Chapter 5B: Performance and Operation of the Everglades Stormwater Treatment Areas

Michael Chimney[1]

Contributors: Holly Andreotta, Michael Chimney, Sarah Bornhoeft, Sam Colios[2], Jacob Dombrowski, Dawn Sierer Finn[2], Brian Garrett, Kevin Grace[2], Gretchen Kruizenga[2], Camille Herteux, Karen Hileman[1], Jill King, Susan Mason, Kimberly Moughon[2], Jim Myles[2], Tracey Piccone, Matthew Powers, Robert Shuford, Jessica Wilson, and Shi Kui Xue

Birds in the Everglades Stormwater Treatment Areas.

Highlights

The construction and operation of large freshwater treatment wetlands, known as the Everglades Stormwater Treatment Areas (STAs), are required by the Everglades Forever Act (EFA) and are an important part of state and federal efforts to preserve the remaining Everglades ecosystem. These wetlands include STA-1 East (STA-1E), STA-1 West (STA-1W), STA-2, STA-3/4, and STA-5/6. The Everglades STAs are located south of Lake Okeechobee and are designed to reduce total phosphorus (TP) concentration in surface water runoff prior to discharging this water into the Everglades Protection Area (EPA), which includes the Everglades Water Conservation Areas (WCAs) and Everglades National Park. The Everglades STAs are operated by the South Florida Water Management District (SFWMD or District) and currently encompass 62,000 total acres (ac) of treatment area permitted to operate, which includes recent expanded treatment areas in STA-1W, STA-2, and STA-5/6.

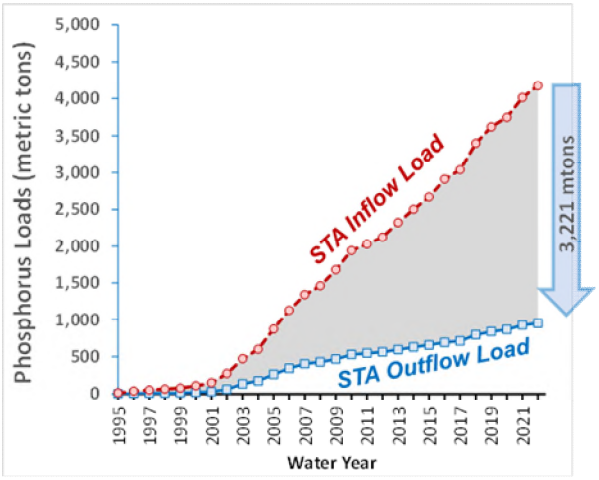
WATER YEAR 2022 PERFORMANCE

In Water Year 2022 (WY2022; May 1, 2021–April 30, 2022), the Everglades STAs treated approximately 1.0 million acre-feet (ac-ft) of water and retained 132 metric tons (t) of TP, resulting in an 83% TP load reduction, and produced an outflow TP flow-weighted mean concentration (FWMC) of 23 micrograms per liter (µg/L). Approximately 108,000 ac-ft of the inflow volume this water year came from Lake Okeechobee, of which 74,000 ac-ft were regulatory releases, while 34,000 ac-ft were delivered either as environmental releases for the Everglades or as supplemental water to maintain cell water levels at target stages in all the Everglades STAs.

[1]Author and contributors work for the South Florida Water Management District unless indicated otherwise. [2]DB Environmental, Rockledge, Florida.

PERIOD OF RECORD PERFORMANCE

Over the past 28 years, the Everglades STAs have treated approximately 25.2 million ac-ft of water (~ 8.2 trillion gallons) and retained 3,221 t of TP with a 77% TP load reduction. The overall outflow TP FWMC from these treatment wetlands during this period has been 30 µg/L. STA-3/4, over its 19-year operational history, has treated the most water (~ 8.3 million ac-ft), retained the most TP load (875 t), achieved the highest percent TP load retained (85%), and discharged water at the lowest outflow TP FWMC (15 µg/L) of all the Everglades STAs.



Cumulative phosphorus load reduction of all STAs combined over the last

WY2022 PERFORMANCE

In WY2022, water from Lake Okeechobee was delivered to each of the Everglades STAs either as environmental releases for the Everglades or as supplemental water to maintain STA cell hydration to the extent practicable during the water year.

STA	Outflow FWMC (µg/L)	Inflow TP Load Retained
STA-1E	22	85%
STA-1W	24	86%
STA-2	15	82%
STA-3/4	15	84%
STA-5/6	50	81%

The outflow TP FWMCs and percent inflow TP load retained are shown in the table to the left.

The consistently good annual treatment performance in STA-3/4 is attributed, in part, to it receiving the lowest inflow TP concentrations over its period of record (POR; 101 µg/L) compared to the other Everglades STAs.

All flow-ways in STA-1W were operational throughout WY2022, although each flow-way was online with restrictions for part of the water year for protection of nesting birds or construction activities. Cells 6-3 and 6-5 (Flow-ways 7 and 8) in STA-5/6 were declared by the District to be in dry-out condition during part of WY2022. Most of the other cells in STA-5/6 partially dried out this water year, but not to the extent that they were declared to be in dry-out condition.

BIRD NESTING

A total of 272 black-necked stilt nests were observed within the Everglades STAs during the 2021 and 2022 nesting seasons. Operational priorities were adjusted in the STAs to avoid disturbing any active nests. No Florida burrowing owls were observed in any of the Everglades STAs during this water year. Additionally, no snail kite nests were observed in the Everglades STAs during WY2022.

Nesting black-necked stilt in STA-2 in May

SFWMD.gov/our-work/wq-stas

INTRODUCTION

A major component of Everglades restoration efforts, the Everglades STAs are freshwater treatment wetlands built and operated to reduce TP concentration in surface water prior to these waters entering the EPA. The STAs were constructed primarily on former agricultural lands and retain nutrients through plant and microbial uptake, particulate settling, chemical sorption, and ultimately accretion of plant and microbial biomass to the sediments. This chapter[2] describes the treatment performance and status of the five Everglades STAs: STA-1E, STA-1W, STA-2, STA-3/4, and STA-5/6 (**Figure 5B-1** and Appendix 5B-1 of this volume) and the operational challenges related to maintaining treatment performance in them. The District operates and maintains all the Everglades STAs.

The construction and operation of large freshwater treatment wetlands, known as the Everglades STAs, are mandated by the EFA (Section 373.4592, Florida Statutes) and are an integral part of state and federal efforts to preserve the remaining Everglades ecosystem. These wetlands (STA-1E, STA-1W, STA-2, STA-3/4, and STA-5/6) are located south of Lake Okeechobee (**Figure 5B-1**) and are designed to reduce TP concentration in surface water runoff prior to discharging this water into the EPA. The Everglades STAs are operated by SFWMD and currently encompass 62,000 total ac of treatment area permitted to operate, which includes the expanded treatment areas of STA-1W, STA-2, and STA-5/6. This chapter and its appendices (Appendices 5B-1 through 5B-4 of this volume) summarize short-term and long-term Everglades STA treatment performance and document any environmental conditions that may have adversely affected treatment performance, the status of these facilities, and operational challenges during WY2022). An analysis of annual Everglades STA treatment performance relative to compliance with the Everglades STA operating permit is reported in Volume III, Appendix 3-1. A status update on the *Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals* (Long-Term Plan; Burns & McDonnell 2003) is covered in Appendix 5B-2 of this volume. This chapter also reports on facility status and operational issues, including relevant maintenance activities, vegetation conditions, and wildlife issues. Research activities conducted as part of the Restoration Strategies *Science Plan for the Everglades Stormwater Treatment Areas* (Science Plan; SFWMD 2013) are documented in Chapter 5C of this volume. More information about the Everglades STAs is available on the District's website: https://www.sfwmd.gov/our-work/wq-stas.

[2] Chapter 5B is an annual report on the condition and performance of the Everglades STA treatment facilities. It combines a report of routine operations, construction activities, vegetation maintenance, and effects of extreme weather conditions or other unusual events. The primary target readers for the chapter are regulatory personnel and various other STA stakeholders. The reported data are linked to other documents, including Restoration Strategies documents, permits, consent orders, operation plans, weekly reports to stakeholders, and electronic programs that are used to track and manage the Everglades STAs. To preserve the continuity of understanding with the stakeholders and agreement with these documents and electronic programs, results reported in Chapter 5B include a mixture of International System of Units (SI) and non-SI units. Non-SI units used in this chapter include wetland surface area as acres (ac), flow rate as cubic feet per second (cfs), water volume as acre-feet (ac-ft), and TP mass as metric tons (t). Conversion factors to express these values in SI units are as follows: 1 ac = 0.40469 hectare or 4,046.9 square meters; 1 cfs = 0.02832 cubic meters per second; 1 ac-ft = 1,233.5 cubic meters; and 1 t = 1,000 kilograms.

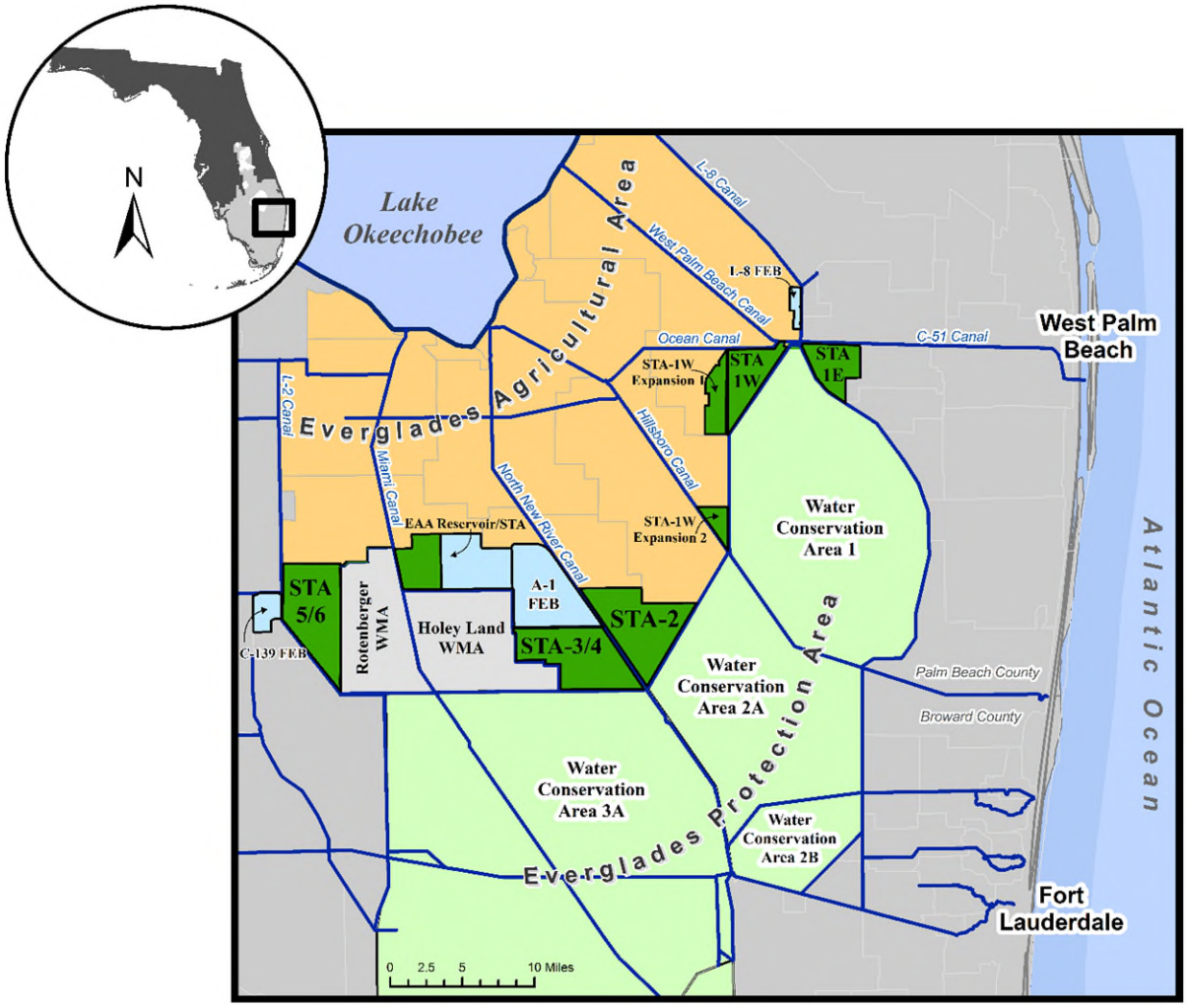


Figure 5B-1. Location of the Everglades STAs (STA-1E, STA-1W, STA-2, STA-3/4, and STA-5/6), STA-1W Expansion Areas 1 and 2, and flow equalization basins (FEBs; A-1, L-8, and C-139) in relation to Lake Okeechobee, the EPA, and other landscape features of South Florida. (Note: WMA – Wildlife Management Area.)

Varying in size, configuration, and length of operation, the Everglades STAs are divided into "cells" by interior levees to form "flow-ways" (i.e., cells arranged in series) within the STAs (see STA maps in Appendix 5B-1 of this volume). Water flows through these systems via water control structures, i.e., pump stations, gated spillways, weirs, and culverts. The Everglades STAs are part of the District's regional flood control system and inflow is primarily from basin runoff. The Everglades STAs were constructed in a phased approach; the first prototype STA, the Everglades Nutrient Removal Project, began operation in 1994. The Everglades STAs currently have a combined treatment area of 61,964 ac. Construction of the A-1 Flow Equalization Basin (FEB) was completed in WY2016 adding approximately 60,000 ac-ft of water storage capacity upstream of STA-3/4 and STA-2. Construction of the L-8 FEB was completed in WY2018, which added approximately 45,000 ac-ft of water storage capacity upstream of STA-1E and STA-1W. The District increased the treatment area of STA-1W by 4,266 ac with the construction of the STA-1W Expansion Area #1 as part of the *Restoration Strategies Regional Water Quality Plan* (SFWMD 2012; see also Chapter 5A and Appendix 5B-2 of this volume).

Aquatic plants in the Everglades STAs are categorized based on their growth habit: emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV), or rooted and non-rooted floating aquatic vegetation (FAV). While all STA cells to varying degrees contain a mixture of these vegetation types, cells are classified based on their target vegetation community, i.e., either EAV or a mixed-marsh community containing both EAV and SAV (EAV/SAV)[3]. Periphyton, the community of attached algae and other microorganisms growing on substrates in aquatic systems, is ubiquitous throughout the STAs. The periphyton community plays an important role in nutrient cycling within wetlands (Kadlec and Wallace 2009).

Reduction in TP concentration and retention of load has varied temporally within each Everglades STA and spatially among STAs and may be influenced by factors such as antecedent land use, soil type, cell topography, condition of the vegetation community, nutrient and hydraulic loading, hydropattern (continuously flooded versus periodic dryout), maintenance activities, and regional flood control operations in response to storm events. The District attempts to maximize Everglades STA treatment performance by balancing TP loading to these wetlands through adaptive management that prioritizes the distribution of water delivered to individual STAs and among flow-ways within each STA. These decisions are based on a weekly evaluation of interior stage (i.e., water levels), outflow TP concentrations, previous hydraulic and TP loading, vegetation condition, maintenance/rehabilitation activities, and any operational restrictions.

This chapter reports on Everglades STA treatment performance, facility status and operational issues, relevant maintenance activities, vegetation conditions, and wildlife issues. Status of the Long-Term Plan is reported in Appendix 5B-2 of this volume. Supporting information on protected birds and SAV coverage in the STAs is presented in Appendices 5B-3 and 5B-4 of this volume, respectively. Details on the District's Restoration Strategies Program and Science Plan are provided in Chapters 5A and 5C of this volume, respectively. Details on monitoring for TP and other water quality parameters mandated by the operating permit for the Everglades STAs are reported in Volume III, Appendix 3-1.

FLOW-WAY OPERATIONAL STATUS

Optimizing the short-term and long-term operation of the Everglades STAs and individual flow-ways is critical to achieve and sustain the desired TP retention of these wetlands. The District has established a management system that includes weekly review of individual flow-way conditions along with TP concentration reduction and TP load retention, i.e., treatment performance. The review includes discussions to prioritize operation of available flow-ways. Operation of an STA flow-way may be suspended entirely (operational status: offline [OFF]) in response to environmental conditions that may reduce TP uptake for construction activities or to complete critical rehabilitation activities. Operation of a flow-way may also be flow- or stage-restricted (operational status: online with restrictions [ONR]) for several reasons, such as to protect recently planted vegetation or to avoid harm to nests of bird species protected under the Migratory Bird Treaty Act or the Endangered Species Act, to facilitate construction or vegetation rehabilitation activities, or to conduct controlled research studies. Flow-ways designated as ONR would be in full operation mode only during emergencies, such as large storm events. During small or moderately sized storms, stormwater may be partially or entirely routed to other STAs or flow-ways for treatment.

[3] The District does not include FAV as a target vegetation type in the Everglades STAs because as FAV coverage expands it can displace existing beds of SAV and EAV. This is not a desirable outcome, although the District has planted rooted FAV in portions of cells that have been too deep to support emergent vegetation. Cells previously referred to as "SAV" or "SAV-dominant" have been managed in recent years to contain a mixed-marsh vegetation community. This management approach has been implemented for a variety of reasons including protection of SAV during major storms, promoting improved flow patterns by adding EAV in areas prone to hydraulic short-circuits, and providing treatment resilience through plant species diversity. These cells are now referred to more accurately as "EAV/SAV" cells.

STA REFURBISHMENT PROJECTS

In WY2020, the District initiated construction of several STA refurbishment projects that are being completed in addition to the projects included in the *Restoration Strategies Regional Water Quality Plan* (see SFWMD 2012 for details[4] and Appendix 5B-2 and Chapter 5A of this volume for an overview and status updates for plan projects). The STA refurbishment projects will improve the hydraulics, vegetation conditions, and treatment performance of the existing STAs. They are being completed as a proactive measure to ensure the facilities are poised to achieve compliance with the water quality based effluent limit (WQBEL)[5] once all the Restoration Strategies projects are complete.

ADJUSTMENT OF TREATMENT AREA VALUES

The treatment area[6] in each Everglades STA was used to calculate the hydraulic loading rate (HLR), Total P loading rate (PLR), and TP removal rate values (see **Table 5B-1** in the *Overview of POR and WY2021* section). Treatment areas are adjusted, if needed, using **Equation 1** based on the fractional period of operation for each STA flow-way during the water year. Flow-ways are always available for operation except for those days when their operational status is designated as OFF. The total treatment area of an Everglades STA during the water year is the summed treatment areas of its individual flow-ways.

$$Adjusted\ Flowway\ Treatment\ Area = Total\ Flowway\ Area \times \frac{\#\ days\ in\ operation}{\#\ days\ in\ year} \quad (1)$$

CALCULATION OF ANNUAL LOADS AND FWM CONCENTATIONS

Annual TP loads and FWM TP concentrations are calculated based on daily TP concentrations interpolated from weekly measurements (sample size [n] = 52) of surface water inflow to and outflow from the Everglades STAs over the entire water year as follows:

$$TP\ Load = \sum_{1}^{n} (C_i V_i + C_{i+1} V_{i+1} + \ldots\ C_{i+n} V_{i+n}) \quad (2)$$

$$FWM\ \text{TP}\ Concentration = TP\ Load \Big/ \sum_{1}^{n} (V_i + V_{i+1} + \ldots\ V_{i+n}) \quad (3)$$

where:

C_i = TP concentration for the ith day during the water year
V_i = Water volume for the ith day during the water year.

All calculations are performed using the District's Nutrient Load Program application.

[4] The Restoration Strategies Projects are efforts mandated under Consent Orders associated with the District's operating permit for the Everglades STAs. The STA Refurbishment Projects are separate work efforts that the District has undertaken voluntarily.

[5] The District's operating permit for the Everglades STAs established a WQBEL for TP concentration in STA discharge that mandates: (1) the annual FWM outflow TP concentration from each STA shall not exceed 19 µg/L in any water year and (2) the annual FWM outflow TP concentration from each STA shall not exceed 13 µg/L in more than three out of five water years on a rolling basis (State of Florida 2017). The first year of the first five years of compliance is WY2027 assuming that the last STA construction and operation milestones are completed by December 31, 2025. For more information of the operating permit, please see Appendix 3-1 in Volume III of this report.

[6] The wetted surface area of the Everglades STAs is referred to as "treatment area" in this chapter and is synonymous with "effective treatment area" used elsewhere in this volume and in other District publications to describe the same wetted surface area.

Water is collected by both grab sampling and with flow-proportioned autosamplers at designated Everglades STA inflow and outflow locations. Autosamplers are triggered based on real-time flow measurements at these sites, and all aliquots collected during the week are composited into a single collection vessel. TP concentrations are calculated preferentially using the autosampler data; grab sample data are used as a backup only on the rare occasion when autosampler data are not available at a site.

VEGETATION MANAGEMENT

Vegetation management in the Everglades STAs includes planting select species, primarily giant bulrush (*Schoenoplectus californicus*), alligator flag (*Thalia geniculata*), and American lotus (*Nelumbo lutea*) and inoculations of SAV, such as southern naiad (*Najas guadalupensis*), spiny naiad (*Najas marina*), eelgrass (*Vallisneria americana)*, Illinois pondweed (*Potamogeton illinoensis*), and muskgrass (*Chara* sp.). In EAV/SAV cells, giant bulrush and alligator flag are planted either in linear strips (i.e., "vegetation strips") or as irregular shaped patches to eliminate hydraulic short-circuits, buffer other plant species from uprooting caused by high wind and discharge events or provide plant cover at locations where the water is too deep for sustained growth of cattail (*Typha latifolia* and *T. domingensis*). Alligator flag and American lotus are also planted to secure unstable sediments, stabilize EAV in areas prone to sediment delamination[7], and minimize the effects of FAV damage in areas where SAV and cattail are difficult to establish. The compartmentalization of EAV/SAV cells with vegetation strips also is thought to provide functional redundancy in nutrient uptake needed to sustain treatment performance in the event of SAV loss[8]. In EAV/SAV cells, the most desired SAV species are muskgrass, Illinois pondweed, southern naiad, and spiny naiad. In EAV cells, the most desired species are cattail[9], giant bulrush, alligator flag, and sawgrass (*Cladium jamaicense*). Other desirable native species that thrive in certain areas of the Everglades STAs are arrowhead (*Sagittaria latifolia*), duck potato (*S. lancifolia*), pickerel weed (*Pontederia cordata*), and spikerush (*Eleocharis* sp.). Hydrilla (*Hydrilla verticillata*), which thrives in areas of elevated water column TP concentrations, also is common in the STAs. Despite hydrilla's ability to remove P, it is not a desired SAV because it is a highly invasive non-native species that suddenly crashes in large die offs. Hydrilla was present in some cells of STA-1E, STA-3/4, and STA-5/6 during WY2022.

Vegetation management in the Everglades STAs also involves herbicide applications and manual removal to control undesired FAV, SAV, and emergent herbaceous and woody species[10]. Herbicides are used only to the extent needed to encourage the growth of desired plant communities when undesired species are removed. Controlling non-rooted FAV, such as water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*), is necessary because these species can form dense beds that shade out SAV species underneath. Dense FAV also can hinder the maintenance and growth of existing EAV beds,

[7] The term "delamination" refers to the separation of a layer of surficial soil from the underlying subsoil. This separated layer of soil often floats on the water surface and may or may not have EAV rooted within it.

[8] Based on lessons learned from managing and operating the Everglades STAs, the District has allowed EAV cover to expand outside of the vegetation strips to create a mixed-marsh vegetation community in EAV/ SAV cells where periodic large-scale loss of SAV cover has occurred previously. The expansion of EAV in these cells is monitored and controlled as necessary based on cell TP concentration reduction.

[9] Cattail in the Everglades STAs can be both a desirable and an undesirable species depending on the situation. In general, cattail is a desired species in EAV cells. However, there are situations where the District controls (i.e., removes) cattail, e.g., when converting a cell from an EAV to an EAV/SAV community or when a stand of cattail has floated thus providing no treatment and the cell needs to be rehabilitated. The vegetation management sections in this chapter only document cattail control measures since cattail establishment and expansion normally occurs on a volunteer basis and requires no intervention by the District.

[10] Widespread harvesting often has been suggested for vegetation management in the Everglades STAs. However, harvesting has not been implemented because (1) mechanical removal is very labor intensive and would be disruptive to the STAs if done on a large scale, (2) the lack of local disposal sites for the collected plant biomass and high transportation costs to reach more distant disposal locations, (3) a viable market for plant byproducts, such as conversion into biofuel, has not materialized in South Florida, and (4) harvesting removes carbon from the system that may be critical to some nutrient removal processes (e.g., nitrogen). A synthesis of the potential benefits and liabilities of harvesting wetland vegetation by Kadlec (2011) influenced SFWMD's decision not to pursue harvesting in the STAs.

damage newly planted vegetation, and impede the even distribution of flow through cells creating hydraulic short-circuits. Woody species, such as primrose willow (*Ludwigia* sp.), are controlled because they tend to displace cattail and do not provide the same level of TP removal as cattail or sawgrass. Trees and large shrubs also encourage bird nesting and rookery formation, which can adversely affect STA operations and may create nutrient hot spots though bird defecation. The District uses United States Environmental Protection Agency-registered herbicides applied by licensed applicators at the dosages recommended by the manufacturer. None of these products bioaccumulate, all are registered for use in aquatic systems, and none are restricted-use category herbicides. While these products are toxic to plants, toxicity is negligible to non-plant organisms at the application rates used in the Everglades STAs and elsewhere throughout District lands. The District's vegetation management program is regulated by the Florida Department of Environmental Protection (FDEP) and fully complies with the STA's National Pollution Discharge Elimination System (NPDES) operating permit regulations.

An accounting of herbicide application rates and quantities used, the acreage treated in each Everglades STA, and the species targeted during WY2022 is provided in Volume III, Appendix 3-1, Attachment E.

VEGETATION SURVEYS

Ground surveys are conducted by airboat within Everglades STA cells designated as EAV/SAV cells on a periodic basis to assess the areal coverage of SAV taxa. Assessments are made at a network of fixed geo-referenced sites arranged in a grid pattern within each cell. The coverage of SAV taxa at each site is evaluated based on the amount of SAV in the water column visible to an observer within the immediate vicinity of the airboat. In addition, a garden rake is dragged along the wetland bottom to collect any plant material not directly visible to the observer to ensure all taxa are detected. Surveys are conducted by scientists from the District and DB Environmental, Inc., using a 4-point ordinal scale to estimate SAV coverage: *None* = no plants observed, *Low* = 1 to 33% coverage, *Medium* = 34 to 66% coverage, and *High* > 66% coverage. Coverage assessments were made for each SAV taxon and for all SAV taxa taken together.

SAV taxa coverage maps for individual cells presented in previous South Florida Environmental Reports (SFERs) have been replaced with stacked-bar plots of SAV frequency of occurrence over the POR for each cell (Appendix 5B-4, Figures 1 through 21). These figures provide a comparison of every survey conducted within a cell to illustrate temporal trends in the SAV community and provide historical context for the latest SAV survey data. Frequency of SAV occurrence is calculated from the number of survey sites in a cell at which a SAV taxon is present divided by the overall number of survey sites. For example, if a taxon is present at every survey site in a cell, its frequency of occurrence would be 1.0, whereas if the taxon is present at only one-half of the sites, its frequency of occurrence would be 0.5. When the frequencies of occurrence for each taxon from a cell survey are plotted as a stacked bar, the stacked bar represents the "overall SAV occurrence" (i.e., summation of all taxa) in the cell and can exceed a value of 1 on the plot's y-axis. For example, if each of three taxa occurred at one-half of a cell's survey sites (i.e., each taxon had a frequency of occurrence = 0.5), the stacked bar of all taxa frequencies for this survey would extend to 1.5 on the y-axis. Because multiple SAV taxa were usually present at multiple sites during cell surveys, stacked bars often exceed a value of 1 on the plot's y-axis. Changes in taxa occurrence and composition of the SAV community over the POR are inferred from examination of the stacked bar plots.

Low-altitude helicopter surveys of the Everglades STAs are conducted monthly to qualitatively assess the condition of the EAV, SAV, and FAV communities. This information is used primarily to guide vegetation maintenance and restoration activities (e.g., the need to treat encroaching FAV or the planting of EAV in areas with sparse coverage), supplement the ground SAV surveys as needed, and track any notable changes in the vegetation that occurred during the water year.

DRYOUT

One of the challenges in managing the Everglades STAs is dealing with periodic dryout. During the dry season in South Florida (approximately October to May), and particularly during prolonged droughts when supplemental water from Lake Okeechobee is not available, portions of or entire cells can dry out. This is especially problematic for cells that have a higher ground elevation than surrounding areas (resulting in water loss through seepage) and cells that are not capable of receiving supplemental water from Lake Okeechobee to keep them hydrated. Dryout is known to affect STA treatment performance and the health of SAV and EAV communities, as well as encourage nesting of protected avian species that can result in conflicts with the operation of flow-ways. Dry conditions promote the rapid oxidation of soil organic matter and subsequent reflooding results in water-column TP concentration spikes due to the flux of mineralized soil P (Martin et al. 1996, DeBusk and Reddy 2003, Bostic and White 2007). The impact of dryout on outflow TP concentrations from the STAs is influenced by factors such as the spatial extent and duration of dry conditions, soil characteristics, type of vegetation, and the lag time between reflooding and cell discharge following the dryout. Operational experience indicates that brief dryout periods in peat-based STA cells usually do not result in large outflow TP concentration spikes, likely due to the ability of the peat material to retain water within the soil matrix. However, in areas where the substrate has a higher mineral content, such as the soil found in some of the cells in STA-5/6, the upper soil column dries out much faster upon loss of surface water and is prone to fluxing soil P upon rewetting. Another contributing factor to the intensity of soil P flux is the duration of the dryout. The impact of annual cycles of dryout and reflooding on treatment performance in Cells 6-3 and 6-5 of STA-5/6 is discussed in Chapter 5 of the *2010 South Florida Environmental Report – Volume I* (see pages 5-100 to 5-105 in Pietro et al. 2010).

While prolonged dryout conditions in EAV/SAV cells can be detrimental to the SAV plant community, dryout in EAV cells for short periods[11] does not appear to have negative effects and may benefit the plants. For example, managed water level drawdowns can encourage recruitment of cattail in STA--3/4. Extended periods of dryout, however, have visibly affected EAV communities causing die-off of wetland vegetation and invasion of terrestrial plant species. When dried cells are rehydrated, EAV generally recovers more quickly than SAV.

The District began implementing the *South Florida Water Management District Everglades Stormwater Treatment Areas (STAs) Drought Contingency Plan* in 2008 to minimize dryout during periods of drought (SFWMD 2015). These procedures were updated in *Water Shortage Suggested Operating Procedures – Stormwater Treatment Areas* (SFWMD 2020). When dry conditions are anticipated, the plan provides guidance regarding raising cell target stages before the end of the wet season to increase storage volume in mixed-marsh EAV/SAV cells, the use of temporary pumps to deliver water to the Everglades STAs from nearby sources when available, and the delivery of supplemental water, when available, from Lake Okeechobee to the Everglades STAs. The plan prioritizes hydration of EAV/SAV cells over EAV cells to minimize impact to the SAV community and sets the minimum target stages in EAV and EAV/SAV cells during drought conditions at 15 to 30 centimeters (cm; ~ 6 to 12 inches) below and 15 cm above the average ground elevation, respectively, to maintain the vegetation community in a healthy condition. FEBs located adjacent to STA-1E and STA-1W (L-8 FEB) and STA-2 and STA-3/4 (A-1 FEB) (**Figure 5B-1**), and the future C-139 FEB that will be adjacent to STA-5/6, are anticipated to increase the supply of water available to the STAs during the dry season. In addition, the capacity of the FEBs to store stormwater runoff at the start of the wet season may allow the District to hold water longer in the STAs before they need to accept more runoff and discharge from reflooded flow-ways that have dried out. This may allow time for the P flux from these rehydrated soils to be re-assimilated before water is released.

Stages in the Everglades STAs during dry conditions when there is little to no basin runoff can recede to levels where there is no hydraulic connection between water at the inflow and outflow structures and any

[11] In general, a "short" period can be up to several weeks in duration, but the exact length of time can vary depending on the soil's ability to retain moisture.

remaining pools of water in the marsh. When this occurs, the District declares the affected flow-ways to be in a "dryout condition" and notifies FDEP that permit-mandated water quality sampling is suspended until water levels increase and reestablish the connection between the structures and the marsh. In addition, a portion of one or more cells in an Everglades STA with higher ground elevation can dry out but not to the extent that the District declares these cells to be in a dryout condition[12]. Note that days when flow-ways are declared to be in dryout condition or experience only partial dryout are classified as being "online" and available for operation when calculating adjusted treatment areas.

STORM IMPACTS

Total P retention in the Everglades STAs can be degraded by large storms events through several mechanisms, whether these storms are tropical cyclones (tropical storms and hurricanes) or simply prolonged periods of heavy rainfall. First, heavy rainfall can substantially increase the volume of runoff coming from a drainage basin. In response to increased runoff, inflow pump stations may operate at or near full capacity for extended periods, which increases water velocities thereby reducing the hydraulic residence time within these wetlands. Second, prolonged heavy pumping also can increase water depths to the point where water levels overtop the vegetation reducing treatment and increasing plant stress. Third, the TP concentration in basin runoff can increase markedly both during and after large storms. Fourth, high wind speeds can damage the vegetation community, thereby reducing the wetland's ability to retain TP. Fifth, wave action generated by high wind speeds can scour the bottom sediments and mix dissolved and particulate P up into the water column. Any of these factors if severe enough, whether singly or in combination, can cause an increase in Everglades STA annual outflow FWM TP concentrations. The Everglades STAs experienced no major impacts from storm events in WY2022.

MIGRATORY BIRD AND SNAIL KITE NESTING

The District, in cooperation with the United States Fish and Wildlife Service (USFWS), finalized the Avian Protection Plan for Black-necked Stilts and Burrowing Owls Nesting in the Everglades Agricultural Area Stormwater Treatment Areas (APP) in 2008 for the Everglades STAs (Pandion Systems 2008). The black-necked stilt (*Himantopus mexicanus*) and Florida burrowing owl (*Athene cunicularia floridana*) are protected species under the Migratory Bird Treaty Act of 1918. Additional protected status has been given to the Florida burrowing owl since it also is listed as a threatened species by the State of Florida. In accordance with the APP, SFWMD conducts surveys within the Everglades STA cells for nests of these two bird species during their nesting seasons. The APP provides SFWMD with a framework to modify Everglades STA operations to minimize potential impacts to active nests of either species. This is accomplished by diverting water around cells or regulating inflow to these cells to avoid raising water levels and flooding nests[13]. Although SFWMD is committed to mortality reduction measures, there may be situations where bird mortality is unavoidable as SFWMD fulfills its flood control and water quality treatment responsibilities. Specifically, during storm events, SFWMD seeks to minimize sending untreated water directly to the Everglades Water Conservation Areas (WCAs). Operation of the Everglades STAs at these times may result in the inadvertent taking of migratory birds or nests. Standardized black-necked stilt

[12] The STAs are not completely flat; ground elevation can vary up to several feet within an STA. As a result, soil at higher elevations can be exposed (i.e., dry out) during the dry season when there is little inflow from basin runoff while soil at lower elevations can remain flooded. Cells so affected are characterized as having partially dried out.

[13] The District is not required to alleviate flooding in cells with nests that is due to direct rainfall onto the Everglades STAs. The District, to the extent practicable, maintains the Everglades STAs at a stage sufficient to keep all cells completely flooded, especially during the dry season. This dissuades black-necked stilts from using the STAs as nesting areas. In cases where black-necked stilts have nested in the Everglades STAs, SFWMD maintains inflow to the affected cells at a restricted stage to prevent any further cell dry out, which would attract more nesting birds.

nesting surveys were conducted in all the STAs during the 2021 and 2022 nesting seasons[14] following protocols outlined in the APP. The number of black-necked stilts, a ground-nesting species, attracted to the Everglades STAs each year is largely a function of available nesting habitat, which can vary from year to year. This species prefers mudflats and shallow water for nesting. Low water levels in the Everglades STAs can expose areas of these wetlands suitable for nesting. To the extent practicable, SFWMD attempts to keep the Everglades STAs completely flooded during the spring to discourage nesting. However, keeping the Everglades STAs flooded is subject to the availability of water in the basin, which is a function of rainfall patterns. In addition, EAV coverage in many treatment cells has increased as the STAs have matured. This has resulted in limiting the amount of habitat that black-necked stilts find suitable for nesting even when water levels are low. Survey results are summarized in each STA section of this chapter and reported in more detail in Appendix 5B-3 of this volume.

In addition to SFWMD's nest surveys for black-necked stilts and Florida burrowing owls, the University of Florida conducts annual nest surveys in the Everglades STAs for the snail kite (*Rostrhamus sociabilis plumbeus*), which has federal status as an endangered species. USFWS is consulted and SFWMD follows a set of voluntary guidelines (SFWMD 2016) on modifying construction, maintenance activities, and STA operations to avoid disturbing any active nests. Survey results are summarized in each STA section of this chapter and reported in more detail in Appendix 5B-3 of this volume.

[14] Survey results for the 2021 and 2022 nesting seasons that fall within WY2022 are reported in this chapter even though the 2021 season began before the start of WY2021, and the 2022 season continued after the end of WY2022.

OVERVIEW OF POR AND WY2022

OVERVIEW OF TREATMENT PERFORMANCE

The Everglades STAs combined, over their 28 years of operation, have treated approximately 25.2 million ac-ft of water (~ 8.2 trillion gallons) and retained 3,221 t of TP or 77% of the TP load that entered these facilities (4,173 t). The marked increase in the combined inflow water and TP loads to the Everglades STAs that began after WY2001 reflected an increase in treatment capacity as additional STAs were built and came online (**Figure 5B-2**). The POR inflow FWM TP concentration for all the Everglades STAs through WY2022 is 134 µg/L, while the POR outflow FWM TP concentration is 30 µg/L (**Table 5B-1**).

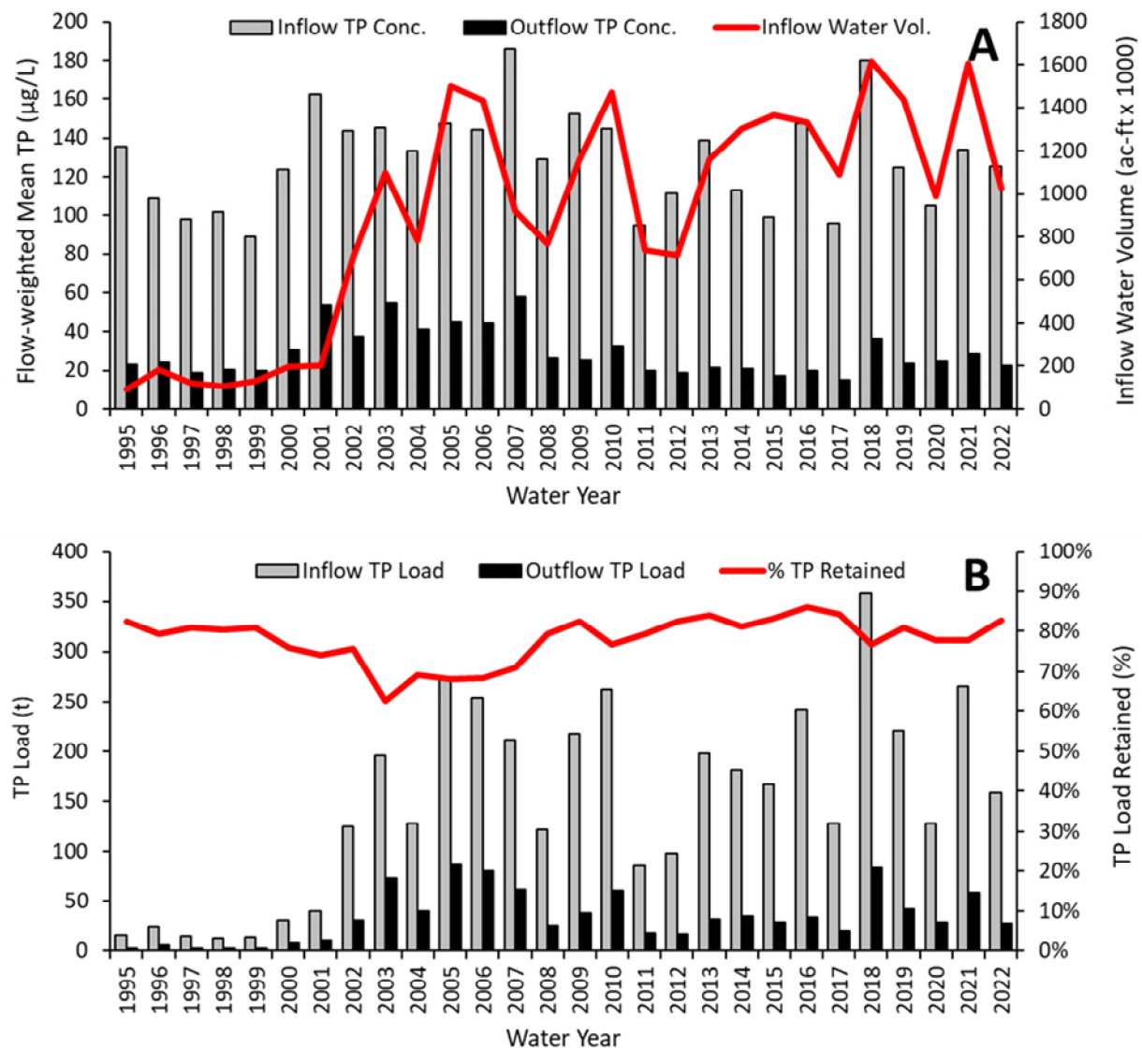


Figure 5B-2. POR time series in all the Everglades STAs combined for (A) annual inflow and outflow FMW TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

Table 5B-1. Summary of treatment performance in each Everglades STA and all STAs combined for WY2022 and the POR.

Parameter (Unit [a])	STA-1E	STA-1W	STA-2	STA-3/4	STA-5/6	All STAs
Treatment Area (ac)	4,994	10,810	15,495	16,327	14,338	61,964
Adjusted Treatment Area (ac) [b]	2,733	10,810	13,947	15,245	13,841	56,576
WY2022 Inflow						
Inflow Water Volume (ac-ft)	173,000	57,000	289,000	330,000	178,000	1,027,000
Inflow TP Load (t)	25	11	32	37	53	159
FWM Inflow TP Concentration (µg/L)	119	158	90	91	243	125
Hydraulic Loading Rate (cm/d)	5.3	0.4	1.7	1.8	1.1	1.5
TP Loading Rate ($g/m^2/yr$)	2.3	0.3	0.6	0.6	1.0	0.7
WY2022 Outflow						
Outflow Water Volume (ac-ft)	143,000	53,000	300,000	309,000	169,000	974,000
Outflow TP Load (t)	4	2	6	6	10	27
FWM Outflow TP Concentration (µg/L)	22	24	15	15	50	23
TP Retained (t)	22	10	26	31	43	132
TP Removal Rate ($g/m^2/yr$)	1.9	0.2	0.5	0.5	0.8	0.6
TP Load Retained (%)	85%	86%	82%	84%	81%	83%
POR						
Start Date	September 2004 [c]	October 1993 [d]	June 1999	October 2003	December 1997	
Inflow Water Volume (ac-ft)	2,360,000	4,798,000	6,524,000	8,279,000	3,263,000	25,225,000
TP Inflow Load (t)	473	1,070	810	1,032	788	4,173
FWM Inflow TP (µg/L)	162	181	101	101	196	134
Outflow Water Volume (ac-ft)	2,187,000	4,938,000	6,980,000	8,471,000	3,033,000	25,609,000
TP Outflow Load (t)	101	273	184	156	238	952
FWM Outflow TP Concentration (µg/L)	37	45	21	15	64	30
TP Retained (t)	372	797	627	875	550	3,221
% TP Retained	79%	74%	77%	85%	70%	77%

a. Conversion factors: 1 ac = 0.40469 hectares or 4,046.9 square meters; 1 ac-ft = 1,233.5 cubic meters; 1 metric ton (t) = 1,000 kilograms; and 1 centimeter per day (cm/d) = 0.39370 inches per day. Note: $g/m^2/yr$ – grams per square meter per year.

b. Adjusted treatment area is time and area weighted to exclude any cells that were off-line; refer to **Table 5B-2**.

c. STA-1E was operated in WY2005 for emergency flood control purposes and to establish wetland vegetation; it became fully operational in WY2006.

d. Flow-through operations in STA-1W did not begin until August 1994.

All the Everglades STAs combined received approximately 1.0 million ac-ft of inflow during WY2022 (**Table 5B-1**). Of this inflow water volume, approximately 108,000 ac-ft were Lake Okeechobee releases directed to the STAs; 74,000 ac-ft were regulatory releases, while 34,000 ac-ft were delivered as either environmental releases to the Everglades[14] or as supplemental water to maintain water levels at target stages in the Everglades STAs for the benefit of the wetland vegetation.

The Everglades STAs combined received 159 t of inflow TP load during WY2022 and retained 132 t of this mass (**Table 5B-1**), which equated to an 83% load reduction. The overall annual inflow to outflow FWM TP concentrations this water year decreased from 125 to 23 µg/L, respectively. The annual percent TP load retained has ranged from the lowest retention (63%) in WY2003 to the highest (86%) in WY2016 and has been greater than or equal to 77% in each year since WY2008.

Among all the Everglades STAs, both STA-2 and STA-3/4 had the lowest annual outflow FWM TP concentration in WY2022 (15 µg/L), while annual outflow FWM TP concentrations in the other Everglades STAs ranged from 22 to 50 µg/L (**Table 5B-1**). STA-3/4 received the largest inflow water volume (330,000 ac-ft) and STA-5/6 the largest inflow TP load (53 t) this water year, while STA-1W received both the smallest inflow water volume (57,000 ac-ft) and TP load (11 t) (**Figure 5B-3**). All the Everglades STAs retained more than 80% of the inflow TP load in WY2022. Minimum and maximum HLRs during WY2021 were 0.4 centimeters per day (cm/d) in STA-1W and 5.3 cm/d in STA-1E; HLRs in the other Everglades STAs ranged from 1.1 to 1.8 cm/d (**Figure 5B-3**). The PLRs ranged from 0.3 to 1.0 grams per square meter per year ($g/m^2/yr$) in STA-1W, STA-2, STA-3/4, and STA-5/6, while STA-1E had a PLR of 2.3 $g/m^2/yr$.

[14] An environmental release is Lake Okeechobee water that is passed through the Everglades STAs for the express purpose of maintaining downstream Everglades water levels and not to keep water levels in the STAs at target stage.

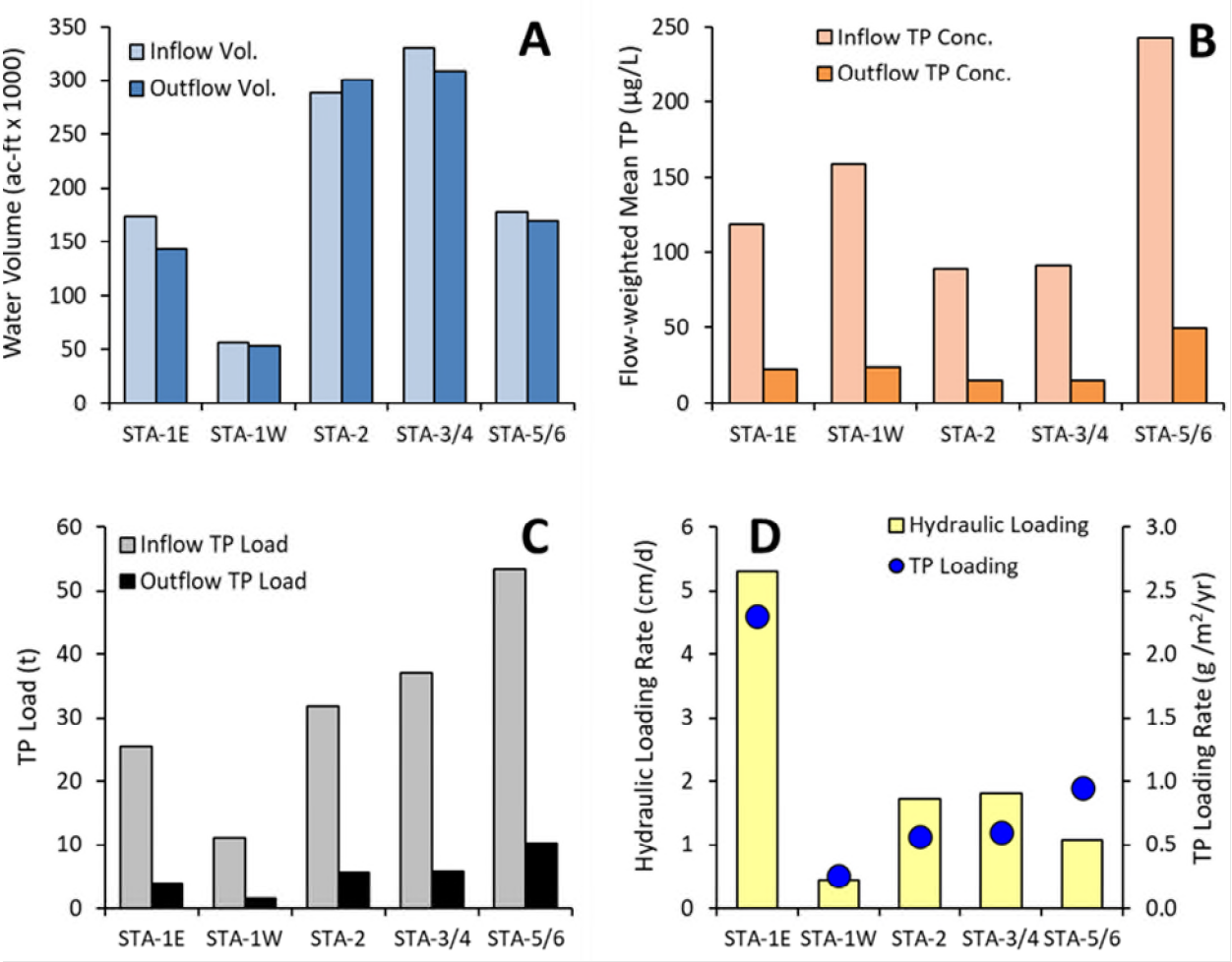


Figure 5B-3. Comparison of (A) inflow and outflow water volumes (Vol.), (B) inflow and outflow FWM TP concentrations (Conc.), (C) inflow and outflow TP loads, and (D) hydraulic and TP loading rates in the Everglades STAs during WY2022.

OVERVIEW OF FACILITY STATUS AND OPERATIONAL ISSUES

The calculated treatment area of STA-1E, STA-2, STA-3/4, and STA-5/6 was adjusted in WY2022 because one or more of their flow-ways were taken offline during part or all of the water year (**Table 5B-2**). In addition, other flow-ways in the Everglades STAs were ONR for at least a portion of WY2022. Details of the operational status of each flow-way are provided in the individual STA sections that follow.

During the 2021 and 2022 nesting seasons, 272 black-necked stilt nests were observed across all the Everglades STAs while no active Florida burrowing owl nor snail kite nests were detected in any cell. Operational priorities were adjusted in the Everglades STAs as needed to avoid disturbing active nests; all such adjustments are discussed in Appendix 5B-3.

Table 5B-2. Operational status of Everglades STA flow-ways during WY2022.

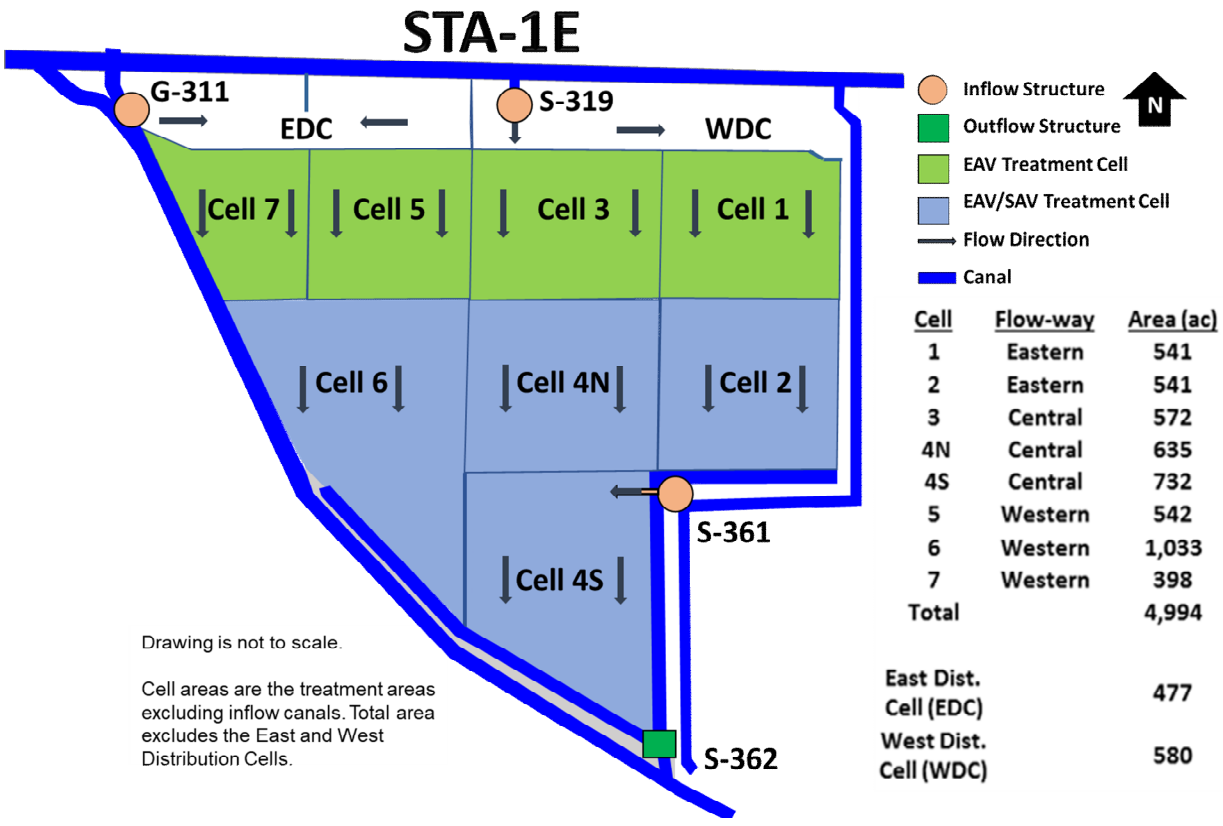
STA	Flow-way	Treatment Area (ac [a])	Operational Status [b]	Comments [c, d]	% Time Online
STA-1E	Entire STA	4,994			55
	Eastern	1,082	OFF: 01/2022 to 04/2022	Vegetation management	73
	Central	1,939	ONR: 05/2021 to 04/2022	Vegetation management	100
	Western	1,973	OFF: 06/2021 OFF: 04/2022 OFF: 05/2021 to 04/2022	BNS nesting BNS nesting RSP: Cells 5 & 7 earthwork and veg. manage.	0
STA-1W	Entire STA	10,810			100
	Eastern	2,171	ONR: 06/2021 ONR: 04/2022 ONR: 05/2021 to 04/2022	BNS nesting BNS nesting Refurbishments construction	100
	Western	1,369	ONR: 05/2021 to 06/2021 ONR: 04/2022 ONR: 05/2021 to 04/2022	BNS nesting BNS nesting Refurbishments construction	100
	Northern	4,956	ONR: 05/2021 to 06/2021 ONR: 05/2021 to 04/2022	BNS nesting Refurbishments construction	100
	Cell 7	1,201	ONR: 06/2021	BNS nesting	100
	Cell 8	1,113	ONR: 05/2021 to 06/2021 ONR: 05/2021 to 04/2022	BNS nesting STA-1W Expansion #2 construction	100
STA-2	Entire STA	15,945			90
	#1	1,840	ONR: 02/2022 to 03/2022 ONR: 03/2022 to 04/2022	Vegetation management Rehydration after stage reduction	100
	#2	2,373	ONR: 05/2021 to 09/2021 OFF: 09/2021 to 04/2022	Refurbishments construction Refurbishments construction	35
	#3	2,296	ONR: 04/2022 ONR: 05/2021 to 04/2022	BNS nesting Vegetation rehabilitation	100
	#4	5,990	ONR: 05/2021 to 04/2022	Vegetation management	100
	#5	2,995	Online: WY2022		100
STA-3/4	Entire STA	16,327			60
	Eastern	6,476	OFF: 05/2021 to 04/2022	Vegetation rehabilitation/cell drawdown	0
	Central	5,349	ONR: 04/2022	BNS nesting	100
	Western	4,502	ONR: 05/2021 to 06/2021	Vegetation management	100
STA-5/6	Entire STA	13,685			97
	#1	2,418	Online: WY2022		100
	#2	2,068	ONR: 05/2021 to 10/2021	Flow restrictions following RSP	100
	#3	1,922	ONR: 05/2021 to 10/2021 ONR: 06/2021	Flow restrictions following RSP BNS nesting	100
	#4	1,871	OFF: 01/2022 to 04/2022	Vegetation management	73
	#5	2,642	Online: WY2022		100
	#6	1,900	ONR: 05/2021 to 06/2021	BNS nesting	100
	#7	621	DO: 04/2022		100
	#8	242	DO: 04/2022		100

a. Conversion factor: 1 acre = 0.40469 hectares or 4,046.9 square meters.
b. DO – District declared dryout; OFF – offline; and ONR – online with restrictions.
c. BNS – black-necked stilt; RSP – Restoration Strategies project.
d. STA operations and maintenance activities modified during WY2022 due to bird nesting are detailed in Appendix 5B-3 of this volume.

STA-1E

STA-1E is in Palm Beach County approximately 32 kilometers (km; ~ 20 miles) west of West Palm Beach, south of State Road 80 and the C-51 canal, adjacent to the northeast boundary of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR), and directly east of the STA-1 Inflow and Distribution Works (referred to as the STA-1 Inflow Basin) (**Figure 5B-1**). This facility was flooded in WY2005 to establish wetland vegetation. STA-1E provides a total treatment area of 4,994 ac arranged into three parallel treatment trains, or flow-ways, that contain eight cells (Piccone et al. 2019; **Figure 5B-4**). The East and West Distribution cells are not considered part of the STA-1E treatment area. STA-1E receives inflow primarily from the C-51 West basin and smaller water volumes from the L-8 and S-5A basins, and the Rustic Ranches subdivision (see Figure 1 in Appendix 5B-2). In WY2007, STA-1E started receiving runoff from Wellington Acme Basin B. During the dry season, supplemental water is delivered from Lake Okeechobee if needed and when available to maintain hydration in the treatment cells. The flow-way nomenclature for STA-1E is as follows:

- Eastern Flow-way = Cells 1 and 2
- Central Flow-way = Cells 3, 4N, and 4S
- Western Flow-way = Cells 5, 6, and 7



Cell	Flow-way	Area (ac)
1	Eastern	541
2	Eastern	541
3	Central	572
4N	Central	635
4S	Central	732
5	Western	542
6	Western	1,033
7	Western	398
Total		4,994

East Dist. Cell (EDC)	477
West Dist. Cell (WDC)	580

Figure 5B-4. Simplified schematic of STA-1E showing major inflow and outflow water control structures, the treatment area of each cell, flow direction, and dominant/target vegetation types. Treatment areas do not include pump stations, levees, roads, or other upland areas. A detailed structure map of STA-1E is provided in Appendix 5B-1 of this volume. (Note: Dist. – distribution.)

A number of issues have affected STA-1E operations over its POR, including high hydraulic loadings during large storm events (particularly Hurricane Wilma in October 2005, an unnamed storm in February 2006, Tropical Storm Isaac in August 2012, multiple large rainfall events in June 2017, and Hurricane Irma in September 2017), the repair of internal water control structures by the United States Army Corps of Engineers (USACE), uneven ground topography that results in excessively deep water and hydraulic short-circuiting (particularly in Cells 5 and 7 of the Western Flow-way, see below), dry out of cells during droughts, and vegetation die-off (i.e., the gradual decline of cattail in Cell 7 over time, the mass uprooting of hydrilla in Cell 6 during a high flow event in WY2010, and the complete removal of SAV in Cell 4S from herbivory by the exotic island apple snail [*Pomacea* maculata] in July 2013). Recently, there was damage from pre-storm operations which resulted in a water level draw-down in Cell 2 initiated prior to Tropical Strom Eta in 2020. Adverse impacts from floating cattail tussocks (i.e., hydraulic short circuits) and expansion of willow (*Salix* sp.) and FAV coverage have occurred in the Central and Western Flow-ways.

STA TREATMENT PERFORMANCE

Over its 18-year POR, STA-1E has treated approximately 2.4 million ac-ft of water and retained 372 t of TP or 79% of the inflow TP load (473 t) (**Table 5B-1**). The POR inflow FWM TP concentration to this facility is 162 µg/L, while the corresponding outflow FWM TP concentration is 37 µg/L.

STA-1E received one of its largest inflow water volumes in WY2022 (173,000 ac-ft) (**Figure 5B-5**)[16]. Approximately 4,200 ac-ft of this water year's inflow water volume were Lake Okeechobee releases directed to STA-1E via the S-319 and G-311 structures; 2,300 ac-ft were regulatory releases, while 1,900 ac-ft were delivered as supplemental water to maintain the vegetation communities in the STA. Lake Okeechobee water was received in May, June, August, September and November 2021, and April 2022.

STA-1E retained 85% of the inflow TP load this water year (22 of 25 t; **Table 5B-1**). Annual inflow and outflow FWM TP concentrations were 119 and 22 µg/L, respectively, while the HLR and PLR were 5.3 cm/d and 2.3 g/m^2/yr, respectively. This year's HLR and PLR were the second highest loading rates experienced in STA-1E over its POR[15]. Percent TP retention in this STA has been consistent since WY2011 (**Figure 5B-5**).

[15] To allow construction activities to move forward in STA-1W, inflow water volume to the facility was reduced in WY2022 to lower interior water levels. A portion of the flow that normally would have gone to STA-1W was directed to STA-1E instead, which, in large measure, accounted for the large increases in inflow water volume, HLR, and PLR in STA-1E experienced this water year.

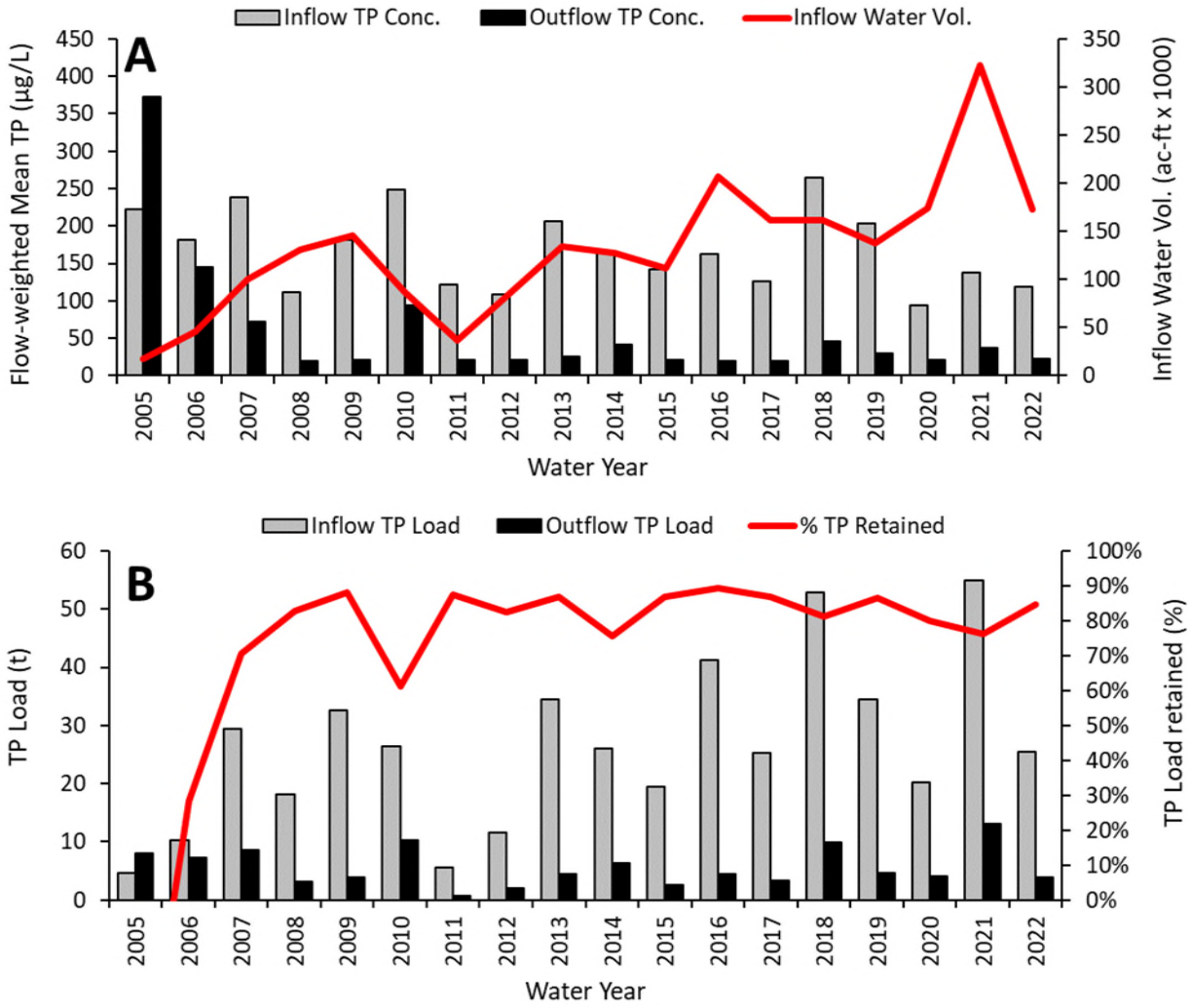


Figure 5B-5. POR time series for STA-1E for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

The Central flow-way of STA-1E was ONR throughout WY2022 for vegetation management activities (**Table 5B-2**). The Western Flow-way was OFF in WY2022 for a Restoration Strategies project to fill and regrade Cells 5 and 7, and vegetation management activities. Black-necked stilt nesting occurred in the Western Flow-way during a portion of the year. The Eastern Flow-way was OFF from January to April 2022 for vegetation management activities associated with the repair of damage that resulted during pre-storm operations related to Hurricane Eta in 2020.

Dryout

STA-1E Cell 2 was taken offline and dried out during part of WY2022 to repair levee damage (and replant vegetation) that occurred during STA operations prior to Hurricane Eta in 2020.

Migratory Bird and Snail Kite Nesting

Black-necked stilt nests were observed in STA-1E Cells 5 and 7 in May and July 2021 and in the West Distribution Cell and Cells 5, 6, and 7 in June 2021. There was one stilt nest in STA-1E Cell 5 in April 2022. No snail kite nests or Florida burrowing owls were observed in STA-1E during this water year. Information on STA-1E operational and maintenance adjustments implemented to protect bird nests during WY2022 is presented in Appendix 5B-3 of this volume.

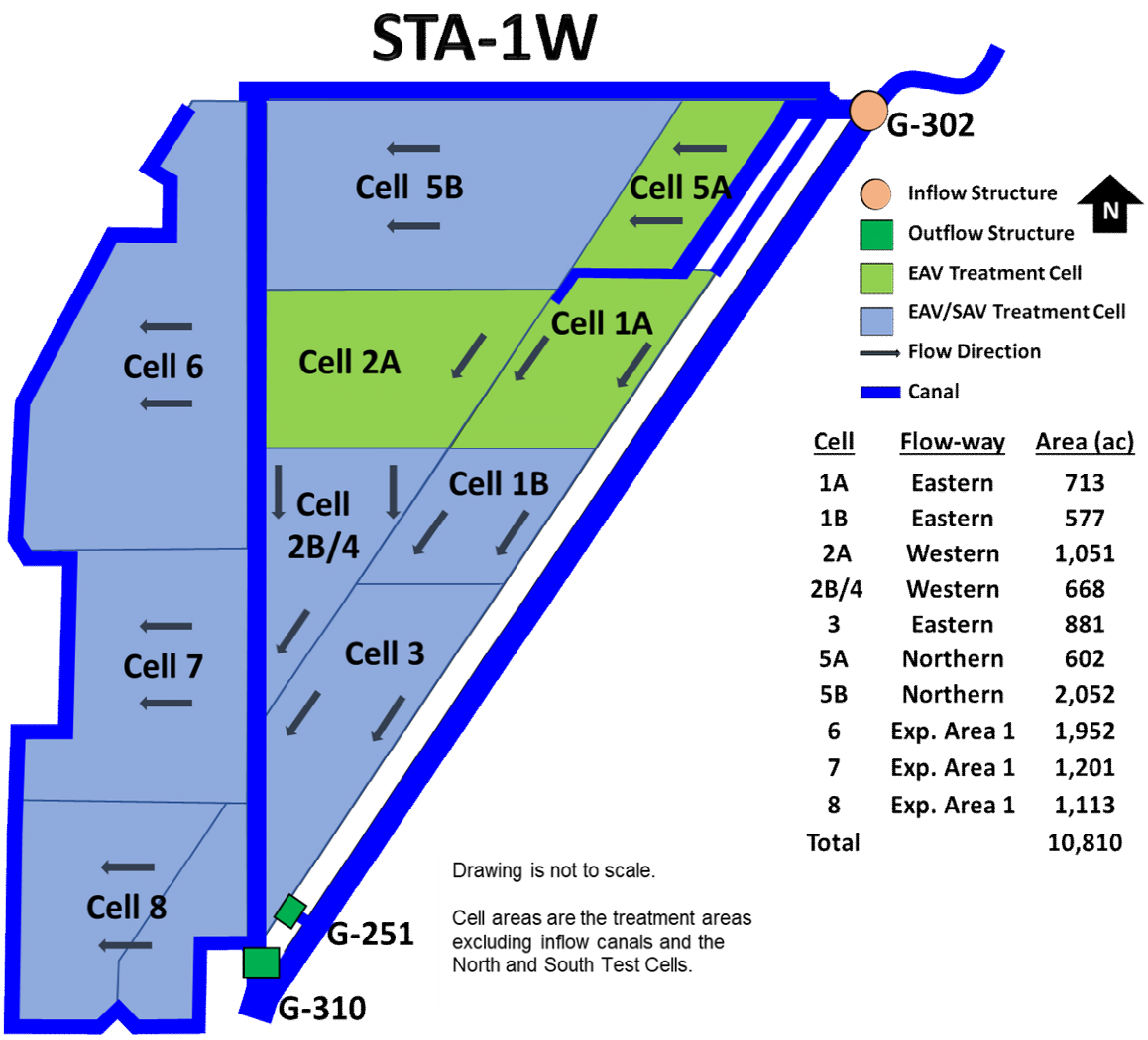
VEGETATION SURVEYS

Ground surveys were conducted in STA-1E in WY2022 at various times: December 2021 and March 2022 in Cells 4N and 4S and March 2022 in Cell 6 (Appendix 5B-4, Figures 1 through 3). Cell 6 could not be accessed during the wet season this year due to construction for a Restoration Strategies project within the Western Flow-way. No SAV was found at 61% of the survey sites, low SAV coverage at 24% of sites, medium SAV coverage at 8% of survey sites, and high SAV coverage at 7% of sites. Six SAV taxa were identified in STA-1E for WY2022: coontail (*Ceratophyllum demersum*), bladderwort (*Utricularia* sp.), hydrilla (*Hydrilla verticillata*), muskgrass (*Chara* sp.), southern naiad (*Najas guadalupensis*), and spiny naiad (*Najas marina*). Southern naiad was the dominant taxon in Cell 4N. Similar frequencies of hydrilla, muskgrass, and southern naiad were observed in Cell 4S. Very little SAV was observed in Cell 6, though bladderwort was the most common species. SAV occurrence in Cells 4N and 4S increased this water year compared to WY2021 but declined in Cell 6, which was OFF for a Restoration Strategies project. There has been a pronounced decline in SAV occurrence in Cells 4N and 6 over their PORs.

STA-1W

STA-1W, which began operation in 1994 as the Everglades Nutrient Removal (ENR) Project, is located in Palm Beach County northwest of LNWR (**Figure 5B-1** and Figure 1 in Appendix 5B-2 of this volume). This STA encompasses 10,810 ac of treatment area arranged into three flow-ways with 11 treatment cells (Piccone et al. 2019; **Figure 5B-6**). The Eastern and Western flow-ways comprised the ENR Project, and the Northern Flow-way was added to the facility in 1999. Compartmentalization of former Cells 1 and 2 was completed in 2007 with the construction of two new interior levees that created Cells 1A, 1B, 2A, and 2B. Construction of an additional interior levee completed in 2015 separated inflow to the Western Flow-way from inflow entering the Eastern Flow-way. The treatment area of STA-1W was further expanded by 4,266 ac when construction of Expansion Area #1 (Cells 6, 7, and 8) was completed in late 2018. These new cells were flooded for most of WY2020 to initiate wetland plant colonization and were used to treat runoff at the end of WY2022. Cell 6 is part of the Northern Flow-way. However, because Cells 7 and 8 can receive water from both the Eastern and Western Flow-ways, they are not considered to be part of either flow-way. The dividing levee that separated Cell 2B from Cell 4 was removed, and these cells were combined as Cell 2B/4 in WY2022. This STA receives inflow primarily from the S-5A drainage basin and East Beach Water Control District (see Figure 1 in Appendix 5B-2). During the dry season, supplemental water is delivered from Lake Okeechobee, if needed and when available, to maintain hydration in the treatment cells. The cell/flow-way nomenclature for STA-1W is as follows:

- Eastern Flow-way = Cells 1A, 1B, and 3
- Western Flow-way = Cells 2A and 2B/4
- Northern Flow-way = Cells 5A, 5B, and 6
- Cells 7 and 8 in the Expansion Area #1



Cell	Flow-way	Area (ac)
1A	Eastern	713
1B	Eastern	577
2A	Western	1,051
2B/4	Western	668
3	Eastern	881
5A	Northern	602
5B	Northern	2,052
6	Exp. Area 1	1,952
7	Exp. Area 1	1,201
8	Exp. Area 1	1,113
Total		10,810

Figure 5B-6. Simplified schematic of STA-1W showing major inflow and outflow water control structures, the treatment area of each cell, flow direction, and dominant/target vegetation types. Treatment areas do not include pump stations, levees, roads, or other upland areas. A detailed structure map of STA-1W is provided in Appendix 5B-1 of this volume.

Over its operational history, STA-1W has been affected by extreme weather events (regional droughts and large storms), maintenance activities that included water level drawdowns and construction, high hydraulic and nutrient loadings, and poor cattail establishment. Major rehabilitation activities were implemented in STA-1W between 2005 and 2007 to reestablish the vegetation communities damaged by hydraulic overloading in previous water years, and to restore treatment performance to all cells. Stage in the Eastern Flow-way was lowered in WY2016 and following water years as part of a major vegetation rehabilitation effort that included planting depth-tolerant species such as giant bulrush and alligator flag.

STA TREATMENT PERFORMANCE

Over its 28-year POR, STA-1W has treated approximately 4.8 million ac-ft of water and retained 797 t of TP or 74% of the inflow TP load (1,070 t; **Table 5B-1**). The POR inflow FWM TP concentration is 181 µg/L, while the POR outflow FWM TP concentration is 45 µg/L.

STA-1W treated approximately 57,000 ac-ft of runoff in WY2022, which was the smallest annual inflow water volume received to date (**Table 5B-1**). Of this inflow water volume, approximately 3,300 ac-ft were Lake Okeechobee releases directed to STA-1W via G-302; 2,500 ac-ft were regulatory releases and 800 ac-ft were delivered as supplemental water to maintain the vegetation communities in the STA. Lake Okeechobee water was received in all months except August to October 2021 and March 2022.

STA-1W had inflow and outflow FWM TP concentrations of 158 and 24 µg/L, respectively, in WY2022 (**Table 5B-1**). STA-1W retained 10 t of TP or 86% of the inflow TP load (11 t) and had an HLR and a PLR of 0.4 cm/d and 0.3 g/m^2/yr, respectively. Total P retention in STA-1W has recovered from the dramatic decline that occurred from WY2002 through WY2006 when the facility was hydraulically overloaded (**Figure 5B-7**). The percent TP load retained in STA-1W has been 80% or greater in each water year since WY2009, which is comparable to the level of treatment performance experienced prior to WY2001.

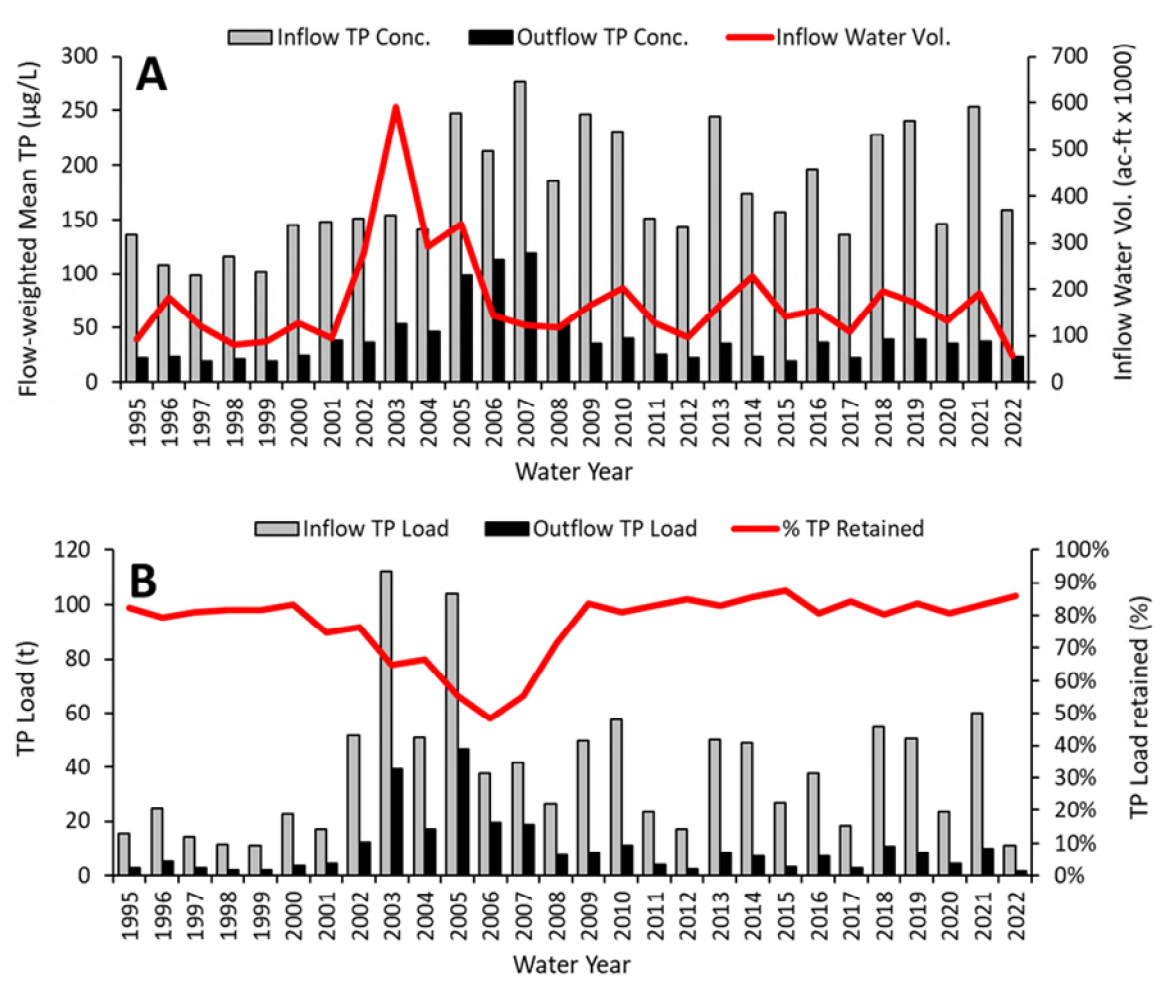


Figure 5B-7. POR time series for STA-1W for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

All STA-1W flow-ways were operational throughout WY2022 (**Table 5B-2**) although flow-ways and Cells 7 and 8 were ONR for portions of the water year due to Refurbishment Project construction, the start of flow-through operation in the STA-1W Expansion Area #1, or black-necked stilt nesting.

Refurbishment Projects

STA-1W Refurbishment Projects involved construction in all three flow-ways to address poor hydraulics and topographic issues that adversely affected vegetation condition and treatment performance and removal of some features from the original ENR Project that had deteriorated over time or were obsolete for the operation of the STA. Projects include reconfiguring the levee between Cells 5B and 2A, topography grading and canal filling in Cell 3, and removal of the levee between Cells 2B and 4; now referred to as Cell 2B/4. All work is scheduled to be completed by early WY2023. Additional details on this work are provided in Chapter 5B of the 2022 SFER – Volume I (Chimney 2022).

Dryout

STA-1W Cell 2A was dried out for part of WY2022 to accommodate Refurbishment Project construction in the downstream Cell 2B/4. All other cells in STA-1W were hydrated during WY2022.

Migratory Bird and Snail Kite Nesting

Black-necked stilt nests were observed in STA-1W Cells 2B, 4, 5B, 6, and 8 in May 2021, in Cells 1B, 2B, 3, 4, 5B, 7 and 8 in June 2021, in Cell 3 in July 2021, and in Cells 1B and 5B in April 2022. No snail kite nests or Florida burrowing owls were observed in STA-1W during this water year. Information on STA-1W operational and maintenance adjustments implemented to protect bird nests during WY2022 is presented in Appendix 5B-3 of this volume.

VEGETATION SURVEYS

Ground surveys were conducted in WY2022 at various times to map SAV areal coverage in STA-1W: December 2021 and April 2022 in Cell 1B; December 2021 and March 2022 in Cell 3; October 2021 and March 2022 in Cells 2B and 4; and November 2021 and March 2022 in Cell 5B (Appendix 5B-4, Figures 4 through 8). Because SAV is still colonizing Cells 6, 7, and 8 of the STA-1W Expansion Area #1, and thus had limited coverage, SAV occurrence data were not included in this year's SFER but will be in future reports. No SAV was found at 79% of the survey sites, low SAV coverage at 10% of survey sites, medium SAV coverage at 6% of survey sites, and high SAV coverage at 4% of survey sites. Five SAV taxa were identified in STA-1W this water year: coontail, muskgrass, southern naiad, spiny naiad, and bladderwort. Coontail or muskgrass were typically dominant in all cells. Southern naiad, spiny naiad and bladderwort were present in lesser quantities relative to the dominant taxa. SAV occurrence this water year was very low in STA-1W, where construction for multiple STA Refurbishments Projects has been ongoing. Lack of SAV was especially evident in the Eastern Flow-way. There has been a progressive decline in SAV occurrence in Cells 2B, 4, and 5B during the latter part of their PORs. The vegetation community in Cells 2B and 4 has become dominated by EAV and rooted FAV including water pennywort (*Hydrocotyl* sp.), water hyssop (*Bacopa monnieri*), and Mexican waterlily (*Nymphaea mexicana*).

STA-2

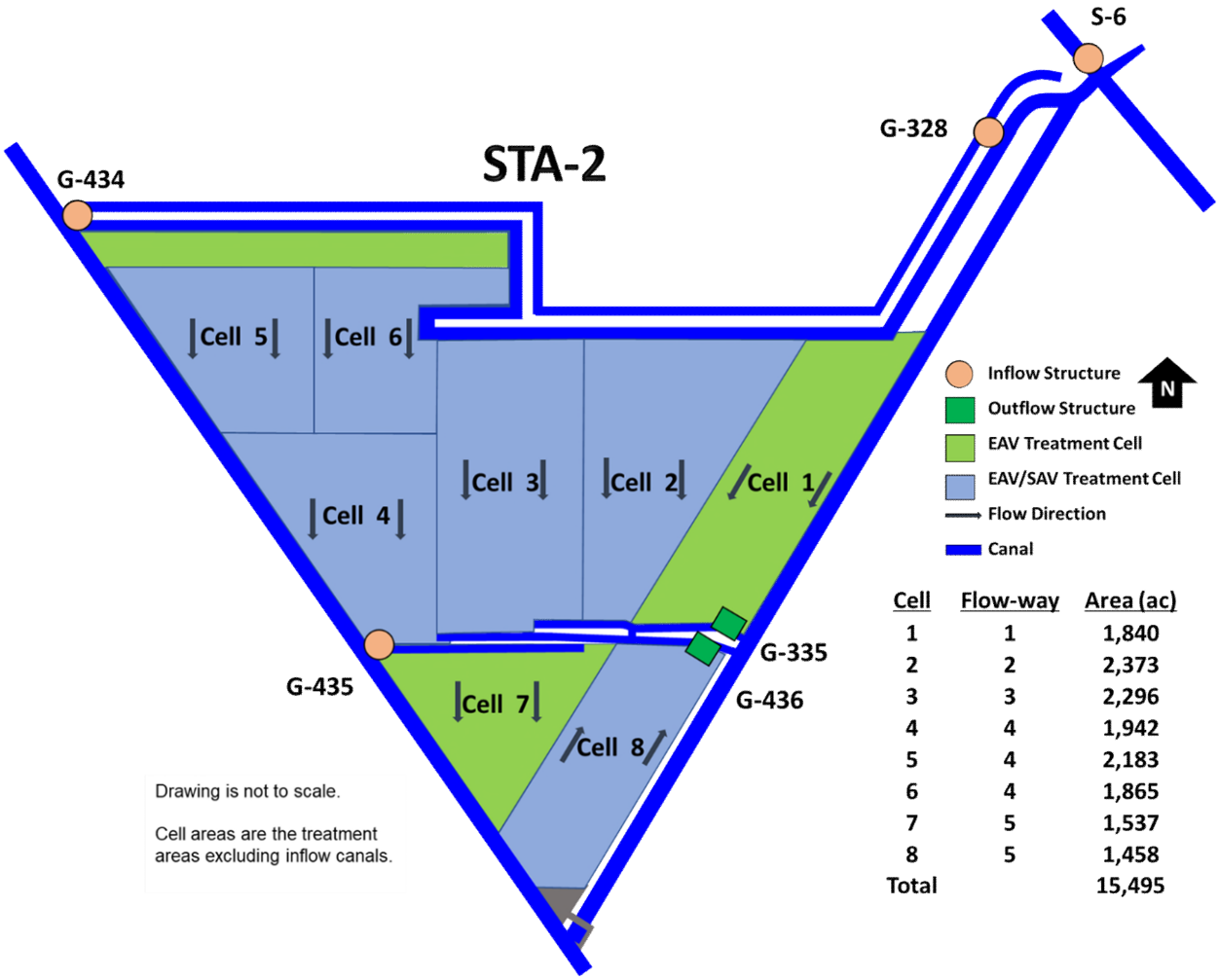
STA-2 is located in Palm Beach County immediately west of WCA-2A (**Figure 5B-1** and Figure 1 in Appendix 5B-2 of this volume). STA-2 originally consisted of three treatment cells (Cells 1, 2, and 3) that began operation in 2000. This facility was expanded with the construction of Cell 4, which was flow capable in December 2006. Cell 4 then went OFF in WY2010 during the construction of Cells 5, 6, 7, and 8, which were completed by WY2013. STA-2 now has five flow-ways with eight cells that have a total treatment area of 15,495 ac (Piccone et al. 2019; **Figure 5B-8**). STA-2 receives agricultural runoff from three Everglades Agricultural Area (EAA) basins; runoff primarily comes from the S-6 and a portion of the S-2 basins but also can come from the S-7 basin and the remaining portion of the S-2 basin. STA-2 also receives runoff from the East Shore Water Control District, the Closter Farms Drainage System, a portion of the S-5A basin (see Figure 1 in Appendix 5B-2), and releases from Lake Okeechobee. During the dry season, supplemental water is delivered from Lake Okeechobee, if needed and when available, to maintain hydration in the treatment cells.

The flow-way nomenclature for STA-2 is as follows:

- Flow-way 1 = Cell 1
- Flow-way 2 = Cell 2
- Flow-way 3 = Cell 3
- Flow-way 4 = Cells 4, 5, and 6
- Flow-way 5 = Cells 7 and 8

The A-1 FEB (Figure 5B-1), a 15,000-ac aboveground storage reservoir and a critical component of the Restoration Strategies Regional Water Quality Plan (SFWMD 2012), was completed and started operation in WY2016. STA-2 began receiving outflows from this facility in November 2015. The primary purpose of the A-1 FEB is to temporarily store stormwater runoff and thereby attenuate peak inflows to STA-2 to help improve its treatment performance. Secondarily, the A-1 FEB may provide a source of water during the dry season and reduce the frequency of dryout conditions in STA-2. For additional information on the A-1 FEB, see the following section on STA-3/4 and Volume III, Appendix 3-3.

Like the other STAs, STA-2 has been affected by regional droughts and large storm events over its POR. For example, Cells 1 and 2 have dried out, either partially or entirely, during past droughts when the supply of supplemental water was limited.



Cell	Flow-way	Area (ac)
1	1	1,840
2	2	2,373
3	3	2,296
4	4	1,942
5	4	2,183
6	4	1,865
7	5	1,537
8	5	1,458
Total		15,495

Figure 5B-8. Simplified schematic of STA-2 showing major inflow and outflow water control structures, the treatment area of each cell, flow direction, and dominant/target vegetation types. Treatment areas do not include pump stations, levees, roads, or other upland areas. A detailed structure map of STA-2 is provided in Appendix 5B-1 of this volume.

STA TREATMENT PERFORMANCE

Over its 21-year POR, STA-2 has treated approximately 6.5 million ac-ft of water and retained 627 t of TP or 77% of the inflow TP load (810 t) that entered this facility (**Table 5B-1**). The POR inflow FWM TP concentration to this facility is 101 µg/L, while the POR outflow FWM TP concentration is 21 µg/L.

STA-2 treated approximately 289,000 ac-ft of runoff in WY2022 (**Figure 5B-9**). Of the inflow water volume this water year, approximately 38,000 ac-ft were Lake Okeechobee releases directed to STA-2 via S-6, G-434, and G-435; 30,000 ac-ft were regulatory releases, while only 8,000 ac-ft were delivered as either environmental releases for the Everglades or as supplemental water to maintain the vegetation communities in STA-2. Lake Okeechobee water was received in every month this water year except August through November 2021.

STA-2 had inflow and outflow FWM TP concentrations of 90 and 15 µg/L, respectively, this water year (**Table 5B-1**). The facility retained 26 t of TP, or 82% of the inflow TP load (32 t) and had an HLR and a PLR of 1.7 cm/d and 0.6 g/m^2/yr, respectively. The treatment performance of STA-2, as measured by the percent TP load retained, has been fairly consistent over its POR (~ 75 to 84%; **Figure 5B-9**).

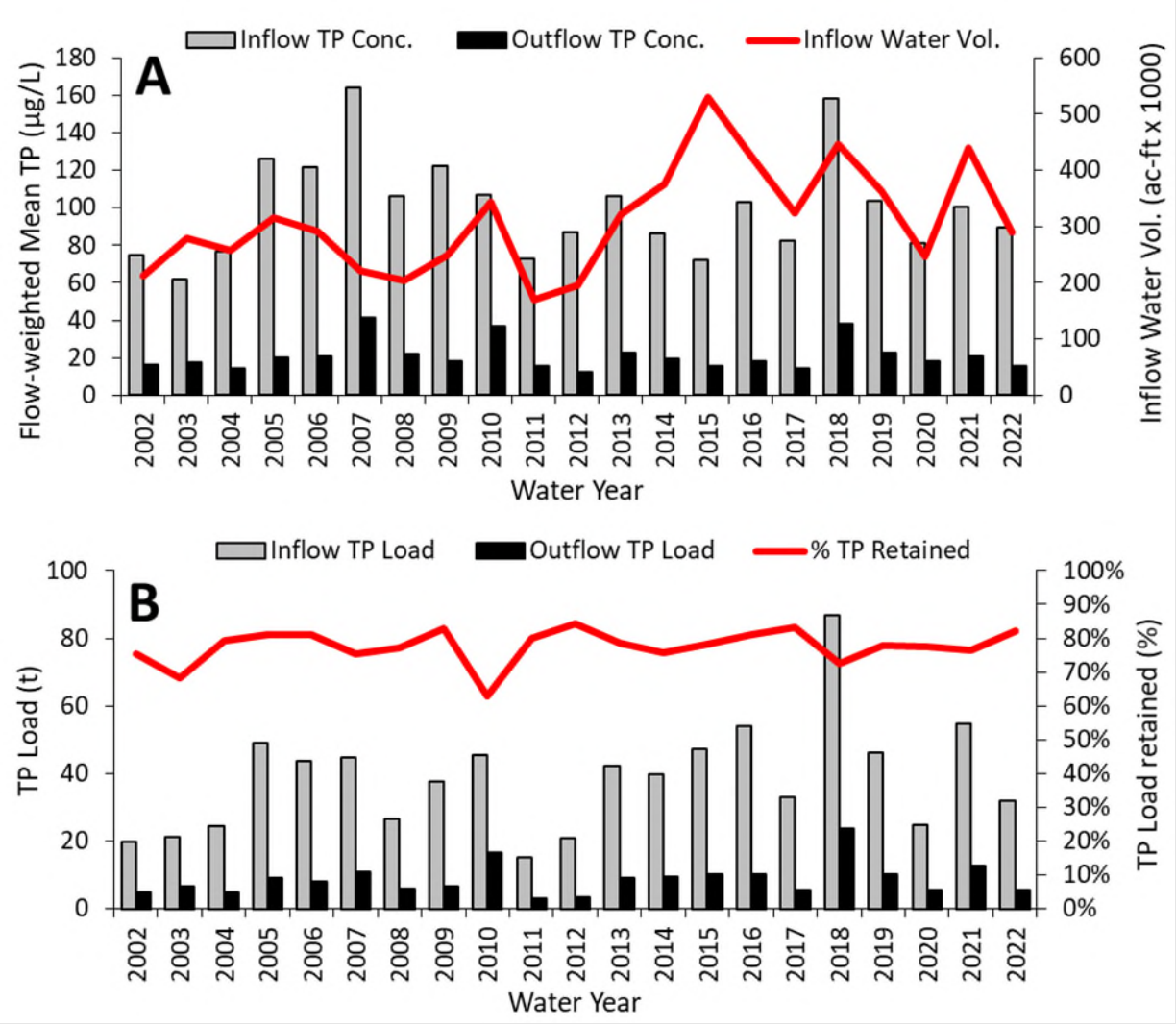


Figure 5B-9. POR time series for STA-2 for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

Flow-ways 1, 3, 4, and 5 of STA-2 were operational throughout WY2022, while Flow-way 2 was OFF from September 2021 through April 2022 for STA Refurbishment Projects construction (**Table 5B-2**). Flow-ways 1, 3 and 4 were ONR for portions of the year due to vegetation management activities. Flow-way 3 also was ONR in April 2022 due to black-necked stilt nesting.

Refurbishment Projects

STA-2 Refurbishment Projects consist of earthwork in Flow-ways 2 and 3 (Cells 2 and 3) to address poor vegetation recruitment and reduced treatment performance caused by hydraulic short-circuits and uneven topography. Cuts in the Cell 3 remnant farm roads were completed in WY2022, and the grading/filling work in Cell 2, which continued in WY2022, is scheduled to be completed in WY2023. Reinforcement of the deteriorated earthen plugs in Cells 2 and 3 borrow canals is also scheduled for WY2023. Additional details on this work are provided in Chapter 5B of the 2022 SFER – Volume I (Chimney 2022).

Dryout

STA-2 Cell 2 was taken offline and dried out in WY2022 for Refurbishment Projects construction. Portions of STA-2 Cell 1 also dried out as low stages were maintained in this cell to minimize lateral seepage that might interfere with construction in the adjacent Cell 2. All other cells in STA-2 were hydrated during WY2022.

Migratory Bird and Snail Kite Nesting

Black-necked stilt nests were observed in STA-2 Cell 2 in May and June 2021 and in Cell 3 in April 2022. No snail kite nests or Florida burrowing owls were observed in STA-2 during this water year. Information on STA-2 operational and maintenance adjustments implemented to protect bird nests during WY2022 is presented in Appendix 5B-3 of this volume.

VEGETATION SURVEYS

Ground surveys were conducted several times in WY2022 to map SAV areal coverage in STA-2: September 2021 in Cell 3, September 2021 and April 2022 in Cells 4, 5 and 6, and December 2021 and March 2022 in Cell 8 (Appendix 5B-4, Figures 9 through 13). Cell 3 could not be accessed during the dry season this year due to low water levels. Approximately one-third of sites in Cell 6 were not surveyed to avoid disturbing ongoing vegetation management activities. No SAV was found at 43% of survey sites, low SAV coverage at 18% of survey sites, medium SAV coverage at 15% of survey sites, and high SAV coverage at 24% of sites. Five SAV taxa were identified in STA-2 this water year: muskgrass, spiny naiad, southern naiad, bladderwort, and coontail. Muskgrass was the dominant taxon observed in Cells 3, 4, 5, and 6. Bladderwort and muskgrass were co-dominant in Cell 8. Coontail, southern naiad, and spiny naiad were found in lesser quantities relative to the dominant taxa. Overall, SAV occurrence increased to varying degrees in STA-2 compared to WY2021, most notably in Cells 5 and 8. The occurrence of muskgrass has increased over the POR in STA-2, while southern naiad, spiny naiad, and Illinois pondweed have declined in occurrence.

STA-3/4

STA-3/4 is in Palm Beach County northeast of the Holey Land Wildlife Management Area and north of WCA-3A (**Figure 5B-1** and Figure 1 in Appendix 5B-2 of this volume). This STA began operation in WY2004, and a new interior levee was constructed in WY2006 to subdivide Cell 3 into Cells 3A and 3B. STA-3/4 is comprised of six treatment cells arranged into three flow-ways with a total treatment area of 16,327 ac (Piccone et al. 2019; **Figure 5B-10**). A 445-ac section of Cell 2B is the site of the District's STA-3/4 Periphyton-based Stormwater Treatment Area (PSTA) Project. The STA-3/4 PSTA Project has been described in past SFERs (see Zamorano et al. 2018). STA-3/4 treats stormwater runoff from the S-2/S-7, S-3/S-8, S-236, and C-139 basins, South Shore Drainage District, and South Florida Conservancy District, and releases from Lake Okeechobee (see Figure 1 in Appendix 5B-2). During the dry season, releases from the A-1 FEB and/or Lake Okeechobee were utilized, when available, to maintain hydration in treatment cells. The flow-way nomenclature for STA-3/4 is as follows:

- Eastern Flow-way = Cells 1A and 1B
- Central Flow-way = Cells 2A and 2B
- Western Flow-way = Cells 3A and 3B

The A-1 FEB (Figure 5B-10) provides the same benefits to STA-3/4 as described for STA-2. That is, it temporarily stores stormwater runoff and attenuates peak inflows to STA-3/4 to help improve its treatment

performance and provide a source of water during the dry season and reduce the frequency of dryout in STA-3/4. See Volume III, Appendix 3-3 for additional information on the A-1 FEB.

STA-3/4 has been affected by extreme weather events such as regional droughts and large storms. High hydraulic loads during and following storms have resulted in excessively deep water for extended periods in cells at the top of the flow-ways. Chronic deep-water conditions have stressed the cattail populations in Cells 1A and 2A causing widespread mortality, especially at the inflow regions of these cells, and subsequent invasion of less desired species, such as non-rooted FAV. In WY2021, a water-level drawdown of Cell 1A was initiated to address the poor EAV condition due to chronically elevated water levels; the drawdown continued in WY2022.

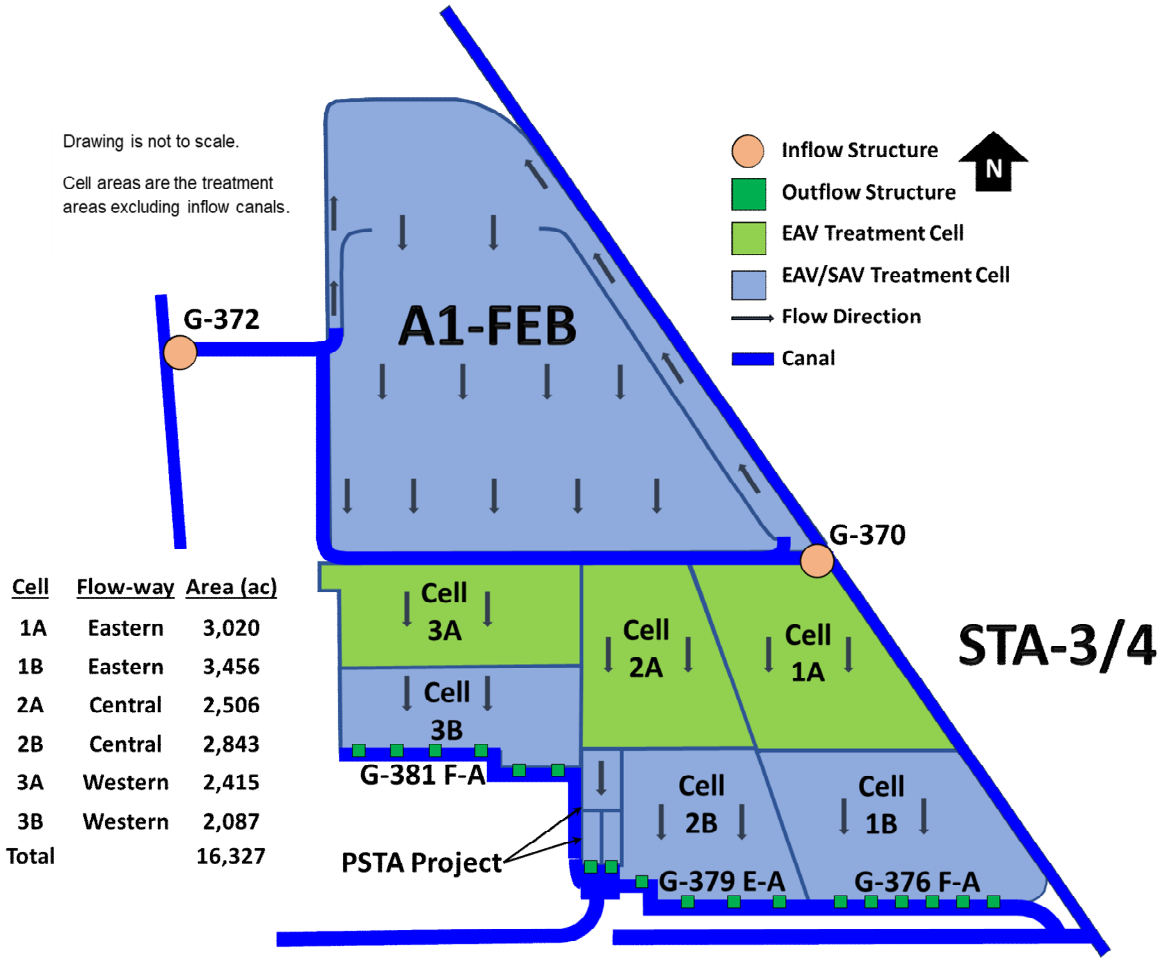


Figure 5B-10. Simplified schematic of STA-3/4 and the A-1 FEB showing major inflow and outflow water control structures, treatment area of each cell, flow direction, and dominant/target vegetation types. Treatment areas do not include pump stations, levees, roads, or other upland areas. Detailed structure maps of STA-3/4 and the A-1 FEB are provided in Appendix 5B-1 of this volume.

STA TREATMENT PERFORMANCE

STA-3/4, over its 19-year POR, has treated the largest volume of water (8.3 million ac-ft) and retained the most TP mass (875 out of 1,032 t) with the greatest treatment efficiency, based on its percent inflow TP load retained (85%), of all the Everglades STAs (**Table 5B-1**). The POR inflow FWM TP concentration for STA-3/4 is 101 µg/L, while the POR outflow FWM TP concentration is 15 µg/L, which is the lowest POR outflow TP concentration among all the Everglades STAs. Based on these metrics, STA-3/4 has been the best performing Everglades STA. The good POR treatment performance of STA-3/4 is attributed, in part, to its relatively low POR inflow TP concentration compared to the other Everglades STAs (see **Table 5B-1**). Past SFER reports have documented moderate regression relationships between annual or POR outflow TP concentration with inflow TP concentration. Depending on the averaging period, inflow TP concentration generally accounted for 50 to 60% of the variability in outflow TP concentration in these analyses. The remaining variability in outflow TP concentration is attributed to other biogeochemical or operational differences and disturbances among the Everglades STAs (e.g., Zhao and Piccone 2020, DBE 2022). A fuller understanding of why treatment performance varies among the Everglades STAs is one of the objectives of the ongoing Science Plan's P Reduction Dynamics in STA-1E, STA-2, STA-3/4, and STA-5/6 referred to as the P Dynamics Study) (see the P Dynamics section in Chapter 5C of this volume for more information on the study).

STA-3/4 treated approximately 330,000 ac-ft of runoff in WY2022 (**Table 5B-1**). Of this inflow water volume, approximately 56,000 ac-ft were Lake Okeechobee releases sent to the STA-3/4 – A-1 FEB complex prior to delivery south to WCA-2A and WCA-3A; 40,000 ac-ft were regulatory releases, and 17,000 ac-ft were delivered either as environmental releases for the Everglades or as supplemental water to maintain the vegetation communities in the STA. Lake Okeechobee water was received in every month this water year except September through November 2021.

STA-3/4 had an inflow FWM TP concentration of 91 µg/L and produced an outflow FWM TP concentration of 15 µg/L this water year, which is among the lowest annual outflow TP concentrations recorded in the Everglades STAs to date (**Table 5B-1**). This facility retained 31 t of TP, or 84% of the inflow TP load (37 t) and had an HLR and PLR of 1.8 cm/d and 0.6 $g/m^2/yr$, respectively. The annual percent TP load retained in STA-3/4 has been relatively constant throughout much of its POR (~ 80 to 90%; **Figure 5B-11**).

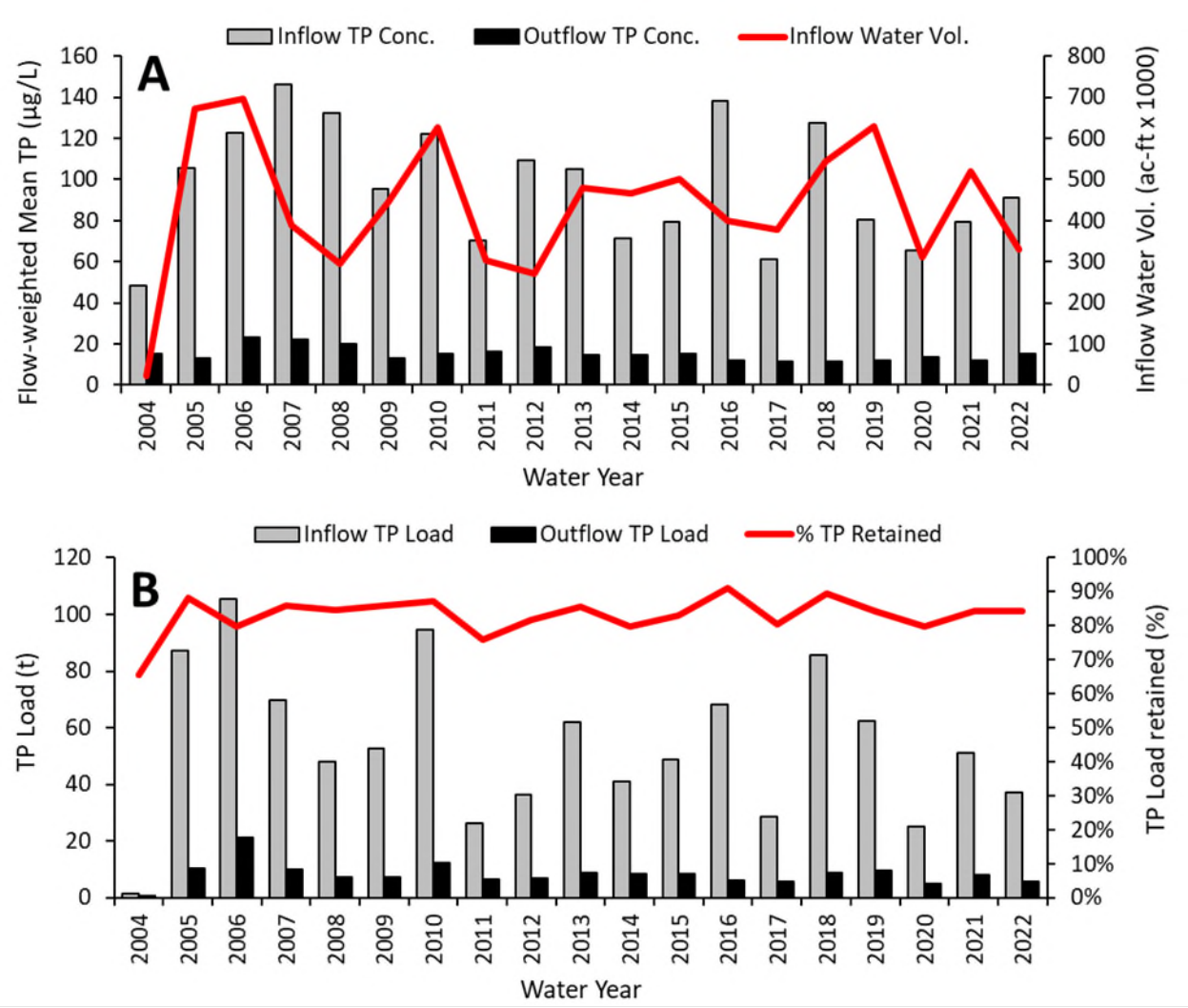


Figure 5B-11. POR time series in STA-3/4 for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

The Central and Western flow-ways of STA-3/4 were online throughout WY2022, while the Eastern Flow-way was OFF the entire water year for vegetation rehabilitation (**Table 5B-2**). The Western and Central Flow-ways were ONR for a portion of the year due to vegetation management activities and black-necked stilt nesting, respectively.

Refurbishment Project

An STA-3/4 refurbishment project was completed in WY2021 and consisted of installing riprap to serve as energy dissipators (i.e., flow deflectors) downstream of all 17 gated box culverts that control inflow to Cells 1A, 2A, and 3A. The culverts discharge into a spreader canal designed to distribute flow evenly across the northern end of each cell. However, after many years of high flow events, much of the EAV along the southern side of the spreader canal opposite the culverts has been displaced resulting in significant short-circuits through the vegetation. The energy dissipators are intended to reduce water velocities immediately downstream of the culverts, to promote more even flow distribution across the cells, and to

allow vegetation to be restored in the short-circuits through planting efforts as well as natural recruitment. Initial vegetation plantings around the energy dissipators were completed this water year but many of the plantings did not survive due to the onset of the wet season and the need to increase flow into STA-3/4. New plantings will be added as needed to reinforce vegetation coverage in the inflow portion of these cells.

Dryout

All online cells in STA-3/4 were hydrated during WY2022.

Migratory Bird and Snail Kite Nesting

Black-necked stilt nests were observed in STA-3/4 Cell 1A in May and June 2021 and in Cell 2B in April 2022. No snail kite nests or Florida burrowing owls were observed in STA-3/4 this water year. Information on STA-3/4 operational and maintenance adjustments implemented to protect bird nests during WY2022 is presented in Appendix 5B-3 of this volume.

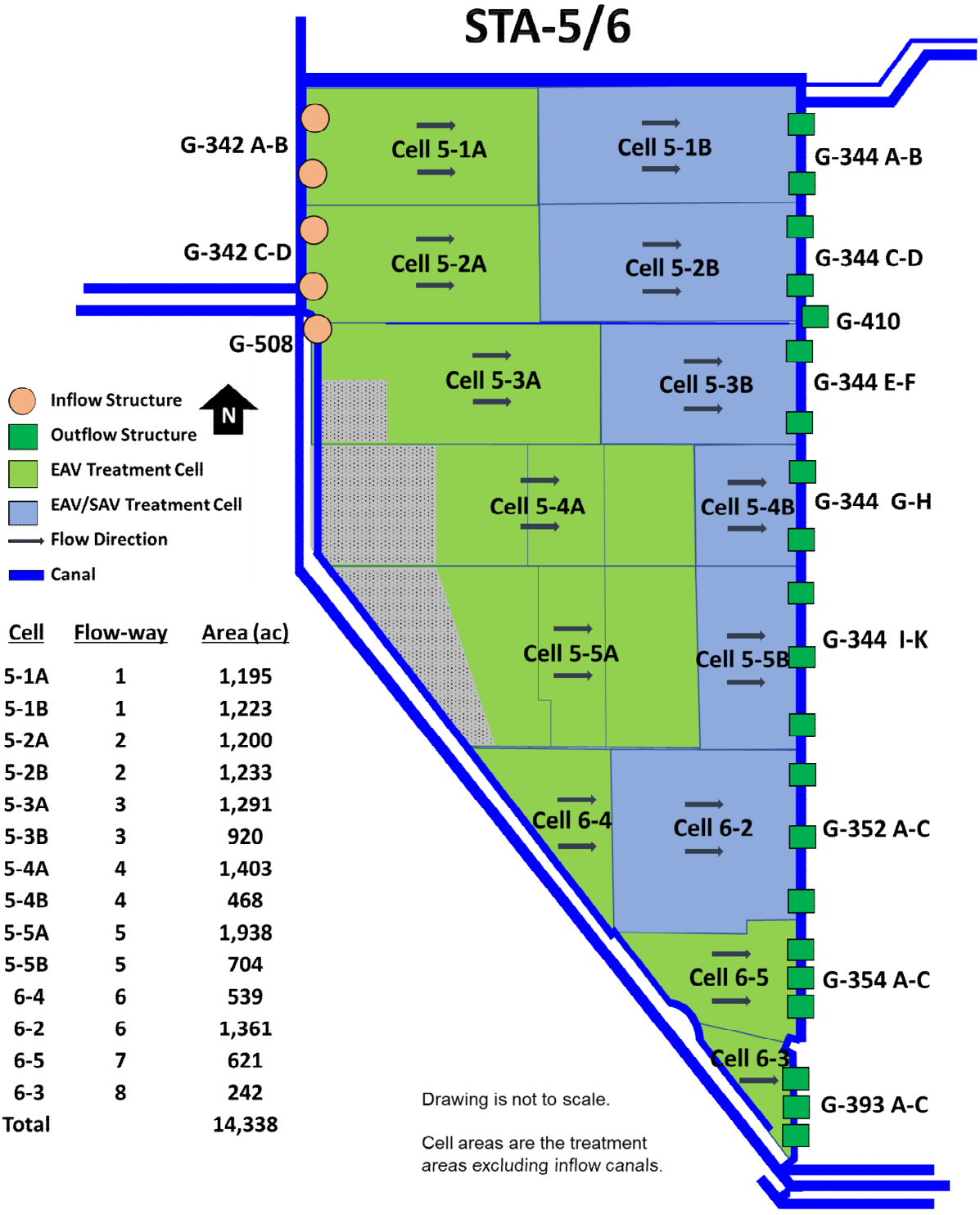
VEGETATION SURVEYS

Ground surveys were conducted in WY2022 to map SAV areal coverage in STA3/4 as follows: March 2022 in Cell 1B and April 2022 in Cell 2B (Appendix 5B-4, Figures 14 through 16). No surveys were completed in Cell 3B during WY2022 due to dense EAV that created unsafe boating conditions at typical water depths in the cell. No SAV was found at 14% of survey sites, low SAV coverage at 30% of survey sites, medium SAV coverage at 22% of survey sites, and high SAV coverage at 34% of survey sites. The following SAV taxa were identified in STA-3/4 this water year: muskgrass, southern naiad, spiny naiad, bladderwort, coontail, and Illinois pondweed. Muskgrass was the dominant taxon in all cells, while all other taxa were observed in lesser quantities. SAV occurrence in Cells 1B and 2B this water year was similar to that observed in WY2021. There has been a progressive decline in SAV occurrence in Cell 3B during the latter part of its POR while increased EAV coverage has been observed within the cell.

STA-5/6

STA-5/6 is in Hendry County and is bordered by the C-139 and C-139 Annex basins on the west and the Rotenberger Wildlife Management Area on the east (**Figure 5B-1**). This STA was created by merging what had been two separate Everglades STAs: STA-5 and STA-6. The original STA-5 (Cells 5-1A, 5-1B, 5-2A, and 5-2B) and STA-6 (Cells 6-3 and 6-5) (**Figure 5B-12**) began operation in WY2000 and WY1998, respectively. STA-5 received inflow primarily from the C-139 Basin and STA-6 treated agricultural runoff from the former United States Sugar Corporation's Southern Division Ranch, Unit 2 (see Figure 1 in Appendix 5B-2)[16]. In 2006, Cells 5-3A and 5-3B were added to STA-5 and Cell 6-2 (formerly known as Section 2) was added to STA-6. Construction of additional treatment cells was completed by 2012 on the remaining portion of the STA-5/6 complex, which has 14 cells arranged into eight flow-ways with a total treatment area of 14,338 ac (Piccone et al. 2019; **Figure 5B-12**). STA-5/6 is operated as an integrated facility to treat runoff from the C-139 Basin. Performance measures that were reported individually for STA-5 and STA-6 in past annual reports have been recalculated for the integrated STA-5/6 complex over its entire POR.

[16] The Southern Division Ranch, Unit 2 was incorporated into STA-5/6 when the treatment area of this STA was expanded.



Cell	Flow-way	Area (ac)
5-1A	1	1,195
5-1B	1	1,223
5-2A	2	1,200
5-2B	2	1,233
5-3A	3	1,291
5-3B	3	920
5-4A	4	1,403
5-4B	4	468
5-5A	5	1,938
5-5B	5	704
6-4	6	539
6-2	6	1,361
6-5	7	621
6-3	8	242
Total		14,338

Figure 5B-12. Simplified schematic of STA-5/6 showing major inflow and outflow water control structures, treatment area of each cell, flow direction, and dominant/target vegetation types. Treatment areas do not include pump stations, levees, roads, or other upland areas. A detailed structure map of STA-5/6 is provided in Appendix 5B-1 of this volume. Gray shading in Cells 5-3A, 5-4A, and 5-5A signify areas of high ground that are not part of the STA-5/6 treatment area

The flow-way nomenclature for STA-5/6 is as follows:

- Flow-way 1 = Cells 5-1A and 5-1B (former STA-5 Northern Flow-way)
- Flow-way 2 = Cells 5-2A and 5-2B (former STA-5 Central Flow-way)
- Flow-way 3 = Cells 5-3A and 5-3B (former STA-5 Southern Flow-way)
- Flow-way 4 = Cells 5-4A and 5-4B
- Flow-way 5 = Cells 5-5A and 5-5B
- Flow-way 6 = Cells 6-4 and 6-2
- Flow-way 7 = Cell 6-5
- Flow-way 8 = Cell 6-3

As with the other Everglades STAs, STA-5/6, over its POR, has been adversely affected by high inflow TP concentrations and extreme weather events, such as regional droughts and large storms. Some of the EAV cells in this STA have dried out almost every dry season, and WY2022 was no exception. High soil P flux has followed rehydration of these cells, usually resulting in temporary spikes in outflow TP concentration.

STA TREATMENT PERFORMANCE

STA-5/6 over its combined 25-year POR has treated approximately 3.3 million ac-ft of water and retained 550 t of TP or 70% of the inflow TP load (788 t) (**Table 5B-1**). The POR inflow FWM TP concentration is 196 µg/L, while the POR outflow FWM TP concentration is 64 µg/L; these are the highest POR inflow and outflow concentrations of any Everglades STA. Based on these metrics, STA-5/6 has been the poorest performing STA. However, treatment performance, as measured by outflow FWM TP concentration, generally improved after WY2013 when this STA began operation as an integrated facility (**Figure 5B-13**).

STA-5/6 treated approximately 177,000 ac-ft of runoff in WY2022 (**Table 5B-1**); 6,400 ac-ft of this inflow water volume was Lake Okeechobee releases delivered as supplemental water to maintain the vegetation communities in the STA. Note that the STA-5/6 inflow structures cannot receive water deliveries directly from Lake Okeechobee due to the lack of the necessary infrastructure. Thus, supplemental water usually comes from other sources[17]. This water year, Lake Okeechobee water was received in May and June 2021 via temporary pumps located at the Manley Ditch north of G-373 and just east of PC-15.

The inflow FWM TP concentration to STA-5/6 this water year was 243 µg/L while the outflow FWM TP concentration was 50 µg/L (**Table 5B-1**). STA-5/6 retained 43 t of TP, which was 81 % of the inflow TP load (53 t) and had an HLR and PLR of 1.1 cm/d and 1.0 $g/m^2/yr$, respectively, in WY2022 (**Figure 5B-3**). Beginning in WY2013, STA-5/6 consistently has had some of the lowest HLRs and PLRs of all the Everglades STAs, which is attributed, in large measure, to the substantial increase in STA-5/6 treatment area once Flow-ways 3, 4, and 5 came online. The percent TP load retained in STA-5/6 from WY2013 through WY2017 (86 to 91%), was comparable with the best treatment performance in the other Everglades STAs during this period (**Figure 5B-13**).

[17] When available, supplemental water, primarily from STA-3/4, can be pumped out of the STA-5/6 discharge canal and delivered via the G-350B, G-507, and G-509 pump stations into Cells 5-1B, 5-2B, 5-3B, and 5-4B to keep them flooded during dry conditions.

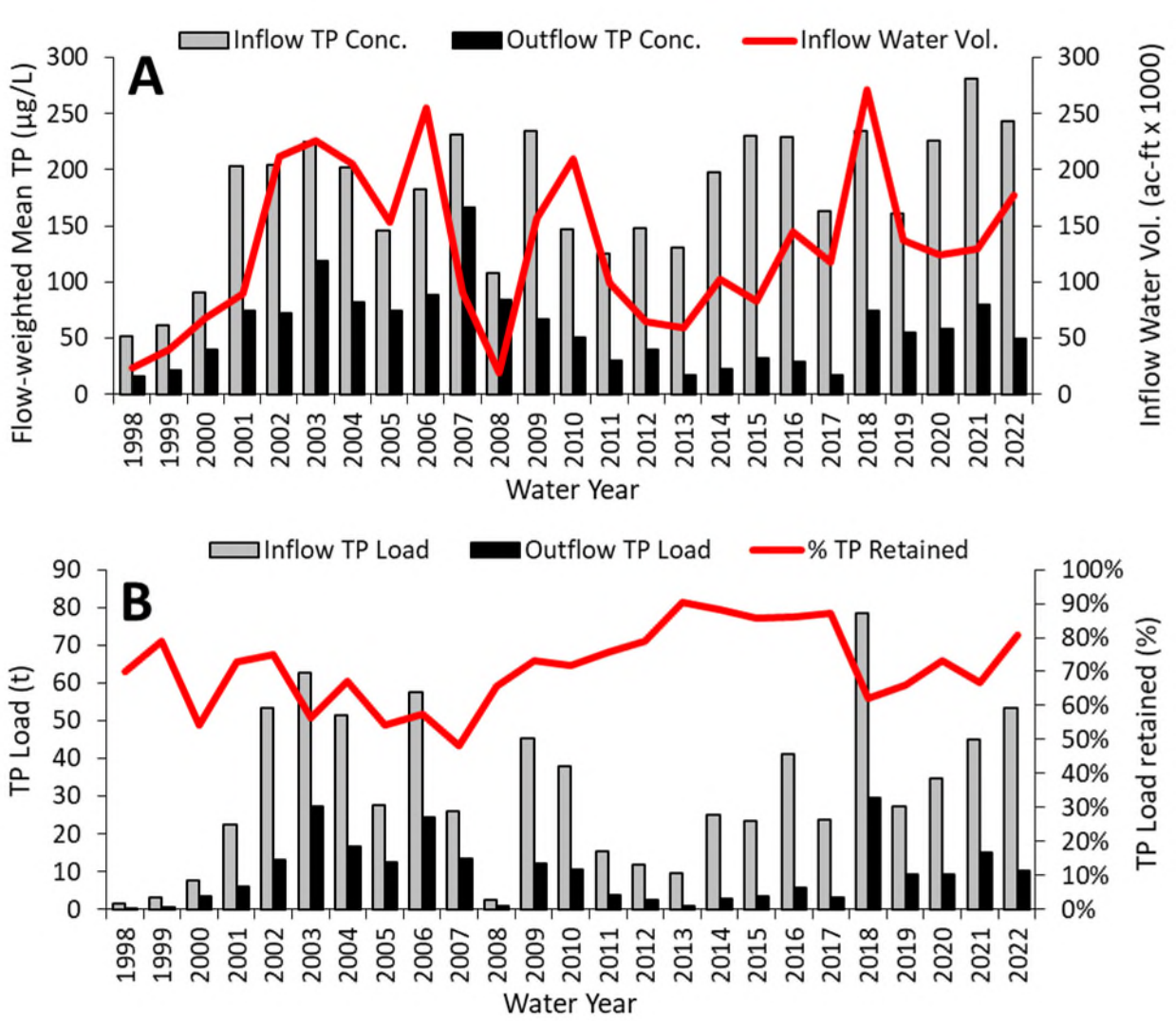


Figure 5B-13. POR time series in STA-5/6 for (A) annual inflow and outflow FWM TP concentration (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent -TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

Most flow-ways in STA-5/6 were online throughout WY2022, except Flow-way 4 that was OFF from January to April 2022 for vegetation management activities (**Table 5B-2**). Flow-ways 2 and 3 were ONR from May to October 2021 following a Restoration Strategies project to grade and lower the ground elevation in parts of Cells 5-2A and 5-3A. Additionally, Flow-ways 3 and 6 were ONR for a portion of the year due to black-necked stilt nesting.

Dryout

The District declared that dryout conditions existed in STA-5/6 Cells 6-3 and 6-5 (Flow-ways 7 and 8) from April through June 2022 and notified FDEP of these developments accordingly. Most of the other cells in STA-5/6 partially dried out this water year, but not to the extent that the District declared them to be in dryout condition.

Migratory Bird and Snail Kite Nesting

Black-necked stilt nests were observed in STA-5/6 Cell 6-4 in May 2021and Cells 5-3A and 6-4 in June 2021. No snail kite nests or Florida burrowing owls were observed in STA-5/6 during this water year. Information on STA-5/6 operational and maintenance adjustments implemented to protect bird nests during WY2022 is presented in Appendix 5B-3 of this volume.

VEGETATION SURVEYS

Ground surveys were conducted over time in WY2022 to map SAV areal coverage in STA-5/6: October 2021 and March 2022 in Cell 5-1B; October 2021 in Cells 2B and 3B; and September 2021 and March 2022 in Cells 5-4B and 5-5B (Appendix 5B-4, Figures 17 through 21). Cells 5-2B and 5-3B were inaccessible during the dry season due to low water levels. No SAV was found at 55% of survey sites, low SAV coverage at 22% of sites, medium SAV coverage at 11% of survey sites, and high SAV coverage at 13% of survey sites. Five SAV taxa were identified in STA-5/6 in WY2022: coontail, muskgrass, hydrilla, southern naiad, and bladderwort. Cell 5-1B contained a diverse SAV community where coontail, muskgrass, and bladderwort were the most prevalent taxa. Bladderwort was the dominant taxon in Cells 5-2B and 5-3B, while coontail was dominant in Cells 5-4B and 5-5B. The other SAV taxa were observed in lesser coverages. SAV occurrence this water year was generally similar to WY2021, though SAV occurrence was slightly higher in Cell 5-5B. There has been a progressive decline in SAV occurrence in all cells during the latter portions of their PORs, while increased EAV coverage has been observed across most cells.

LITERATURE CITED

Bostic, E.M., and J.R. White. 2007. Soil phosphorus and vegetation influence on wetland phosphorus release after simulated drought. *Soil Science Society of America Journal* 71(1):238-244.

Burns & McDonnell. 2003. Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals in the Everglades Protection Area. Prepared for South Florida Water Management District, West Palm Beach, FL.

Chimney, M. (ed.). 2022. Chapter 5B: Performance and Operation of the Everglades Stormwater Treatment Areas. In: *2022 South Florida Environmental Report – Volume I,* South FloridaWater Management District, West Palm Beach, FL. Available online at https://apps.sfwmd.gov/sfwmd/SFER/2022_sfer_final/v1/chapters/v1_ch5b.pdf.

DBE. 2022. *Deliverable 6b under Contract 4600004012-W009: Phosphorus Dynamics in the Stormwater Treatment Areas – Annual Report.* Submitted by DB Environmental Laboratories, Inc. to the South Florida Water Management District, West Palm Beach, FL. January 14, 2022.

DeBusk, W.F., and K.R. Reddy. 2003. Nutrient and hydrology effects on soil respiration in a northern Everglades marsh. *Journal or Environmental Quality* 32:702-710.

Kadlec, R.H. 2011. *Harvest to Remove Phosphorus*. Unpublished white paper, Wetland Management Services, Chelsea, MI. April 2011.

Kadlec, R.H., and S. Wallace. 2009. *Treatment Wetlands.* CRC Press, Boca Raton, FL.

Martin, H.W., D.B. Ivanoff, D.A. Graetz, and K.R. Reddy. 1996. Water table effects on histosol drainage water carbon, nitrogen, and phosphorus. *Journal of Environmental Quality* 6:1062-1071.

Pandion Systems. 2008. Avian Protection Plan for Black-necked Stilts and Burrowing Owls Nesting in the Everglades Agricultural Area Stormwater Treatment Areas. Prepared by Pandion Systems, Inc., Gainesville, FL, for South Florida Water Management District, West Palm Beach, FL.

Piccone, T., J. McBryan, H. Zhao, and Y. Yan. 2019. 2012 Updated Everglades Stormwater Treatment Area Ground Elevations, Stage-Area/Stage-Volume Relationships and Effective Treatment Areas. Technical Publication ASB-WQTT-12-02, South Florida Water Management District, West Palm Beach, FL. Revised November 2019.

Pietro, K., G. Germain, R. Bearzotti, and N. Iricanin. 2010. Chapter 5: Performance and Optimization of the Everglades Stormwater Treatment Areas. In: *2010 South Florida Environmental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2012. *Restoration Strategies Regional Water Quality Plan*. South Florida Water Management District, West Palm Beach, FL. April 27, 2012.

SFWMD. 2013. *Science Plan for the Everglades Stormwater Treatment Areas*. South Florida Water Management District, West Palm Beach, FL. June 2013.

SFWMD. 2015. South Florida Water Management District Everglades Stormwater Treatment Areas (STAs) Drought Contingency Plan. South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2016. 2016 Voluntary Guidelines to Minimize Impacts to Snail Kites within Everglades Stormwater Treatment Areas. South Florida Water Management District, West Palm Beach, FL. January 2016.

SFWMD. 2020. *Water Shortage Suggested Operating Procedures - Stormwater Treatment Areas*. South Florida Water Management District, West Palm Beach, FL.

State of Florida. 2017. *Industrial Wastewater Facility Permit # FL0778451-003-GL7A/NR for STA-1E, STA-1W, STA-2, STA-3/4 and STA-5/6*. Issuance date: September 06, 2017. Permittee: South Florida Water Management District, West Palm Beach, FL.

Zamorano, M.F., K. Grace, T. DeBusk, T. Piccone, M. Chimney, R.T. James, H. Zhao, and C. Polatel. 2018. Appendix 5C-2: Investigation of Stormwater Treatment Area 3/4 Periphyton-based Stormwater Treatment Area Performance, Design, and Operational Factors. In: *2018 South Florida Environemental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

Zhao, H. and T. Piccone. 2020. Large-scale constructed wetlands for phosphorus removal, an effective nonpoint source pollution treatment technology. *Ecological Engineering* 145:105711.