Stormwater Treatment Area 3/4

(STA3/4)

Linda Crean, Water Quality Monitoring Section Administrator	Date
David Struve, Analytical Services Section Administrator	Date
Julianne LaRock, Compliance Assessment and Reporting Section Administrator	Date
Ming Chen, Quality Assurance Administrator	Date

Appendix 1: Site Requirements by Mandate

Station Name	Mandate	Collection Method	Frequency	Parameters
Outflow and Flow-Way End Stations				
G376B G376E G379B G379D G381B G381E	National Pollution Discharge Elimination System (NPDES)	Grab	Weekly Recorded Flow (WRF)	Total Phosphorus (TPO$_4$), pH
		ACF	Weekly (W)	TPO$_4$
	Everglades Forever Act (EFA)	Grab	See Specific Condition 21	Turbidity (TURB)
			WRF	TPO$_4$, Dissolved Oxygen (DO), pH, Specific conductance (Scond), Temperature (Temp)
		ACF	W	TPO$_4$
		Grab	Biweekly Recorded Flow (BWRF)	Nitrite-Nitrate (NOx), Sulfate (SO$_4$), Total Nitrogen (TN^1)
	STA Operations	ACF	W	TPO$_4$
		Grab	W	TPO$_4$, DO, pH, Scond, Temp
		Grab	WRF	Ammonia (NH$_4$), Calcium (Ca), Chloride (Cl), NOx, Orthophosphate (OPO$_4$), SO$_{4,}$ Total Dissolved Phosphorus (TDPO$_4$), Total Kjeldahl nitrogen (TKN), Total Suspended Solids (TSS)
		Grab	Quarterly (Q)	Dissolved Organic Carbon (DOC)
G388 G379E	PSTA	ACF	W	TPO$_4$
		Grab	W	OPO4, TDPO4, TPO4, DO, pH, Scond, Temp
		Grab	BW	Alkalinity (ALKA), Ca, Cl, DOC, Magnesium (Mg), Sodium (Na), NH$_4$, NOx, Potassium (K), SO$_4$, TDS, TKN, TSS, TURB,
Inflow Stations				
G370 G372	NPDES	Grab	WRF	TPO$_4$
		ACF	W	TPO$_4$
	EFA	Grab	WRF	TPO$_4$, pH, Scond, Temp
		Grab	BWRF	NOx, SO$_4$, TN^1
		ACF	W	TPO$_4$
	Everglades Agricultural Area Chapter Rule 40E-63 (EAA Rule)	Grab	W	TPO$_4$
		ACF	W	TPO$_4$
	STA Operations	Grab	W	TPO$_{4,}$ DO, pH, Scond, Temp
		Grab	WRF	Ca, Cl, NH$_4$, NO$_{X,}$ OPO$_4$, SO$_4$, TDPO$_4$, TKN, TSS

Station Name	Mandate	Collection Method	Frequency	Parameters
		Grab	Q	DOC
		ACF	W	TPO_4
Seepage, Diversion and Divide Stations				
G383 **G370S** **G372S**	STA Operations	Grab	Monthly Recorded Flow (MRF)	TPO_4, DO, pH, Scond, Temp
G371 **G373**	EFA	Grab	WRF	TPO_4
	EAA Rule	Grab	W	TPO_4
		ACF	W	TPO_4
	STA Operations	Grab	WRF	TPO_4, DO, pH, Scond, Temp
		ACF	W	TPO_4
Flow-Way Start Stations				
G374B **G374E** **G377B** **G377D** **G380B** **G380E**	STA Operations	Grab	BWRF	Ca, TPO_4, DO, pH, Scond, Temp
Flow-Way Interior Stations				
G378E **G389A** **G389B** **G390A** **G390B**	PSTA	Grab	W	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
		ACF	W	TPO_4
		Grab	BW	ALKA, Ca, Cl, DOC, Mg, Na, NH_4, NOx, K, SO_4, TDS, TKN, TSS, TURB
G375B **G375E** **G378B** **G378D** **G384B** **G384E**	STA Operations	Grab	MRF	CA, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp

[1] TN is calculated as the sum of TKN and NOx

Note: Mg, K, and Na are reported with all Ca requests

Appendix 2: Mercury and Other Toxicants Monitoring Plan

Flow-Path: Central
Stormwater Treatment Area 1E
EFA Permit No. 0311207

Monitoring of water-column concentrations of total mercury (THg) and methylmercury (MeHg) began in December 2003 at STA-3/4. The eastern flow-way (Flow-way 1 consisting of Cells 1A and 1B) met the mercury startup criteria as specified in Exhibit C of EFA Permit No 0192895 in January 2004, the western flow-way (Flow-way 3 consisting of Cell 3A and 3B) met the mercury startup criteria in June 2004, and the central flow-way (Flow-way 2 consisting of Cells 2A and 2B) met the mercury startup criteria in August 2004 (see Chapter 4 of the 2005 South Florida Environmental Report [SFER]). The Florida Department of Environmental Protection (Department) issued minor permit modification 0192895-011 June 6, 2008, approving transfer of STA-3/4 mercury monitoring from Phase 2 – Tier 1: Routine Monitoring during Stabilization Period to Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9 for all flow ways.

In October 2012, all Phase 3 – Tier 1 mercury monitoring criteria were met (see correspondence from H. Andreotta (District) dated January 17, 2013). February 20, 2013 the Department approved transfer of STA-3/4 mercury monitoring from Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9 to Phase 3 – Tier 3: Routine Operational Monitoring After Year 9. This implemented the termination of all site specific mercury monitoring at STA-3/4.

Operational Project Monitoring Plan

For

Western Flow-Way

Stormwater Treatment Areas 5 and 6
Rotenberger Wildlife Management Area

(Project Code: STA5/6 and RTBG)

01/07/2013

This monitoring plan is adaptive and therefore subject to change based on operational needs. It will be reviewed and/or modified at a minimum, on an annual basis.

Water Quality Monitoring Section
Water Quality Bureau, Water Resources Division
South Florida Water Management District

SFWMD-FIELD-MP-074-02

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Figures

Tables

Appendices

1.0 Glossary

ACF	Autosampler collection based upon flow trigger
ACT	Autosampler collection based upon time trigger
CLQM	Chemistry Laboratory Quality Manual (SFWMD)
Department	Florida Department of Environmental Protection or FDEP
District	South Florida Water Management District or SFWMD
DQOs	Data Quality Objectives
EAA	Everglades Agricultural Area
ECP	Everglades Construction Project
EFA	Everglades Forever Act
EPA	Everglades Protection Area
F.S.	Florida Statute
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FSQM	Field Sampling Quality Manual (SFWMD)
GPS	Global Positioning System
NAD83 HARN	North American Datum of 1983 High Accuracy Reference Network
NPDES	National Pollutant Discharge Elimination System
QMP	Quality Management Plan
RTBG	Rotenberger (project code)
RWMA	Rotenberger Wildlife Management Area
SFER	South Florida Environmental Report
SFWMD	South Florida Water Management District
SOP	Standard Operating Procedures
STA	Stormwater Treatment Area
ST5R	Stormwater Treatment Area 5 Research
USEPA	U.S. Environmental Protection Agency
WQB	Water Quality Bureau

2.0 Project Organization

Overall project organization and responsibilities are detailed in the South Florida Water Management District (SFWMD or District) Applied Sciences (ASB) and Water Quality Bureau (WQB) Quality Management Plan (QMP). Field activity responsibilities are detailed in the District's Field Sampling Quality Manual (FSQM). Laboratory analysis and data validation responsibilities are detailed in the District's Chemistry Laboratory Quality Manual (CLQM). These documents define the procedures used by SFWMD personnel to meet the Florida Department of Environmental Protection's (FDEP or the Department) Quality Assurance Rule, Florida Administrative Code (F.A.C.) 62-160. Refer to these documents for details on key personnel and relevant responsibilities.

3.0 Project Description

3.1 Project Introduction and Background

This document serves as a reference for surface water quality monitoring for Western Flow Way Stormwater Area 5/6 (STA5/6) and the Rotenberger (project code RTBG) Wildlife Management Area (RWMA). This integrated operational plan for the STA5/6 and RTBG project contains detailed structure specifications including brief descriptions of the mandate and/or permit required monitoring at each station. Current project status, schematics and the project operations plan can be viewed at the District's STA status page.

STA5/6 consists of Stormwater Treatment Area 5 (STA5), the Compartment C, and the Stormwater Treatment Area 6 (STA6). With the completion of Compartment C Built-out facilities, the total effective treatment area of STA5/6, is estimated to 13,008 acres, and will be distributed within eight parallel treatment cells or flow ways (Figure 2).

3.1.1 STA5 and the RWMA

STA5 is a part of the Everglades Construction Project (ECP), which is required by the Everglades Forever Act (EFA), Section 373.4592 of Florida Statute (F.S.). The original STA5 began operation in June 1999 and was designed to treat agricultural runoff and discharges from the C-139 Basin received from the L2 canal. Water was directed through two parallel flow-ways each subdivided into two treatments cells by interior levee. Each flow-way consists of two inflow structures (G342A-B; G342C-D); four interior structures (G343A-D; G342E-H) to control water flow and water elevation, and to optimize the cells performance; and two outflow structures (G344A-B; G344C-D) discharging into the STA5/6 discharge canal. G406 structure can be used in conjunction with G407 and G408 to facilitate diversion of Stormwater around STA5/6. The seepage pumps G349A and G349C can be used to return seepage to Cell 5-1A and Cell 5-1B. Pump stations G507 and G350B, located in the northeast side of STA5 can also provide supplemental water to Cell 5-1B and Cell 5-2B from the discharge canal. G-411 structure located within the STA5/6 Discharge Canal divides post treatment water from STA5/6 into north segment (waters from flow ways 1 and 2) and south segment (waters from flow ways 3 through 8). When G411 structure is closed, G350B, G410, and G507 Pump Stations deliver water composited of Miami Canal and the north segment of the STA5/6 discharge canal to the cells associated to each pump; when open, the water delivered is a composite of the entire STA5/6 discharge Canal and Miami Canal. Water can be transferred as well into flow-way

1 and 2 from flow-way 3 spreader canal via the G519, G520 and G521 transfer culverts equipped with manually operated gates.

The operation and maintenance of the RWMA Hydro pattern Restoration Project shall be consistent with the Florida Department of Environmental Protection (FDEP) approved RWMA Operation Plan and the objectives of the ECP, as outlined in the EFA, Section 373.4592 of Florida Statute (F.S.). Discharges to RWMA are for the purpose of hydrologic restoration of the approximate 29,000-acre wildlife management area. The G410 Pump Station which is located within the STA5/6 discharge canal along the eastern perimeter of STA5/6, north of the G411 structure, is the unique inflow for Rotenberger Wildlife Management Area (RWMA), and allows a portion of STA5/6 discharge canal to be routed to the RWMA and to the Miami canal through the RWMA discharges structures G402A-D. Monitoring for RWMA, through RTBG project, was initiated in July 2001.

3.1.2 Compartment C

The Compartment C Project is a 10,140 acre parcel of land located west of RWMA between STA-5 Flow-way 2 and STA-6 Section 1. Expansion of the STA5 and STA6 was being implemented in two phases. Phase 1, which was the Initial Expansion of STA-5 and STA-6 over an area of 3,844 acres, is complete and included construction of two additional flow-ways known as STA-5 Flow-way 3 (Cells 5-3A and 5-3B), and STA-6 Section 2 (Cell 6-2), which is a portion of flow way 6. Operation began at flow way 3 in July 2008 and at STA6 Section 2 in July 2007. Implementation of Phase 2 will allow for the expansion of the STAs into the remaining 6,296 acre area of Compartment C. This phase of implementation is known as the Compartment C Build out, and expected to further improve the quality of water entering the Everglades Protection Area (EPA). Upon completion of construction of the Build out on 2012, the entire STA-5, STA-6, and Compartment C Build out complex will be known as STA5/6. Phase 2 became flow capable in August 2012. Flow-way 4 (Cell 5-4A, and Cell 5-4B), and flow-way 6 (Cell 6-4, and Cell 6-2) built during Phase 2 began the phosphorous Start up testing at the end of October 2012, and received FDEP acknowledgement on 12/21/12. Upon passing the TPO4 Start up Test, these Cells can accept water either from G508 pump station, G508 seepage pump station, and G406 structure; also discharge is allowed from the outflow structures associated at these cells. However, due to the delay caused by the cultural resource work in Flow way 5, and the unavailability of water to hydrate this flow way after the completion of this work, the phosphorous start up test cannot not be performed in this flow way. Therefore, flow way 5 will be in operation when water is available during the 2013 rainy season.

Compartment C accepts waters from the inflow canal, which is supplied either by the main inflow G508 pump station, G342O gated culverts, G508 seepage pump station, G406 (via G342E and F, or G351). The inflow supply canal, through eight inflow structures, G342G-N, distributes water to the four flow ways components of Compartment C. G342G and H serve flow way 3 (Cell 5-3A and Cell 5-3B), G342I-J serve flow way 4 (Cell 5-4A and Cell 5-4B), G342K-M serve flow way 5

(Cell 5A and Cell 5B), and G342N serves flow way 6 (Cell 6-4 and Cell 6-2). Each flow-way is subdivided into two treatments cells by an interior levee. Flow ways 4 and 5 also include two intermediate berms in the upstream cells to minimize dry out of the treatment cells. Each structure of the seven G342G-M inflow structures consists of a single gated culvert, while G342N inflow structure is equipped of a two gated culverts. Treated water from the outflow structures G344F-K and from G352A-C is conveyed east to the STA5/6 discharge canal, south side of G411 structure. G344E and F serve flow way 3 (Cell 5-3A and Cell 5-3B), G344G-H serve flow way 4 (Cell 5-4A and Cell 5-4B), G344I-K serve flow way 5 (Cell 5A and Cell 5B), and G352A-C serve flow way 6 (Cell 6-4 and Cell 6-2). While each of the G352 structures and G344E-F are equipped of a double leaf gate to allow release of water from the upper section of the lower gate, each of the remaining G344 structures consists of a single gate culvert only.
G509 rehydration pump station, which is part of the Compartment C Built out, is located on the eastern levee between Cell 5-4B and Cell 5-5B at the discharge canal. G509 pump station will be used mainly during drought to withdraw water from STA5/6 discharge canal (south segment) to Cell 5-4B and Cell 5-5B for delivery to the other cells.

3.1.3 STA6

STA-6 is part of the ECP; the construction, operation and maintenance is required by the 1994 EFA, Section 373.4592 F.S. The original Stormwater Treatment Area 6 (STA6), which began operation in 1997, is designed to treat an effective area of 870 acres by means of two Cells, 6-5 and 6-3, known as Section 1 (both cells), or flow ways 7 and 8 respectively. After the completion of Compartment C, flows to STA6 is pumped south by G508 pump station, from the L2 canal to the inflow canal and then routed through G351 (open) and the inflow structures G353A-C. Each of the STA6 inflow structures is located along of the east levee of the L3 canal between G407 and G408 structures and is equipped of a single gate. G406 can also be operated to deliver water to STA6 (via the G408); the G351 and G407 structures would remain closed. Six outflow structures, G393A-C, and G354A-C, located along of the east perimeter release treated water from 6-3 and 6-5 into the STA5/6 discharge canal (south segment). These six outflow structures consist of a fixed weir box on the upstream end of the culvert to limit drawdown of flow ways, known as STA6 Section 1.G407 structure located within the L3 canal may be operated to allow diversion of Stormwater around STA5/6 via the seepage/L3 canal.

3.1.4 ST5R

Stormwater Treatment Area 5 Research (ST5R) water quality data are collected for research into STA nutrient removal optimization. ST5R is comprised of monitoring at interior structures located between Cells A and B. The STA5/6 interior works are divided into parallel treatment flow ways, each consisting of two treatment cells in series flowing in an easterly direction. Flow way 1(5-1A and 5-1B), flow way 2 (5-2A and 5-2B), flow way 3 (5-3A and 5-3B), flow way 4 (5-4A and 5-4B), flow way 5 (5-5A and 5-5B), and flow way 6 (6-4 and 6-2. All the G343s (G343A-O), and G396A-C are interior structures. Some of the monitoring stations were formerly monitored as part of a marsh dry-out research project and were subsequently incorporated into the optimization research.

3.2 Mandates and Permits

Station locations, sampling frequencies, and parameters to be sampled are dictated by the mandate and/or permits governing this project (see Appendix 1 for details). In addition, the mercury and toxicants monitoring program required by Everglades Forever Act Permit (0311207) is included as Appendix 2.

As part of the Western Flow-way for the Everglades Construction Project, STA5/6 is subject to both the Everglades Forever Act Permit #0311207 and the National Pollutant Discharge Elimination System Industrial Wastewater Facility (NPDES) Permit FL0778451, both issued on September 10, 2012 and expiring on September 09, 2017. These permits dictate the types and frequencies of monitoring to be done, and the parameters to be analyzed, and can be viewed at:

- Everglades Forever Act Permit
  http://www.dep.state.fl.us/water/wqssp/everglades/docs/ecp-sta/draft-watershed-efa-permit.pdf
- NPDES Permit
  http://www.dep.state.fl.us/secretary/news/2012/06/npdes_watershed_permit_consent_order.pdf

Additional stations, parameters and frequencies are required as part of operational monitoring are detailed in Appendix 1.

3.2.1 STA5/6

On September 10, 2012, the FDEP has issued the permit number 0311207 in conjunction with the NPDES permit number FL0778451 for all the Everglades Construction Projects. In these permits, the *"Western Flow-path: Stormwater Treatment Area 5/6 (Palm Beach, Broward and Hendry Counties)"* refers to the complex STA5, STA6, and Compartment C. Both permits will expire on September 09, 2017. In addition, structures G-342A-D, G-406, and G-508/G-342O monitored under this project are mandated by the C-139 Rule, Chapter 40E-63, which mandates that the District monitor and quantify the total phosphorus concentrations in the water entering and leaving the EAA.

3.2.2 Rotenberger Wildlife Management Area (RWMA)

In accordance with the current EFA permit 0311207 (see Specific Conditions 12), the District is authorized to operate and maintain the RWMA consistently with the DEP approved RWMA Operation plan and the objectives of the ECP. The District monitors the unique inflow G410 pump station, the G402 outflow structures, the rainfall and evapotranspiration (ET) at nearby stations in order to analyze and report these data in the South Florida Environmental Report (SFER). In 2000, with the completion of the inflow and the outflow control structures, RWMA is flow capable.

3.3 Project Objectives

The primary objective of this monitoring project is to:

1. Assess compliance with applicable water quality standards and phosphorus discharge limits;
2. Aid in determining the nutrient concentrations to quantify the tons of nutrients removed by the STA annually;
3. Guide mid and long term resource management decisions for nutrient removal capabilities of the STA.

3.4 Duration

3.4.1 Initiation Conditions

Monitoring of the original STA-5 and STA-6 projects was initiated in June 1999 and April 1997, respectively. Upon completion of Compartment C Phase 1 build-out in July 2008 monitoring of Flow way 3 began; in July 2007 monitoring of STA6 Section 2 stations was initiated. Monitoring for the Compartment C Phase 2 components began on August 2012.

3.4.2 Modification or Termination Conditions

The mandated monitoring described in this document will be ongoing as required by the EFA 0311207 and NPDES FL0778451 permits, which are renewed once every 5 years. Conditions for modification or termination of the project are detailed in the permit(s) that specify the conditions of the project. Monitoring for operations will continue indefinitely in support of the project goals and objectives. Monitoring may increase or decrease over time, depending upon individual cell operations, data results, end user needs and permit requirements. Short-term changes to collection events may be made as a result of an extreme weather conditions (i.e., droughts and tropical storms/hurricanes), other safety concerns, or construction activities.

4.0 Geographic Location

4.1 Regional Area

The STA5/6 and RTBG projects consist of 54 monitoring stations in Palm Beach County (Figure 1). Table 1 provides the station names, global positioning system (GPS) coordinates, and a description of each monitoring station. The locations of all monitoring stations are depicted on the map in Figure 1.

4.2 Sampling Locations

The locations of all monitoring stations are depicted in Figure 1 with exact locations described in Table 1.

4.3 Access and Authority

The gates on roadways into the Build-out are secured with a District “C” lock. The lock requires a ”C” key which can be obtained through a request made through the FPM and/or Field Supervisor. Samples are collected on the upstream side of structures/culverts.

Table 1: STA5/6 Surface Water Monitoring Sites and GPS Coordinates

Station	Latitude	Longitude	Description
G342A	262742.661	805646.627	Cell 1A inflow
G324B	262654.733	805646.627	Cell 1A inflow
G342C	262652.813	805647.167	Cell 2A inflow
G342D	262604.755	805644.887	Cell 2A inflow
G406	262600.521	805647.994	Inflow structure for Compartment C and STA6
G343B	262721.644	805455.807	Interior structure located between Cells 1A and 1B
G343C	262709.197	805455.706	Interior structure located between Cells 1A and 1B
G343F	262632.364	805455.176	Interior structure located between Cells 2A and 2B
G343G	262619.897	805455.023	Interior structure located between Cells 2A and 2B
G344A	262729.460	805300.230	Cell 1B outflow
G344B	262703.670	805259.680	Cell 1B outflow
G344C	262637.940	805258.850	Cell 2B outflow
G344D	262612.200	805258.260	Cell 2B outflow
G349A	262742.170	805612.880	Seepage return pump station located at NW portion of Cell1A
G349C	262741.936	805453.761	Seepage return pump station located at NW portion of Cell 1B
G507	262731.520	805259.569	Cell 1B inflow from discharge canal (hydration pump for SAV cells)
G350B	262559.171	805257.841	South seepage canal pump station
G508, G342O	262558.706	805642.892	Inflow pump station/gravity inflow through pump station
G508S	262557.347	805644.778	G508 seepage return
G342G	262544.279	805643.896	Cell 3A inflow
G342H	262520.436	805643.895	Cell 3A inflow
G342I	262453.794	805643.781	Cell 4A inflow
G342J	262426.97	805643.866	Cell 4A inflow
G342K	262400.721	805627.658	Cell 5A inflow
G342L	262335.053	805605.124	Cell 5A inflow
G342M	262307.947	805541.359	Cell 5A inflow
G342N	262234.575	805512.087	Cell 4 inflow
G343I	262544.455	805425.675	Flow-way 3 interior structure
G343J	262519.756	805425.378	Flow-way 3 interior structure
G343K	262452.659	805339.711	Flow-way 4 interior structure
G343L	262426.954	805339.786	Flow-way 4 interior structure
G343M	262358.479	805337.385	Flow-way 5 interior structure
G343N	262334.707	805337.142	Flow-way 5 interior structure
G343O	262308.306	805336.847	Flow-way 5 interior structure
G396B	262215.680	805419.046	Interior structure located between cell 6-4 and cell 6-2

Station	Latitude	Longitude	Description
344E	262545.997	805257.918	Cell 3B outflow
G344F	262520.042	805257.253	Cell 3B outflow
G344G	262452.516	805256.874	Cell 4B outflow
G344H	262426.793	805256.287	Cell 4B outflow
G344I	262400.619	805255.640	Cell 5B outflow
G344J	262334.466	805255.066	Cell 5B outflow
G344K	262307.448	805254.463	Cell 5B outflow
G352B	262215.704	805253.139	Section 2 outflow
G509	262414.609	805255.486	Cells 4B & 5B hydration pump
G351	262135.838	805422.593	Seepage return or divide structure located at the south end of STA5/6 inflow canal
G353A	26126.468	805414.234	Section 1 cell 5 inflow
G353B	262106.069	805356.658	Section 1 cell 5 inflow
G353C	262046.584	805339.698	Section 1 cell 3 inflow
G354C	262100.262	805250.727	Section 1 cell 5 outflow
G393B	262011.505	805255.769	Section 1 cell 3 outflow
G406	262600.521	805647.994	Divide/diversion structure between L-2 & L-3 canals
G407	262000.538	805259.830	Diversion structure at south end of L-3 canal
G410	262610.687	805256.123	Pump station discharging from STA5/6. Discharge canal to RWMA
G402A	262117.725	804734.205	Outflow structure from RTBG to the Miami Canal
G402C	262531.761	804834.718	Outflow structure from RTBG to the Miami Canal

The standard positional goal for site coordinates is ±1 meter. This standard can be obtained with a professional grade DGPS system. The coordinates are relative to NAD83 HARN horizontal datum.

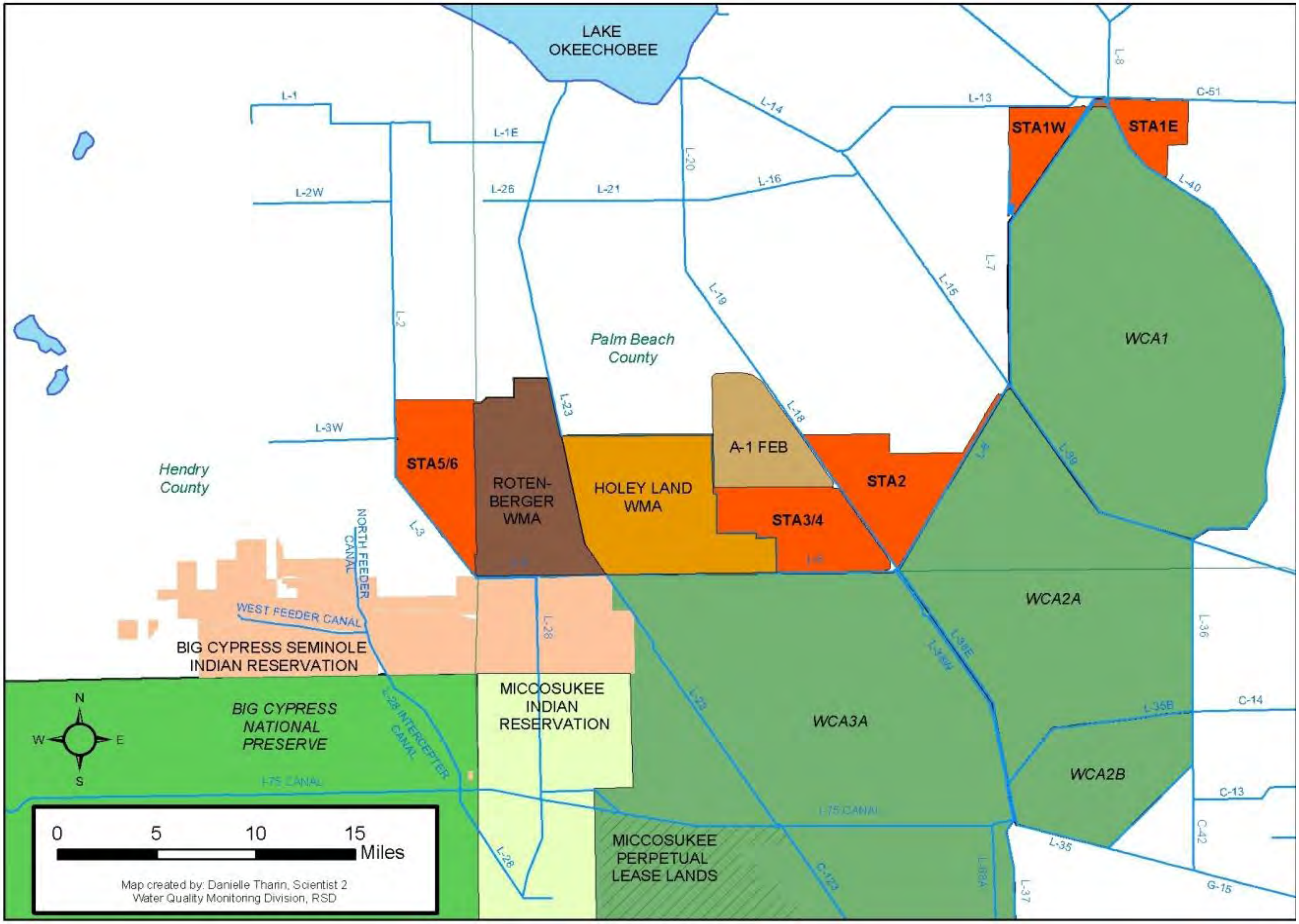
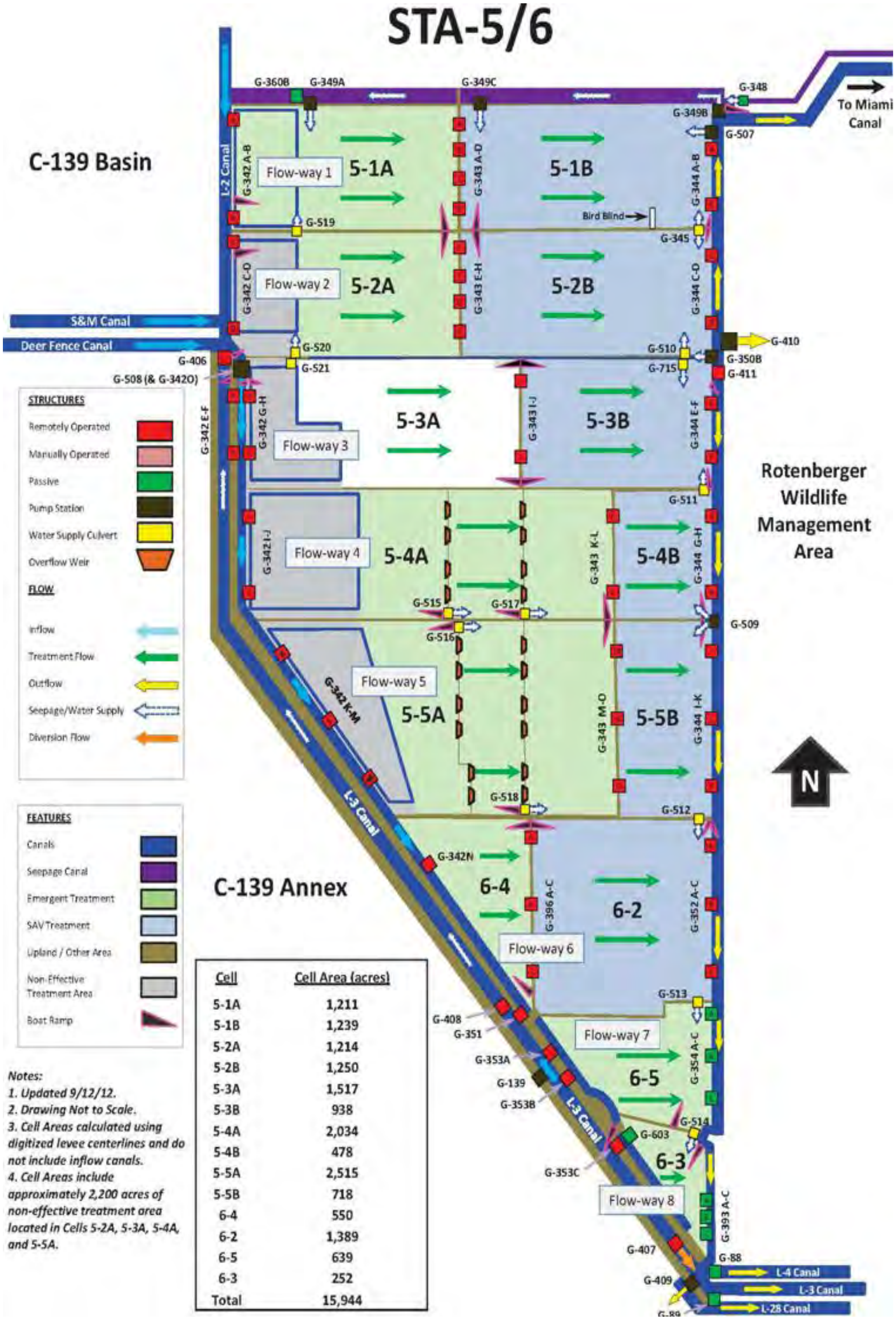


Figure 1: Regional Map including Compartment C, STA-5, STA-6, RTBG and EAA



Cell	Cell Area (acres)
5-1A	1,211
5-1B	1,239
5-2A	1,214
5-2B	1,250
5-3A	1,517
5-3B	938
5-4A	2,034
5-4B	478
5-5A	2,515
5-5B	718
6-4	550
6-2	1,389
6-5	639
6-3	252
Total	15,944

Notes:
1. Updated 9/12/12.
2. Drawing Not to Scale.
3. Cell Areas calculated using digitized levee centerlines and do not include inflow canals.
4. Cell Areas include approximately 2,200 acres of non-effective treatment area located in Cells 5-2A, 5-3A, 5-4A, and 5-5A.

Figure 2: STA5/6 Structures and Flow

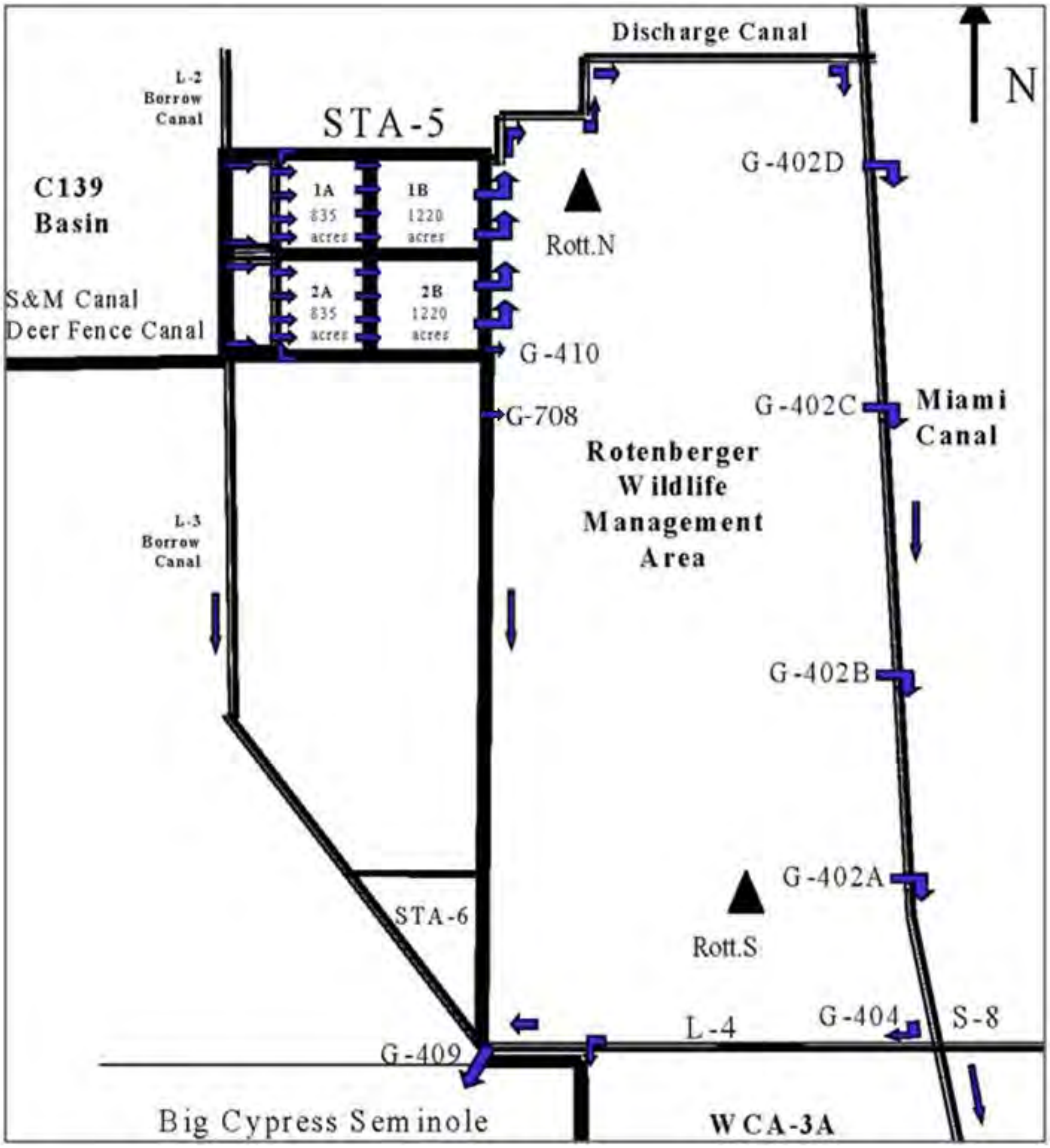


Figure 3: Rotenberger Wildlife Management Area Structures and Flow

Table 2: STA5/6 Grab/Autosampler Sample Frequency and Parameter ACODES

Station Name	Type	Frequency	Analytical Parameters
STA5/6 Outflow Stations			
G344A G344B G344C G344D G344E G344F G344G G344H G344I G344J G344K G352B G354C G393B	Grab	Weekly	TPO$_{4,}$ DO, pH, Scond, Temp
	ACF	Weekly	TPO$_4$
	Grab	Weekly Recorded Flow	Ca, Cl, NH$_4$, NOx, OPO$_4$, SO$_4$, TDPO$_4$, TKN, TSS
	Grab	Quarterly	DOC
STA5/6 Inflow Stations			
G406	ACT	Weekly	TPO$_4$
G508[1] G342O G342A G342B G342C G342D	ACF	Weekly	TPO$_4$
G406 G508[1] G342O G342A G342B G342C G342D	Grab	Weekly	TPO$_{4,}$ DO, pH, Scond, Temp
		Weekly Recorded Flow	Ca, Cl, NH$_4$, NOx, OPO$_4$, SO$_4$, TDPO$_4$, TKN, TSS
		Quarterly	DOC
STA5/6 Diversion Stations			
G406 G407	Grab	Weekly Recorded Flow	TPO$_{4,}$ DO, pH, Scond, Temp
STA5/6 Flow Way Starts, Ends and Interior Stations			
G342G G342H G342I G342J G342K G342L G342M G342N G353A G353B G353C	Grab	Biweekly Recorded Flow	Ca, TPO4, DO, pH, Scond, Temp

Station Name	Type	Frequency	Analytical Parameters
G343B **G343C** **G343F** **G343G** **G343I** **G343J** **G343K** **G343L** **G343M** **G343N** **G343O** **G396B**	Grab	Monthly Recorded Flow	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
STA5/6 Divides and Seepage Structures			
G349C **G507** **G350B** **G509**	Grab	WRF	TPO_4, DO, pH, Scond, Temp
G351 **G508S**	Grab	Monthly Recorded Flow	TPO_4, DO, pH, Scond, Temp
G349A	Grab	Monthly Recorded Flow	Ca, OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
RTBG Inflow Stations			
G410	Grab	Weekly Recorded Flow or Quarterly	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp
RTBG Outflow Stations			
G402A **G402C**	ACF	Weekly	TPO_4
	Grab	Weekly if Flowing or Recorded Flow else Quarterly	OPO_4, $TDPO_4$, TPO_4, DO, pH, Scond, Temp

[1] G508 is a representative monitoring site for G342O

5.0 Field Activities

5.1 Monitoring Frequencies by Site and Parameters

All samples required for collection by sampling are depicted in Table 2. Some stations within the monitoring network are collected based on whether flow has been recorded. Specifically, structure operation activity is determined within a specified timeframe through the review of electronic data. If no flow (i.e., no operations) has been recorded, the sample is considered a No Bottle sample (NOB) and the structure is not visited. Conversely, if flow has been recorded during the specified timeframe, a sample is collected.

5.2 Project Specific Guidelines

All surface water samples shall be collected on the upstream side of any structure at a depth of 0.5 m unless vegetation and/or other conditions inhibit the collection of a representative sample upstream. Prior to sampling an alternative site, a consultation with a Field Technician Supervisor and/or the FPM must take place; this action must be documented in the field notes.

Backup grab samples will accompany the autosampler collection based upon flow trigger (ACF) samples collected on a weekly basis. In addition, in situ readings (i.e., Temperature, pH, DO and Specific Conductance) are measured as the grab samples are being collected. Samples collected on upstream side of structures/culverts.

G351, a divide structure, may have flow occur in either direction. Flow originating from the G508 pump station (via the inflow canal) shall be considered the upstream location for the purposes of this monitoring plan and flows originating from the seepage canal (from G406 to G408) and the remaining of the L3 canal (from G408 to G407) shall be considered as reverse flow for this structure.

5.3 Grab Sampling Procedures

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District's FSQM.

5.4 Field Testing Procedures

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District's FSQM. The field parameters for this project are described in Table 3 below.

Table 3: Field Analytical Parameters Collected

Parameter	Resolution	Accuracy
Dissolved Oxygen	0.01 mg/L	0-20 mg/L, ± 0.2 mg/L
Specific Conductance	0.001 µS/cm	± 0.5% of reading ± 0.001 µS/cm
Temperature	0.01°C	± 0.15°C
pH	0.01 unit	± 0.2 unit

5.5 Field Quality Control Requirements

Field quality control requirements shall follow the procedures found in the Quality Control Section of the District's FSQM.

5.6 Autosampler Collection

Samples are collected with flow-proportional (ACF) autosamplers at all inflow and outflow stations with the exception of G402A and G402C, the Rotenberger (RTBG) outflow stations and G406, see Table 2. Frequency for ACF collections is determined by a "trigger volume" established through the protocols established by Abtew and Powell (2004). The autosampler at G406 is programmed as time proportional (ACT) sampling. Data from this structure will be compared to G508; if these data are found to be statistically insignificantly different G406 sampling will discontinue and G508 will be used as its surrogate. The frequency of ADT collection is set by the FPM following discussions with the data end user(s).

Following the completion of construction of Compartment C, Cell 6-4 (November 23, 2010) the autosampler at G396B was taken offline; this autosampler was decommissioned on January 9, 2013 along with the autosamplers at G343B, G343C, G343F, G343G, G343J, G349A, G353A, G353B, and G353C. On September 17, 2012, the autosampler at G407 was also decommissioned. Consequently, only grab samples are collected at these decommissioned stations. For as long as the start-up phase for flow way 5 (Cell 5-5A and Cell 5-5B) does not demonstrate a net reduction in phosphorous level in those cells, the autosamplers at G344I-K will remain on flow to capture any unexpected flow event that might occur at these structures.

5.7 Sample Submission

Following completion of sample collection for each day, the samples are placed in ice and transported in coolers at ≤ 6°C to the laboratory for analysis. Samples are submitted to the laboratory on the same day as collection or via courier the following day. Samples are submitted according to the requirements outlined in the District's FSQM. If samples are submitted to other than the District's laboratory, the laboratory must be a District approved laboratory.

6.0 Data Quality Objectives

6.1 Data Uses

The data from STA5/6 and RTBG are compiled and reported in the District's South Florida Environmental Report (SFER). The SFER can be found at the District's website www.sfwmd.gov/sfer/.

6.2 Data Quality

All monitoring described herein shall meet the indicators conveyed in the FDEP's Quality Assurance Rule, 62-160 F.A.C. The District has adopted a uniform set of Data Quality Objectives (DQOs) following criteria detailed within the "Analytical Methods and Default QA/QC Targets" table of the CLQM.

The DQOs of the field testing parameters for this project are covered by the table entitled Field Quality Assurance Objectives found in the field testing section of the FSQM. This manual is updated regularly, and therefore, the most recent version of the District's FSQM details the specific field testing DQOs for this project at the time of sample collection.

Samples are analyzed according to the provisions within the FDEP Rule 62-160 F.A.C. and the District's CLQM. This manual is updated regularly, and therefore, the most recent version of the District's CLQM details DQOs for this project at the time of sample collection for each specific laboratory analysis. Data are qualified in accordance with the FSQM, CLQM and applicable data validation SOPs.

6.3 Completeness Targets

The completeness target (i.e., the number of samples successfully collected and analyzed) shall be set at 95% annually for this project. Sampling attempts shall be included in the completeness target. At times samples will not be able to be collected on an attempt due to no flow or low water conditions, unsafe station conditions, equipment malfunction, site maintenance, or other unforeseen problems that might affect sample collection and/or quality. If samples cannot be collected on an attempt, collectors shall document "no bottle" (NOB) to indicate and attempt was made and/or the sample could not be collected for the documented reasons. Attempted collection (NOB) of samples will be considered a collected sample when calculating completeness targets.

7.0 Data and Records Management

The laboratory shall evaluate the data in accordance with the data quality objectives stated in the FSQM and CLQM. All data submittals shall conform to existing District guidelines.

7.1 Data Deliverables

There are no contract deliverables for this project.

7.2 Data Storage

After the data validation process, all data and records are maintained so that end users can retrieve and review all information relative to a sampling event. Field records are maintained in NuGenesis by scanning actual field note pages records directly into NuGenesis (See SFWMD-FIELD-SOP-022). All analytical data and specified metadata are sent to a database (DBHYDRO) for long-term storage and retrieval.

The District shall maintain master copies of field and laboratory generated records. It is the responsibility of the District to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. At least quarterly, any contractor performing work for the project shall provide all original field records to the District's WQB for permanent archival.

Records shall be maintained for the life of the project and a minimum of five years thereafter, in a manner that will protect the physical condition and/or integrity of the records. Storage shall follow the SOP for Archive Records Storage and Retention (SFWMD-FIELD-SOP-022). Corrections of data or records shall follow the applicable District SOPs and FSQM.

8.0 Revisions and Modifications

Date	Section	Page Number(s)	Change From	Change To	Reason
01/01/2013	All	All			Monitoring plan modified to conform to requirements of EFA Permit # 0311207, NPDES Permit # FL0778451, and their associated Consent Orders as well as STA Operational considerations.

References:

Abtew, Wossenu & Powell, B. Water Quality Sampling Schemes for Variable Flow Canals at Remote Sites. Journal of the American Water Resources Association. October, 2007. Pp 1197 – 1204.

FDEP (Florida Department of Environmental Protection). Quality Assurance Rule, 62-160 Florida Administrative Code (F.A.C.)

South Florida Water Management District, Chemistry Laboratory Quality Manual (CLQM), Version 1.0, October 2011 or a newer version if available.
http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/analytical%20services/tab2/tab5/2011%20quality%20manual.pdf

South Florida Water Management District, Field Sampling Quality Manual (FSQM), Version 7.0, December 2011 or a newer version if available.
http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/water%20quality%20monitoring%20division/subtab%20-%20wqm%20-%20qa/tab24442257/fsqm_sfwmd-field-qm-001-07.pdf

South Florida Water Management District, Field Sampling Quality Management Plan (QMP), Version 3.0, June 2011 or a newer version if available.
http://my.sfwmd.gov/portal/page/portal/restoration%20sciences/portlets/subtab%20-%20qaqc/tab21630104/rsd_qmp_v3_0.pdf

Signature Page

Monitoring Plan

For

Western Flow Way
Stormwater Treatment Area 5/6 and Rotenberger
(STA5/6 and RTBG)

Linda Crean, Water Quality Monitoring **Date**
Section Administrator

David Struve, Analytical Services **Date**
Section Administrator

Julianne LaRock, Compliance Assessment and Reporting **Date**
Section Administrator

Ming Chen, Quality Assurance **Date**
Administrator

Appendix 1: Monitoring Requirements by Mandates

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
WFW Outflow and Flow Way Ends Stations				
G344A **G344B** **G344C** **G344D** **G344E** **G344F** **G354C** **G393B** **G352B** **G344G** **G344H** **G344I** **G344J** **G344K**	Everglades Forever Act (EFA)	Grab	Weekly Recorded Flow (WRF)	Total Phosphorus (TPO_4), Dissolved Oxygen (DO), pH, Specific Conductance (Scond), Temperature (Temp)
		Grab	Biweekly Recorded Flow (BWRF)	Nitrate-nitrogen (NOx), Sulfate (SO_4), Total Nitrogen (TN^1)
		ACF	Weekly (W)	TPO_4
	National Pollution Discharge Elimination System (NPDES)	Grab	WRF	TPO_4, pH
		ACF	W	TPO_4
	STA Operations	Grab	W	TPO_4, DO, pH, Scond, Temp
		Grab	WRF	Ammonia (NH4), Calcium (Ca), Chloride (Cl), NOx, ortho-Phosphorus (OPO_4), SO_4, Total Dissolved Phosphorus ($TDPO_4$), Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS)
		Grab	Quarterly (Q)	Dissolved Organic Carbon (DOC)
		ACF	W	TPO_4
WFW Inflow Stations				
G342A **G342B** **G342C** **G342D** **G508** **(G342O)**	EFA	Grab	WRF	TPO_4, pH, Scond, Temp
		Grab	BWRF	NOx, TN, SO_4
		ACF	W	TPO_4
	NPDES	Grab	WRF	TPO_4
		ACF	WRF	TPO_4
	C-139 Rule	Grab	W	TPO_4
		ACF	W	TPO_4
	STA Operations	Grab	W	TPO_4, DO, pH, Scond, Temp
		Grab	WRF	Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
		Grab	Q	DOC
		ACF	W	TPO_4
G406 **(also classified as Diversion Structure, when operated in concert with G407)**	EFA	Grab	WRF	TPO_4, pH, Scond, Temp
		Grab	BWRF	NOx, SO_4, TN
	NPDES	Grab	WRF	TPO_4
	C-139 Rule	Grab	W	TPO_4
		ACT	W	TPO_4
	STA Operations	ACT	W	TPO_4
		Grab	W	TPO_4, DO, pH, Scond, Temp
		Grab	WRF	Ca, Cl, NH_4, NOx, OPO_4, SO_4, $TDPO_4$, TKN, TSS
		Grab	Q	DOC

Station Name	Mandate	Collection Method	Frequency	Analytical Parameters
WFW Seepage and Diversion Stations				
G407	EFA	Grab	WRF	TPO$_4$
	STA Operations	Grab	WRF	TPO$_4$, DO, pH, Scond, Temp
G508S **G351**	STA Operations	Grab	Monthly Recorded Flow (MRF)	TPO$_4$, DO, pH, Scond, Temp
WFW Flow Way Start Stations				
G342G **G342H** **G342I** **G342J** **G342K** **G342L** **G342M** **G342N** **G353A** **G353B** **G353C**	STA Operations	Grab	BWRF	Ca, TPO$_4$, DO, pH, Scond, Temp
WFW Flow Way Interior Stations				
G343B **G343C** **G343F** **G343G** **G343I** **G343J** **G343K** **G343L** **G343M** **G343N** **G343O** **G396B**	STA Operations	Grab	MRF	Ca, OPO$_4$, TDPO$_4$, TPO$_4$, DO, pH, Scond, Temp
WFW Hydration Stations				
G349A	Mission Driven	Grab	MRF	Ca, OPO$_4$, TDPO$_4$, TPO$_4$, DO, pH, Scond, Temp
G349C **G350B** **G507** **G509**	Mission Driven	Grab	WRF	TPO$_4$, DO, pH, Scond, Temp
RTBG Inflow Station				
G410	STA Operations	Grab	WRF	OPO$_4$, TDPO$_4$, TPO$_4$ DO, pH, Scond, Temp
RTBG Outflow Stations				
G402A **G402C**	STA Operations	Grab	WF/WRF/Q	OPO$_4$ TDPO$_4$ TPO$_4$ DO, pH, Scond, Temp
		ACF	W	TPO$_4$

[1] TN is calculated as the sum of TKN and NOx.

Appendix 2: STA5/6 Mercury and Other Toxicants Monitoring Program

Flow-Path: Western
Stormwater Treatment Area 5/6
EFA Permit No. 0311207

Monitoring of water-column concentrations of total mercury (THg) and methylmercury (MeHg) began in 1999 at STA-5 Flow-ways 1 and 2. These flow-ways met the mercury startup criteria as specified in Exhibit C of EFA Permit No. 0131842 in September 1999. In October 1999, the Florida Department of Environmental Protection (Department) issued Emergency Order 99-1748 in response to Hurricane Irene which included authorization for short-term temporary flow-through operations of STA-5 and acknowledgment that the mercury EFA permit startup requirements had been met. Because of drought conditions that followed and the detection of high phosphorus concentrations at the outflows, STA-5 did not begin routine flow-through until June 2000 for the Flow-way 2 and August 2000 for the Flow-way 1 (see Chapter 4 of the 2001 Everglades Consolidated Report). STA-5 Flow-ways 1 and 2 met Phase 3 – Tier 1 conditions contained in "*A Protocol for Monitoring Mercury and Other Toxicants"* (dated April 2011; hereafter referred to as the *Protocol*) in February 2008 (see data summary provided in correspondence from R. Bearzotti, SFWMD dated April, 2008). STA-5 Flow-ways 1 and 2 met Phase 3 – Tier 3 conditions "Routine Operational Monitoring After Year 9" in November 2008 (see data summary provided in correspondence from G. Vince, SFWMD dated October 12, 2009 and data for the final November 2009 fish collection submitted to the Department in December 2009 by H. Andreotta, SFWMD).

The District completed construction of a new southern flow-way (known as Flow-way 3 - consisting of Cells 5-3A and 5-3B) of STA-5 in May 2007. The flow-way was inundated in July 2008, met the mercury startup criteria as specified in Exhibit D of EFA Permit No. 0131842 in August 2008, and is currently in Phase 2 – Tier 1: Routine Monitoring During Stabilization Period.

STA-6 Section 1 (Cells 6-3 and 6-5) met the mercury start-up criteria as specified in Exhibit "C" of EFA Permit No. 262918309 in November 1997, and began flow-through operation in December 1997. Routine monitoring of mercury in STA-6 Section 1 was initiated in the first calendar quarter of 1998. The Department issued minor permit modification 0236905-001 June 6, 2008, approving transfer of mercury monitoring from Phase 2 – Tier 1: Routine Monitoring during Stabilization Period to Phase 3 – Tier 3: Routine Operational Monitoring from Year 4 to Year 9 for STA-6 Section 1. Phase 3 – Tier 3 implemented the termination of all site specific mercury monitoring at STA-6 Section 1.

STA-6 Section 2 (Cell 6-2) met the mercury startup criteria as specified in Exhibit "C" of EFA Permit No. 0236905-001 in September 2007, and began flow-through operation in December 2007. Routine monitoring of mercury in Section 2 was initiated January 2008, and is currently in Phase 2 – Tier 1: Routine Monitoring During Stabilization Period.

In September 2012, the District completed construction of the EAA Compartment C Buildout Project (Compartment C). Compartment C includes the G-508 pump station, STA-5 Flow-way 4 (consisting of Cells 5-4A and 5-4B), STA-5 Flow-way 5 (consisting of Cells 5-5A and 5-5B), and STA-6 Cell 6-4. STA-6 Cell 6-4, combined with the existing Cell 6-2, formed Flow-way 6. The entire STA-5, STA-6, and Compartment C Buildout complex is now referred to as STA5/6.

Startup monitoring for mercury and other toxicants was performed for Compartment C in September (mosquitofish) and October (sediment) of 2011 to capture the "first-flush effect" when the project was initially inundated. Compartment C met the mercury and other toxicant startup criteria as specified in Specific Condition 23 of EFA Permit No. 0311207 in October 2011 (see data summary provided in correspondence from H. Andreotta, SFWMD dated December 14, 2012). December 20, 2012, the Department approved transfer of monitoring from Phase 1 – Tier 2: Field Sampling for Initial Startup Monitoring Prior to Discharge to Phase 2 – Tier 1: Routine Monitoring During Stabilization Period for Compartment C (Flow-ways 4, 5, and 6).

Based on the performance of STA-5/6 flow-ways 1 through 8 and the guidance contained in the *Protocol*, the District shall conduct monitoring as follows:

- Phase 3 – Tier 3: Routine Operational Monitoring After Year 9 for STA-5/6 flow-ways 1, 2, 7, and 8
- Phase 2 – Tier 1: Routine Monitoring During Stabilization for STA-5/6 flow-ways 3, 4, 5, and 6

2.0 Phase 2: Monitoring During Three-Year Stabilization Period

2.1 Phase 2 - Tier 1: Routine Monitoring During Stabilization Period

2.1.1. Water

An unfiltered surface water sample (n = 1) shall be collected in accordance with Chapter 62-160, F.A.C. at the inflow pump station (G-508) and immediately upstream of the outflow structures (G-344F (Flow-way 3 outflow), G-344H (Flow-way 4 outflow), G-344J (Flow-way 5 outflow), and G-352B (Flow-way 6 outflow) (Figure 1) on a quarterly frequency and analyzed for THg and methylmercury (MeHg) (sulfate is being monitored under the EFA permit required routine WQ monitoring program). In addition, flow shall be monitored at the inflow and outflow to allow for load estimation to and from the project (it should be recognized that quarterly sampling would allow for only an approximate estimation of loads).

This data set will be assessed to determine if outflow concentrations exceed state water quality standards (WQS), and whether annual outflow loads of analytes are significantly greater than inflow loads, including atmospheric loading; load estimates will include confidence intervals that describe uncertainty in measures of flow and concentration (e.g., field and analytical precision) and resulting from interpolation (note: assessment protocol to be determined with permitting authority). Failure to satisfy these assessment measures would trigger Tier 2 Expanded Monitoring and Risk Assessment (see below).

2.1.2. Fish Tissues

Samples of fish from multiple trophic levels will be collected from each independently operated flow-way of the STA and from a single downstream site in the receiving water of the project (Figure 1). Specifically, mosquitofish will be collected quarterly from multiple locations within each flow-way, i.e., STA-5/6 Cells 5-3A and 5-3B (Flow-way 3), Cells 5-4A and 5-4B (Flow-way 4), Cells 5A and 5B (Flow-way 5), and Cells 6-4 and 6-2 (Flow-way 6) and physically composited into one spatially-averaged sample (to total at least 100 fish) per flow-way for THg analysis (note, a single aliquot will be analyzed per composite). Additionally, mosquitofish (to total at least 100 fish) will be collected from a site located in the STA-5/6 receiving waters immediately downstream from the project (station RA1 located within RWMA) and a site downstream of G-352B in the STA-5/6 discharge canal (station STA6DC) and analyzed for THg.

Sunfish (n should be greater than or equal to 5) and largemouth bass (*Micropterus salmoides);* (n should be greater than or equal to 5) shall be collected from a site within STA-5/6 Flow-way 3 (i.e., Cell 5-3B), Flow-way 4 (i.e., Cell 5-4B), Flow-way 5 (i.e., Cell 5-5B), Flow-way 6 (i.e., Cell 6-2), from stations located in the STA-5/6 receiving waters (station RA1 located within RWMA) (station STA6DC) on an annual basis and individually analyzed for THg (i.e., whole sunfish and fillets from the bass). Based on the *Protocol* (page 14, 2nd paragraph), if after one year of monitoring, sufficient data are collected to demonstrate that conditions within the different flow-ways are equivalent, collection of large-bodied fish can be reduced to one flow-way with the highest observed concentration and assess results as "worst case". This assessment shall be re-evaluated annually based on Hg levels observed in mosquitofish, which will continue to be collected from each of the flow-ways. To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections should target *Lepomis macrochirus* (bluegill) ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches). However, other Lepomids or sizes are to be collected if efforts fail to locate targeted fish. Owing to similar trophic status, if bluegill cannot be collected, first priority will be given to spotted sunfish, *Lepomis punctatus*. If neither sunfish nor bass are present, consideration should be given to sampling other species.

Assessment

To detect and minimize any adverse effects as early as possible (and to provide a basis for identifying adaptive management options, if deemed necessary), the results of this monitoring will be assessed based on the criteria and time table described under Phase 2 – Tier 1 in the *Protoco*l. Monitoring results will be provided to the Department in accordance with the reporting requirements described below.

Table 1 summarizes the monitoring requirements for Phase 2 - Tier 1: Routine Monitoring During Stabilization Period.

Table 1. Phase 2 - Tier 1: Routine Monitoring During Stabilization Period

Matrix	Location	Collection Method	Frequency	Parameter
Surface Water	G-508, G-344F, G-344H, G-344J, G-352B	Grab	Quarterly	THg, MeHg
Mosquitofish	STA-5/6 flow-ways 3, 4, 5, 6 & two downstream stations (RA1 and STA6DC)	Net or Trap	Quarterly	THg
Bass & Sunfish (n=5 each)	STA-5/6 Cells 5-3B, 5-4B 5-5B, 6-2, & two downstream stations (RA1 and STA6DC)	Electroshock or Hook and Line	Annually	THg

2.2 Phase 2 - Tier 2: Expanded Monitoring and Risk Assessment

In accordance with the Protocol, if Tier 1 data exceed the action levels identified under Phase 2 – Tier 2 Expanded Monitoring and Risk Assessment, the District shall notify the Department and after obtaining the Department's concurrence, shall expand monitoring and undertake all necessary steps consistent with the *Protocol*.

3.0 Operational Monitoring

The monitoring plan and associated data will be re-evaluated on an annual basis beginning after year 3 (following startup of Flow-ways , 4, and 5, and 6) to determine if criteria specified in the *Protocol* are being satisfied. Based on that assessment, and with the concurrency of the Department, monitoring and assessment efforts may be reduced (as identified in Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9 of the *Protocol*) or eliminated altogether at the project level to be subsumed by regional monitoring (as identified in Phase 3 – Tier 3: Routine Operational Monitoring After Year 9). However, if monitoring reveals anomalous conditions as described under Phase 3 – Tier 2: Expanded Monitoring and Risk Assessment, the District shall expand monitoring and undertake all necessary steps under Phase 3 – Tier 2: Expanded Monitoring and Risk Assessment in the *Protocol*.

3.1 Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9

3.1.1 Fish Tissues

Semiannually, mosquitofish will be collected from multiple locations within each flow-way (i.e., STA-5/6 Cells 5-3A and 5-3B (Flow-way 3), Cells 5-4A and 5-4B (Flow-way 4), Cells 5-5A and 5-5B (Flow-way 5), and Cell 6-4 and 6-2 (Flow-way 6)), and physically composited into one spatially-averaged sample (to total at least 100 fish) per flow-way for THg analysis (note, a single aliquot will be analyzed per composite). Additionally, mosquitofish (to total at least 100 fish) will be collected from two sites located in the STA-5/6 receiving waters immediately downstream from the project (RA1 located within RWMA and STA6DC in the STA-5/6 discharge canal) and analyzed for THg.

To assess "worst case" conditions, large-bodied fish will be collected only from the flow-way with the highest observed concentration and the downstream station identified above once every three years. This limited spatial sampling of large-bodied fish within the STA is to revert back to include formerly sampled stations, if Tier 2 is triggered or if mosquitofish demonstrate significantly altered spatial patterns in mercury biomagnification.

Specifically, sunfish (n should be greater than or equal to 5) should be collected from each station and individually analyzed as whole-fish. At the same time, largemouth bass (*Micropterus salmoides*; n should be greater than or equal to 5) should be collected from each station and individually analyzed (fillets) for THg. To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections will target bluegill (*Lepomis microchirus*) ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches); however, other lepomis (due to similar trophic status, first priority being given to spotted sunfish (*L. punctatus*) or sizes will be collected if efforts fail to locate targeted fish.

This data will then be used to track the following:

- THg levels in individual mosquitofish composite;
- Annual average THg levels in mosquitofish;
- THg levels in large-bodied fish
-

Table 2 summarizes the monitoring requirements for Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9.

Table 2. Phase 3 – Tier 1: Routine Operational Monitoring from Year 4 to Year 9

Matrix	Location	Collection Method	Frequency	Parameter
Mosquitofish	STA-5/6 flow-ways 3, 4, 5, 6, & two downstream stations (RA1 and STA6DC)	Net or Trap	Semiannually	THg
Bass & Sunfish (n=5 each)	Flow-way with historically highest [THg] (To Be Determined)	Electrofish or Hook & Line	Triennially	THg

3.2 Phase 3 - Tier 2: Expanded Monitoring and Risk Assessment

Tier 2 monitoring and assessment is triggered if one of the following action levels is exceeded during operation:

- If annual average THg levels in mosquitofish progressively increased over time (i.e., two or more years) or any (semi-annual) mosquitofish composite exceeds the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeds the 75th percentile concentration for the period of record for all basins; or

- If triennial monitoring of large-bodied fish reveal tissue Hg levels in fishes have statistically increased progressively over time or have become elevated to the point of exceeding the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeded the 75th percentile concentration for the period of record for all basins.

The following steps will be taken if any action level in Tier 2 is triggered:

Step 1: Notify the Department;

Step 2: Resample fish species that triggered Tier 2;

If results of Step 2 (i.e., re-sampling) demonstrate that the anomalous condition was an isolated event, the Department will be notified that the project will revert back and continue with Tier 1 monitoring. Alternatively, if results of Step 2 reveal the anomalous condition was not an isolated event, proceed to Step 3.

Step 3: Expanding monitoring program as follows:

- Increase frequency of mosquitofish collection from semiannually to monthly.
- If Tier 2 was triggered by levels in fish at the downstream site, possibly due to excessive loading from the STA outflow, then quarterly water-column sampling at outflow stations will begin. If necessary (i.e., if loading uncertainty is high), increase frequency of surface water collection to monthly (reducing temporal interpolation), or as appropriate for hydraulic retention time (HRT).
- If Tier 2 was triggered by levels in fish within only one of the treatment trains, further define spatial extent of problem by collecting multiple mosquitofish composites from within the treatment train exhibiting anomalous conditions.
- If Tier 2 was triggered by tissue levels in large-bodied fish, increase sample size of large-bodied fish to n = 20, i.e., 20 each of sunfish (collect various species and sizes) and/or bass (collect various sizes and extract otolith from bass for age determination).
- To evaluate possible trends in methylation rates in sediments (i.e., to determine if methylation rates are increasing or decreasing), replicate sediment cores (0-4 cm) can be collected from the suspected methylation “hot spot” and reference locations within the component (for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe)) over a given period of time (i.e., 2 to 4 months). At these same locations and collection times, collect pore water samples and analyze for THg, MeHg, and sulfides, or if no acceptable pore water protocol has been developed, then acid-volatile sulfide (AVS) on solids shall be completed.

Projects shown to have (spatially) large or multiple MeHg “hotspots” should consider use of the

Everglades Mercury Cycling Model (E-MCM) or comparable model as an assessment tool (i.e., to synthesize results of expanded monitoring).

Step 3 will also include the notification of the Department that anomalous conditions are continuing. The Department and the District may then develop an adaptive management plan using the data generated from the expanded monitoring program. This plan will evaluate the potential risks from continued operation under existing conditions (i.e., through a risk assessment for appropriate ecological receptors). If risk under existing operational conditions is deemed acceptable, then project monitoring would continue under a modified Tier 2 scheme to monitor exposure. On the other hand, if risk under existing operational conditions is deemed unacceptable, then the adaptive management plan would then proceed to determine potential remedial actions to (1) reduce exposure and risk (e.g., signage for human health concerns[1], reduce fish populations, reduce forage habitat suitability)) and (2) affect mercury biogeochemistry to reduce net methylation (e.g., modify hydroperiod or stage, water quality).

In developing this adaptive management plan, the Department may conduct a publicly noticed workshop to solicit comments from the District, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Park Service, the Florida Fish and Wildlife Conservation Commission, and other interested persons.

The next step would then be to carry out such remedial or corrective action. If the remedial or corrective action is demonstrated to be successful, then the project would revert back to Tier 1 monitoring. Alternatively, if monitoring data indicate that the remedial action was unsuccessful in reducing fish tissue concentrations or downstream loading, the Department and the District would then initiate a peer-reviewed, scientific assessment of the benefits and risks of the project.

3.3 Phase 3 - Tier 3: Termination of Monitoring After Year 9

If fishes collected under Phase 3 - Tier 1 have not exceeded action levels by year 9, project-specific monitoring would be discontinued; future assessments would be based on regional monitoring.

4.0 Annual Mercury Monitoring Report

The District shall notify the Department immediately if monitoring data indicate that any of the action levels are exceeded. In addition, the District shall submit an annual report to be incorporated into the SFER and submitted to the Department no later than March 1st of each year. The annual report shall summarize the most recent results of the monitoring as defined above and compares them with the cumulative results from previous years. This report shall also evaluate assessment performance measures (i.e., action levels) outlined above.

5.0 Adaptive Management Strategy

It is the intent that this monitoring plan will be carried out within the context of an adaptive management strategy that will allow for appropriate changes based on new, better understanding of mercury cycling, fate and transport as conveyed in the guidance contained in the *Protocol*.

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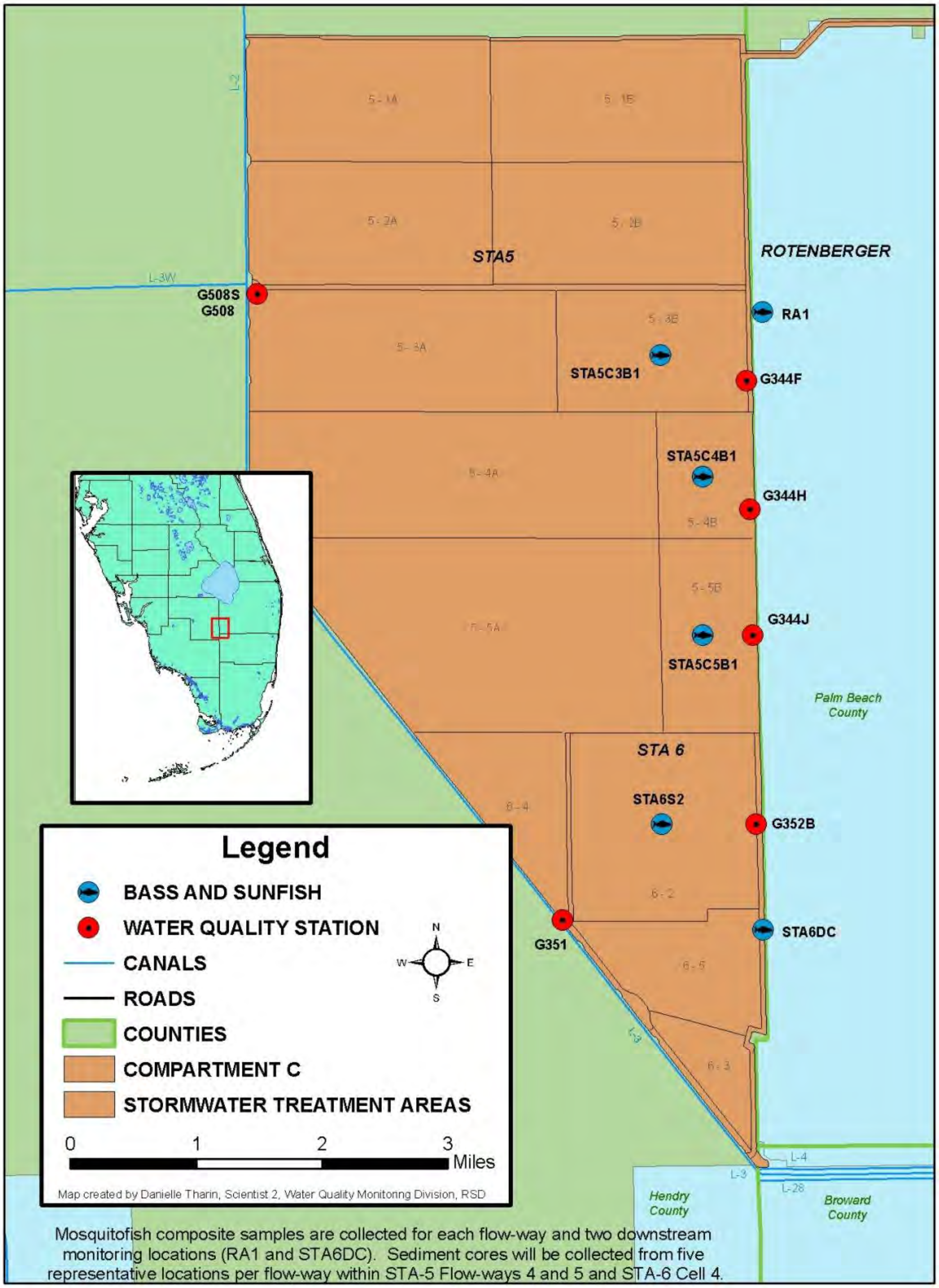
[1] Note that assessment of potential human health impacts and corrective actions (i.e., signage) will require the involvement of the Florida Department of Health)



Mosquitofish composite samples are collected for each flow-way and two downstream monitoring locations (RA1 and STA6DC). Sediment cores will be collected from five representative locations per flow-way within STA-5 Flow-ways 4 and 5 and STA-6 Cell 4.

Map of STA-5/6 Mercury Monitoring Locations