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

Edited by Michael Chimney

Contributors (in alphabetical order): Holly Andreotta, Michael Chimney, Eric Crawford, Cassandra A. Cummins[1], Jacob Dombrowski, Dawn Sierer Finn[1], Aubrey O. Frye[1], Brian Garrett, Kimberly Hellman[1], Michelle Kharbanda[1], Jill King, Matthew Powers, Nathan Ralph, Robert Shuford, Jessica Wilson, Shi Kui Xue, and Hongying Zhao

SUMMARY

The construction and operation of large freshwater treatment wetlands, known as the Everglades Stormwater Treatment Areas (STAs), are mandated by the Everglades Forever Act (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-1 East [STA-1E], STA-1 West [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 total phosphorus (TP) concentration in surface water runoff prior to discharging this water into the Everglades Protection Area (EPA). The STAs are operated by the South Florida Water Management District (SFWMD or District). The total area of the STAs, including infrastructure components, is roughly 68,000 acres (ac)[2], with 57,000 ac of treatment area currently permitted to operate including the expansions of STA-2 and STA-5/6. This chapter and its appendices (Appendices 5B-1 through 5B-4 of this volume) summarize short- and long-term STA treatment performance and document any environmental conditions that may have adversely affected treatment performance, the status of these facilities, and operational challenges during Water Year 2018 (WY2018; May 1, 2017–April 30, 2018). An analysis of annual STA treatment performance relative to compliance with the STA operating permit is reported in Volume III, Appendix 3-1. A status update on implementing the *Long-Term Plan for Achieving Water Quality Goals in the*

[1] DB Environmental Laboratories, Inc., 365 Gus Hipp Boulevard, Rockledge, FL 32955.

[2] Chapter 5B is an annual report on the condition and performance of the 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 values 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 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 = 0.40468 hectare or 4,046.8 square meters; 1 cfs = 0.02832 cubic meters per second; 1 ac-ft = 1,233.5 cubic meters; and 1 t = 1,000 kilograms.

Everglades Protection Area (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 presented in Chapter 5C of this volume. More information about the STAs is available on the District's website: https://www.sfwmd.gov/our-work/wq-stas.

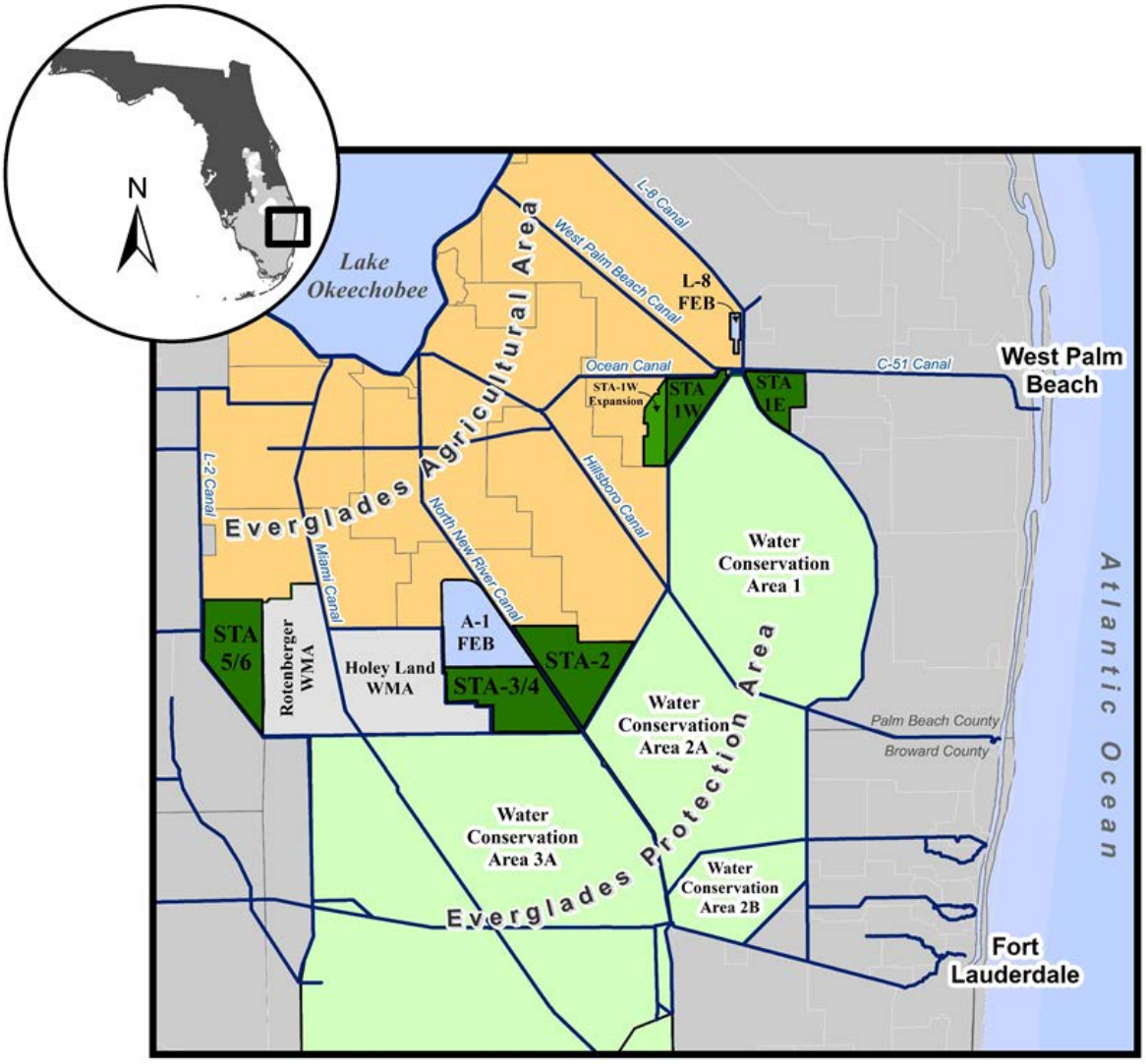


Figure 5B-1. Location of the STAs (STA-1E, STA-1W, STA-2, STA-3/4, and STA-5/6), the STA-1W Expansion Area, and the flow equalization basins (FEBs; A-1 and L-8) in relation to Lake Okeechobee, the EPA, and other landscape features of South Florida.
(Note: WMA – Wildlife Management Area.)

A summary of findings for the STAs for WY2018 is as follows:

- Over the past 24 years, the STAs in combination have treated approximately 20.1 million acre-feet (ac-ft) of water (~ 6.6 trillion gallons) and retained 2,604 metric tons (t) of TP with a 77% TP load reduction. The overall outflow flow-weighted mean (FWM) TP concentration from these treatment wetlands during this period has been 31 micrograms per liter (µg/L). STA-3/4, over its 15-year operational history, has treated the most water (~ 6.5 million ac-ft), retained the most TP load (728 t), achieved the highest percent TP load retained (85%), and discharged water at the lowest outflow FWM TP concentration (16 µg/L) of all the STAs.
- In WY2018, the STAs treated a combined 1.6 million ac-ft of water and retained 275 t of TP, which equated to a 77% TP load reduction and produced an outflow FWM TP concentration of 36 µg/L. Approximately 159,000 ac-ft of the total inflow volume in WY2018 came from Lake Okeechobee, of which 107,000 ac-ft were treated in the STAs, while 52,000 ac-ft were delivered as supplemental water to maintain cell water levels at target stages in STA-1E, STA-1W, STA-2, and STA-3/4.
- South Florida was impacted by two large storm events this water year: an unnamed storm in June 2017 and Hurricane Irma in September 2017. The primary effects to the District were very heavy rainfall during both storms and high winds during the hurricane. The District-wide average precipitation from the June storm was 20 centimeters (cm; 8 inches) and 21 cm (8.4 inches) during the hurricane. The entire District also experienced tropical storm or hurricane force winds during Hurricane Irma. Inflow water volumes and TP loads to all the STAs were markedly higher in June, September, and October 2017 compared to the other months in WY2018.
- The outflow FWM TP concentrations from individual STAs in WY2018 were 47, 39, 38, 12, and 74 µg/L in STA-1E, STA-1W, STA-2, STA-3/4, and STA-5/6, respectively. Except for STA-3/4, outflow FWM TP concentrations from the STAs were markedly higher in WY2018 compared to outflow concentrations in recent water years. This increase was attributed primarily to impacts from a large rain event in June 2017 and Hurricane Irma in September 2017. The percent TP load retained in WY2018 ranged from 62 (STA-5/6) to 90% (STA-3/4).
- All STAs were operational throughout WY2018. However, some flow-ways in all the STAs had operational restrictions for at least part of this water year for various reasons including protection of nesting birds, vegetation maintenance, structure repairs, construction, or operation requirements of Science Plan research studies.
- With the exception of numerous cells in STA-5/6, all other cells in the STAs remained hydrated throughout WY2018, due, in part, to the timely delivery of supplemental water.
- One hundred and forty-seven black-necked stilt (*Himantopus mexicanus*) nests were observed across all the STAs during the 2018 nesting season. Two active Everglade snail kite (*Rostrhamus sociabilis*) nests were found in STA-1E, Cell 1. Operational priorities were adjusted in the STAs, as needed, to avoid disturbing active nests. No active burrowing owl (*Athene cunicularia floridana*) nests were found in any STA.

INTRODUCTION

A major component of Everglades restoration efforts, the STAs are freshwater treatment wetlands built and operated to reduce TP concentration in surface runoff 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 describes the treatment performance and status of the five 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 STAs.

Varying in size, configuration, and length of operation, the 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 STAs are part of the District's regional flood control system and inflow is primarily from basin runoff. The STAs were constructed in a phased approach; the first prototype STA, the Everglades Nutrient Removal Project, became operational in 1994. The STAs currently have a combined treatment area of 57,000 ac and occupy a total area, including infrastructure, of about 68,000 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 July 2017, which adds approximately 45,000 ac-ft of water storage capacity upstream of STA-1E and STA-1W. The District is currently expanding STA-1W 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 STAs are categorized based on their growth habit: emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV), or floating aquatic vegetation (FAV). While all STA cells contain a mixture of these vegetation types, cells are classified based on their target vegetation community, i.e., either SAV or EAV[3]. Periphyton, the community of attached algae and other microorganisms growing on substrates in aquatic systems, is ubiquitous throughout the STAs.

Reduction in TP concentration and load has varied temporally within each STA and spatially among STAs and may be influenced by factors such as weather conditions, 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. The District attempts to maximize 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 operation restrictions.

This chapter reports on STA treatment performance, facility status and operational issues, relevant maintenance activities, vegetation conditions, and wildlife issues. Discussion of recreational facilities and implementation of the Long-Term Plan is provided 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 permit monitoring for TP and other water quality parameters that are mandated for the STAs are presented in Volume III, Appendix 3-1.

[3] The District does not include FAV as a target vegetation type in the STAs because as FAV coverage expands it often displaces existing beds of SAV and EAV, which is not a desirable outcome. The District has tried planting rooted FAV in portions of cells that have been too deep to support other emergent vegetation.

FLOW-WAY OPERATIONAL STATUS

Short-term and long-term operation of the STAs and individual flow-ways is critical in achieving and sustaining the desired treatment performance in the STAs. The District has established a comprehensive system that includes weekly review of individual flow-ways' treatment performance and condition, and discussions to prioritize operation of available flow-ways. Operation of an STA flow-way may be suspended entirely (operational status: offline) in response to environmental conditions that may adversely affect phosphorus (P) uptake, to allow for construction activities, or to allow the completion of critical rehabilitation activities. Operation of a flow-way may also be flow and/or stage-restricted (operational status: online with restrictions [ONR]) for a number of reasons, such as to protect vulnerable vegetation or to avoid and minimize impacts 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, storm water may be partially or entirely routed to other STAs or flow-ways for treatment.

ADJUSTMENT OF THE EFFECTIVE TREATMENT AREA VALUES

The effective treatment area in each STA was used to calculate the hydraulic loading rate (HLR), P loading rate (PLR), and P removal rate values (see **Table 5B-1** in the *Overview of Water Year 2018* section). Effective treatment areas are adjusted, if needed, using the following equation based on the operational period of each flow-way during the water year:

$$Adjusted\ Effective\ Treatment\ Area = Total\ Area \times \frac{\sum_1^n Daily\ Online\ Percentage}{\#\ days\ in\ year} \quad (1)$$

CALCULATION OF ANNUAL LOADS AND FLOW-WEIGHTED MEAN CONCENTRATIONS

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

$$Load = \sum_1^n (C_i V_i + C_{i+1} V_{i+1} + \ldots\ C_{i+n} V_{i+n}) \quad (2)$$

$$FWM\ Concentration = Load \Big/ \sum_1^n (V_i + V_{i+1} + \ldots\ V_{i+n}) \quad (3)$$

where

C_i = TP concentration for the i^{th} sampling interval during the water year
V_i = Water volume for the i^{th} sampling interval during the water year.

All calculations were performed using the District's web-based nutrient load program.

Water is collected by both grab sampling and with flow-proportioned autosamplers at 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. Total P 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 efforts in the STAs include herbicide applications and limited mechanical or manual removal to control undesired FAV, SAV, and emergent herbaceous and woody species[4]. Controlling non-rooted FAV, such as water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*), is necessary in SAV cells where these species can form dense beds that shade out the SAV underneath. Dense non-rooted FAV can also hinder the growth of EAV, impede flow through cells, and lead to hydraulic short-circuiting. Woody plant species, such as primrose willow (*Ludwigia* spp.), are controlled because they tend to displace cattail (*Typha* spp.) and do not provide the same level of P removal as cattail or sawgrass (*Cladium jamaicense*). The District uses United States Environmental Protection Agency-registered herbicides applied by licensed applicators at the dosages recommended by the manufacturers. None of these products bioaccumulate, all are registered for use in aquatic systems, and none are restricted category herbicides. While these products are certainly toxic to plants, toxicity is negligible to non-plant organisms at the application rates used in the STAs. The District's vegetation management program is regulated by the Florida Department of Protection (FDEP) and fully complies with STA operating permit regulations. An accounting of herbicide application rates and quantities used, the acreage treated in each STA, and the species targeted during WY2018 is provided in Volume III, Appendix 3-1, Attachment E.

Vegetation management and restoration efforts also include planting select species, primarily giant bulrush (*Schoenoplectus californicus*), alligator flag (*Thalia geniculata*), and American lotus (*Nelumbo lutea)* plus inoculations of SAV, such as southern naiad (*Najas guadalupensis*), spiny naiad (*Najas marina*), tape grass (*Vallisneria americana)*, pondweed (*Potamogeton illinoensis*), and muskgrass (*Chara* sp.). Giant bulrush and alligator flag are normally planted in linear strips (i.e., vegetation strips) to minimize hydraulic short-circuits, buffer other plant species against high wind and flow events, and provide plant cover at locations where the water is too deep for sustained growth of cattail. Alligator flag and American lotus are also planted to stabilize sediments and minimize the effects of non-rooted FAV damage in areas where SAV and cattail are difficult to establish. The compartmentalization of SAV cells with vegetation strips provides some redundancy in nutrient reduction capacity to maintain treatment performance in the event of SAV loss[5]. In EAV cells, the most desired species are cattail[6], giant bulrush, alligator flag, and sawgrass. Other desirable native species that thrive in certain areas of the STAs are arrowhead (*Sagittaria latifolia*), duck potato (*S. lancifolia*), and spikerush (*Eleocharis* spp.). In SAV cells, the most desired species are coontail (*Ceratophyllum demersum*), muskgrass, pondweed, southern naiad, and spiny naiad. Another species commonly found in the STAs is hydrilla (*Hydrilla verticillata*); however, despite this species' ability to remove P, it is not desirable due to its invasive nature and tendency for sudden population die-offs. Hydrilla, which thrives in areas of high water column TP concentrations, was a common SAV species in STA-1E and STA-5/6 during WY2018.

[4] Widespread harvesting often has been suggested as a way to manage vegetation in the STAs. However, harvesting is not under consideration for a number of reasons including (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 the District's decision not to pursue harvesting in the STAs.

[5] Based on lessons learned from managing and operating the STAs, the District has allowed EAV cover to expand outside of the vegetation strips to create a mixed-marsh vegetation community in some SAV-designated 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 treatment performance.

[6] Cattail in the 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 a 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.

VEGETATION SURVEYS

Ground surveys were conducted by airboat within STA cells designated as SAV cells on a periodic basis to map the coverage of SAV taxa. Assessments were made at a network of fixed geo-referenced sites established within each cell where the coverage of each SAV species was assessed by visual inspection in the field. The coverage of all SAV taxa considered together was also assessed. Details on the sampling methodology used and SAV coverage maps made from these surveys are provided in Appendix 5B-4 of this volume.

Helicopter surveys of the STAs were conducted on a monthly basis to qualitatively assess condition of the vegetation community. This information was used primarily to guide vegetation maintenance and restoration activities but also supplemented the ground SAV surveys to track any notable changes in SAV coverage that occurred during the water year.

DRYOUT

One of the challenges in managing the 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 STA cells can dry out. This is especially problematic for cells that have a higher ground elevation than surrounding areas (due to 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 outflow P spikes due to the flux of mineralized soil P to the water column (Bostic and White 2007, DeBusk and Reddy 2003, Martin et al. 1996). 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 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 more quickly upon loss of surface water and is prone to fluxing soil P upon rewetting. 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* (Pietro et al. 2010).

While prolonged dryout conditions in SAV cells can be detrimental to the plant community, dryout in EAV cells for short periods[7] does not appear to have negative impacts and may benefit the plants. For example, managed water level drawdowns have been effective in encouraging recruitment of new 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 has implemented the *South Florida Water Management District Everglades Construction Project (ECP) Stormwater Treatment Areas (STAs) Drought Contingency Recommendations and Considerations* (Drought Contingency Plan; DCP), since 2008 to minimize dryout during periods of drought (SFWMD 2008). When dry conditions are anticipated, the DCP provides guidance regarding raising cell target stages before the end of the wet season to increase storage volume in SAV cells, the use of temporary pumps to deliver water to the STAs from nearby sources when available, and the delivery of supplemental water when available from Lake Okeechobee to the STAs. The DCP prioritizes hydration of

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

SAV cells over EAV cells to minimize impact to the SAV community and sets the minimum target stages in EAV and SAV cells during drought conditions at 15 cm (6 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 spring stormwater runoff may allow the District, to some extent, to hold water longer in the STAs at the onset of the wet season without discharging from flow-ways that have dried out and allow more time for the flux of soil P to be reassimilated before water is released.

Stage in the STAs during dry conditions can recede to levels where there is no hydraulic connection between water at the inflow and outflow structures and any 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 water quality sampling is suspended until water levels increase and reestablish the connection between the structures and the marsh. For the purposes of assessing dryout during the water year, cells were categorized as hydrated unless they had been declared to be in a dryout condition.

STORM IMPACTS

Treatment performance in the STAs can be degraded by large storms events through a number of mechanisms, whether these storms are tropical cyclones (tropical storms and hurricanes) or simply prolonged periods of heavy rainfall. First, heavy rainfall can dramatically increase the volume of runoff coming from a drainage basin. In response to increased runoff, STA inflow pump stations may operate at or near full capacity for extended periods, which increases STA water velocities and reduces the hydraulic residence time within these wetlands. Second, prolonged heavy pumping also can increase water depths in the STAs to the point where much water overtops the vegetation and receives reduced treatment. Third, the TP concentration in basin runoff can increase dramatically both during and for a period of time after large storms. Fourth, high wind speeds can damage the vegetation community within an STA, 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 STA annual outflow FWM TP concentration.

The District experienced two large storm events in WY2018. The first was an unnamed storm on June 5–7, 2017, that delivered about 20 cm (8 inches) of rain over much of the Everglades Agricultural Area (EAA). In addition, the EAA received a total of 43 cm (17 inches) of precipitation that month, making it the wettest June since 2005. The second storm was Hurricane Irma, which transited South Florida on September 8–11, 2017. The center of the storm approached from the south, moved up through the Florida Keys and then along the western side of the District. Most of the District received heavy rainfall over the three-day period; the District-wide average rainfall was 21 cm (8.4 inches), although some areas received up to 27 cm (10.8 inches) of rain (see Appendix 2-2 of this volume). In addition, tropical storm or hurricane force winds occurred over most of the District. Wind speeds were highest on the District's western side where a wind gust of 228.5 kilometers per hour (kph; 142 miles per hour [mph]) was recorded in Naples, FL. Aerial overflights and ground SAV surveys were conducted following Hurricane Irma to evaluate the condition of the vegetation communities in the STAs. As a result of these two large rain events, inflow water volumes and TP loads to most of the STAs were substantially higher in June, September, and October 2017 compared to inflow water volumes and TP loads during the other months of WY2018. Consequently, because annual outflow TP concentrations from the STAs are calculated as flow-weighted means, treatment performance during June, September, and October 2017 had a greater influence on annual mean concentrations than the other months.

MIGRATORY BIRD AND SNAIL KITE NESTING

The District, in cooperation with USFWS, finalized the *Avian Protection Plan for Black-necked Stilts and Burrowing Owls Nesting in the Everglades Agricultural Area Stormwater Treatment Areas*, or simply the Avian Protection Plan (APP), in 2008 for the STAs (Pandion Systems 2008). The black-necked stilts and burrowing owls are afforded protected status under the Migratory Bird Treaty Act of 1918. Additional protected status has been given to the burrowing owl since it is also listed as a species of special concern in the State of Florida. In accordance with the APP, the District conducts surveys within the STA cells for nests of these two bird species during their nesting seasons. The APP provides the District with a framework to modify STA operations to minimize potential impacts to active nests of either species. This is accomplished by diverting water around cells with nests or regulating inflow to these cells to avoid raising water levels and flooding nests[8]. Although the District is committed to mortality reduction measures, there may be situations where bird mortality is unavoidable as the District fulfills its flood control and water quality treatment responsibilities. Specifically, during storm events, the District seeks to minimize sending untreated water directly to the Everglades Water Conservation Areas (WCAs). Operation of the STAs at these times may result in the inadvertent taking of migratory birds or their nests. Standardized black-necked stilt nesting surveys were conducted in all the STAs during the 2018 nesting seasons following protocols outlined in the APP. The number of black-necked stilts, a ground-nesting species, attracted to the STAs each year is a function of available nesting habitat, which can vary from year to year. This species prefers mudflats and areas near shallow water for nesting. Low water levels in the STAs can expose portions of the bottom, which creates ideal nesting habitat. To the extent practicable, the District attempts to keep the STAs completely flooded during the spring to discourage nesting. However, keeping the STAs flooded is subject to the availability of water in the basin, which in turn is a function of rainfall patterns. In addition, EAV coverage in many treatment cells has increased as the STAs have matured, which has further limited the habitat that black-necked stilts find suitable for nesting. 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 the District's nest surveys for black-necked stilts and Florida burrowing owls, the University of Florida conducts Everglade snail kite nest surveys each nesting season in the STAs. The Everglade snail kite has federal status as an endangered species. USFWS is consulted and the District 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.

OVERVIEW OF WATER YEAR 2018

The STAs combined, over their 24 years of operation, have treated approximately 20.1 million ac-ft of water (~6.6 trillion gallons) and retained 2,604 t of TP or 77% of the TP load that entered these facilities. The increase in the combined inflow water and TP loads to the STAs that began in WY2000 reflected an increase in treatment capacity as additional STAs came online (**Figure 5B-2**). The period of record (POR) inflow FWM TP concentration for all the STAs up through WY2018 is 137 µg/L, while the POR outflow FWM TP concentration is 31 µg/L (**Table 5B-1**).

All the STAs received a combined 1.6 million ac-ft of inflow during WY2018 (**Table 5B-1**). This was the greatest annual inflow water volume to the STAs over their POR (**Figure 5B-2**) and is attributed, in part, to rainfall from an unnamed storm in June 2017 and Hurricane Irma in September 2017. Of this total

[8] The District is not required to alleviate flooding in cells with nests that is due to direct rainfall onto the STA. The District, to the extent practicable, maintains the 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 STAs, the District maintains inflow to the affected cells at a restricted stage to prevent any further cell dry out, which would attract more nesting birds.

water volume, approximately 159,000 ac-ft were Lake Okeechobee releases directed to the STAs; 107,000 ac-ft of these releases were treated in the STAs, while 52,000 ac-ft were delivered as supplemental water to maintain water levels at target stages in STA-1E, STA-1W, STA-2, and STA-3/4.

The STAs received a combined 359 t of inflow TP load during WY2018 and retained 272 t of this mass (**Table 5B-1**), which represented a 77% load reduction. This was the greatest annual inflow TP load to the STAs over the POR and was approximately 30% higher than the next highest inflow TP load in WY2005 (**Figure 5B-2**). The overall annual FWM TP concentrations in the STAs decreased from 180 µg/L (inflow) to 36 µg/L (outflow). This was the second highest annual inflow FWM TP concentration over the POR. Except for treatment performance in WY2018, the POR time series revealed a fairly consistent increase in the annual percent TP load retained from the lowest retention in WY2003 (63%) to high values in recent water years (84 to 86%).

STA-3/4 had an annual outflow FWM TP concentration of 12 µg/L in WY2018, while annual outflow FWM TP concentrations in the other STAs ranged from 38 to 74 µg/L (**Table 5B-1**). STA-3/4 received the largest inflow water volume and both STA-2 and STA-3/4 the largest TP load this water year, while STA-1E received both the smallest inflow water volume and TP load (**Figure 5B-3**). HLRs during WY2018 ranged from 1.7 centimeters per day (cm/d) in STA-5/6 and 2.4 to 2.8 cm/d in STA-1E, STA-1W, STA-2, and STA-3/4 (**Figure 5B-3**). The PLRs were 1.3 to 1.4 grams per square meter per year ($g/m^2/yr$) in STA-2, STA-3/4, and STA-5/6 and 2.6 and 2.1 $g/m^2/yr$ in STA-1E and STA-1W, respectively.

Annual outflow FWM TP concentrations from STA-1E, STA-1W, STA-2, and STA-5/6 in WY2018 (**Table 5B-1**) were noticeably higher than corresponding annual outflow FWM TP concentrations observed in recent water years. The increased outflow TP concentrations during WY2018 were attributed to reduced STA treatment performance during the June 2017 rainfall event and Hurricane Irma (see discussion in the *Storm Impacts* Section) that negatively influenced treatment performance for the entire water year. Indeed, STA-1E, STA-1W, STA-2, and STA-5/6 received from 78 to 88% of their entire WY2018 TP load, while STA-3/4 received 68% of its WY2018 TP load, in June, September, and October 2017. If the flows and TP loads during these three months are removed from the calculation of annual outflow FWM TP concentrations, WY2018 treatment performance in STA-1E, STA-1W, STA-2, and STA-5/6 is comparable to that observed in recent water years. Interestingly, there was no indication that treatment performance in STA-3/4 during WY2018 was affected by the storms based on a comparison of annual outflow FWM TP concentrations.

None of the STA effective treatment areas were adjusted in computations for WY2018 because no flow-ways were taken offline during the water year (**Table 5B-2**). However, most flow-ways were ONR for at least a portion of WY2018. Details of the operational status of each flow-way are provided in the individual STA sections that follow.

During the 2018 nesting season, 147 black-necked stilt nests were observed across all the STAs, while no active burrowing owl nests were detected in any STA. Two active Everglade snail kite nests were found in STA-1E Cell 1 this water year. Operational priorities were adjusted in the STAs as needed to avoid disturbing active nests; any such adjustments are discussed in Appendix 5B-3.

Table 5B-1. Summary of treatment performance in each STA and all STAs combined for WY2018 and the POR.

Parameter (unit [a])	STA-1E	STA-1W	STA-2	STA-3/4	STA-5/6	All STAs
Effective Treatment Area (ac)	4,994	6,544	15,494	16,327	13,685	57,044
Adjusted Effective Treatment Area (ac) [b]	4,994	6,544	15,494	16,327	13,685	57,044
WY2018 Inflow						
Inflow Water Volume (ac-ft)	161,000	195,000	445,000	543,000	271,000	1,623,000
Inflow TP Load (t)	53	55	87	87	78	359
FWM Inflow TP Concentration (µg/L)	265	228	158	128	234	180
Hydraulic Loading Rate (cm/d)	2.7	2.5	2.4	2.8	1.7	2.4
Phosphorus Loading Rate ($g/m^2/yr$)	2.6	2.1	1.4	1.3	1.4	1.6
WY2018 Outflow						
Outflow Water Volume (ac-ft)	173,000	225,000	506,000	631,000	324,000	1,860,000
Outflow TP Load (t)	10.0	10.8	23.8	9.0	29.7	83
FWM Outflow TP Concentration (µg/L)	47	39	38	12	74	36
TP Retained (t)	43	44	63	74	49	272
TP Removal Rate ($g/m^2/yr$)	2.1	1.7	1.0	1.1	0.9	1.2
TP Load Retained (%)	81%	80%	73%	90%	62%	77%
POR						
Start Date	September 2004	October 1993 [d]	June 1999	October 2003	December 1997	WY1994–WY2018
Inflow Water Volume (ac-ft)	1,552,000	4,250,000	5,164,000	6,487,000	2,693,000	20,153,000
TP Inflow Load (t)	338	925	652	856	627	3,400
FWM Inflow TP (µg/L)	177	177	102	107	189	137
Outflow Water Volume (ac-ft)	1,479,000	4,393,000	5,557,000	6,652,000	2,446,000	20,528,000
TP Outflow Load (t)	75	249	149	128	194	795
FWM Outflow TP Concentration (µg/L)	41	46	22	16	64	31
TP Retained (t)	263	677	503	728	433	2,604
% TP Retained	78%	73%	77%	85%	69%	77%

a. Conversion factors: 1 ac = 0.40468 hectares or 4,046.8 square meters; 1 ac-ft = 1,233.5 cubic meters; 1 metric ton (t) = 1,000 kilograms; and 1 cm/d = 0.39370 inches per day.

b. Adjusted effective treatment area is time and area weighted to exclude any cells that were temporarily 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.

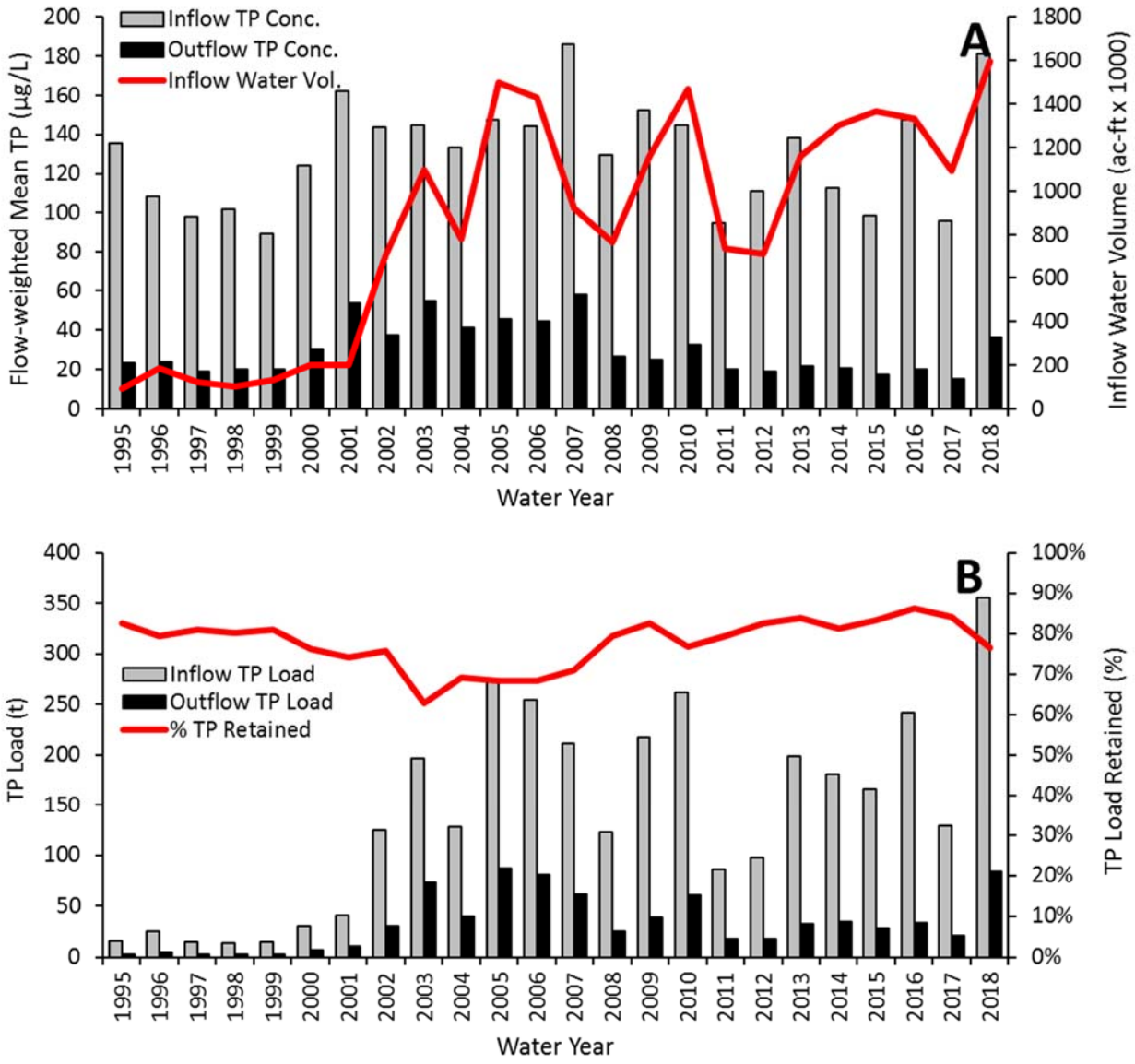


Figure 5B-2. POR time series in all the STAs combined for (A) annual inflow and outflow FMW TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

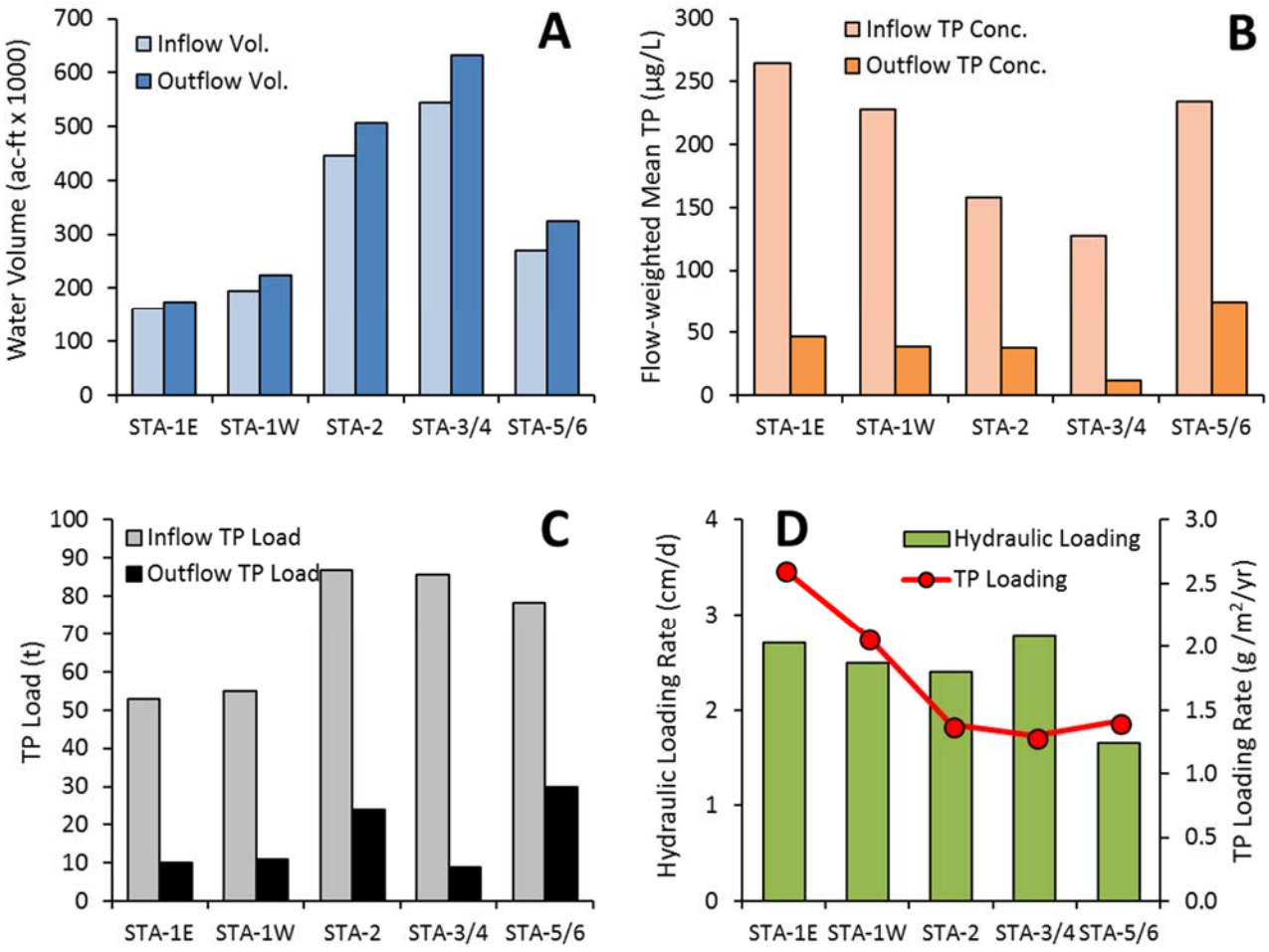


Figure 5B-3. Comparison of (A) inflow and outflow water volumes (Vol.), (B) inflow and outflow FWM TP concentrations (Conc.), (C) inflow and outflow TP loads, and (D) hydraulic and TP loading rates in the STAs during WY2018.

Table 5B-2. Operational status of STA flow-ways during WY2018.

STA	Flow-way	Effective Treatment Area (ac[a])	Operational Status [b]	Comments [c, d]	% Time Online
STA-1E	Entire STA	4,994			100
	Eastern Flow-way	1,082	ONR: 05/2017 to 07/2017	SK nesting	100
	Central Flow-way	1,939	Online all year		100
	Western Flow-way	1,973	ONR: WY2018 ONR: 05/2017 to 06/2017 & 04/2018	Deep water due to topography, structure repairs, vegetation maintenance BNS nesting	100
STA-1W	Entire STA	6,544			100
	Eastern Flow-way	2,171	ONR: 06/2017 ONR: 02/2018 to 04/2018	BNS nesting STA-1W Expansion Area construction	100
	Western Flow-way	1,369	ONR: 06/2017 ONR: 02/2018 to 04/2018	BNS nesting STA-1W Expansion Area construction	100
	Northern Flow-way	3,004	ONR: 06/2017 ONR: 05/2017 to 07/2017 ONR: 02/2018/ to 04/2018	BNS nesting STA-1W Expansion Area construction STA-1W Expansion Area construction	100
STA-2	Entire STA	15,494			100
	Flow-way 1	1,840	ONR: 05/2017 to 07/2017 & 11/2017	Maintain stage/flow for RSSP research study	100
	Flow-way 2	2,373	Online all year		100
	Flow-way 3	2,296	ONR: 06/2017 ONR: 04/2018	BNS nesting Maintain stage/flow for RSSP research study	100
	Flow-way 4	5,990	ONR: 05/2017 to 06/2017 ONR: 08/2017 to 04/2018	BNS nesting Vegetation maintenance	100
	Flow-way 5	2,995	ONR: 06/2017 ONR: 02/2018 to 04/2018	BNS nesting Vegetation maintenance	100
STA-3/4	Entire STA	16,327			100
	Eastern Flow-way	6,476	ONR: 05/2017 to 07/2017	Vegetation maintenance	100
	Central Flow-way	5,349	ONR: 07/2017 ONR: 03/3018 to 04/2018	Maintain stage/flow for RSSP research study Vegetation maintenance	100
	Western Flow-way	4,502	ONR: 07/2017 to 08/2017	Maintain stage/flow for RSSP research study	100
STA-5/6	Entire STA	13,685			100
	Flow-way 1	2,418	DO: 05/2017 to 06/2017	Cell dryout (Cell 1A)	100
	Flow-way 2	2,068	DO: 05/2017 to 06/2017	Cell dryout (Cell 2A)	100
	Flow-way 3	1,922	DO: 05/2017 to 06/2017	Cell dryout (Cell 3A)	100
	Flow-way 4	1,871	DO: 05/2017 to 06/2017	Cell dryout (Cell 4A)	100
	Flow-way 5	2,642	ONR: 05/2017 to 06/2017 DO: 05/2017 to 06/2017	BNS nesting Cell dryout (Cell 5A)	100
	Flow-way 6	1,900	ONR: 05/2017 DO: 03/2018 to 04/2018	BNS nesting Cell dryout (Cells 6-4 & 6-2)	100
	Flow-way 7	621	DO: 05/2017 to 06/2017 DO: 03/2018 to 04/2018	Cell dryout (Cell 6-5)	100
	Flow-way 8	242	DO: 05/2017 to 06/2017 DO: 03/2018 to 04/2018	Cell dryout (Cell 6-3)	100

a. Conversion factor: 1 acre = 0.40468 hectares or 4,046.8 square meters.

b. DO: dryout; OFF: offline; and ONR: online with restrictions.

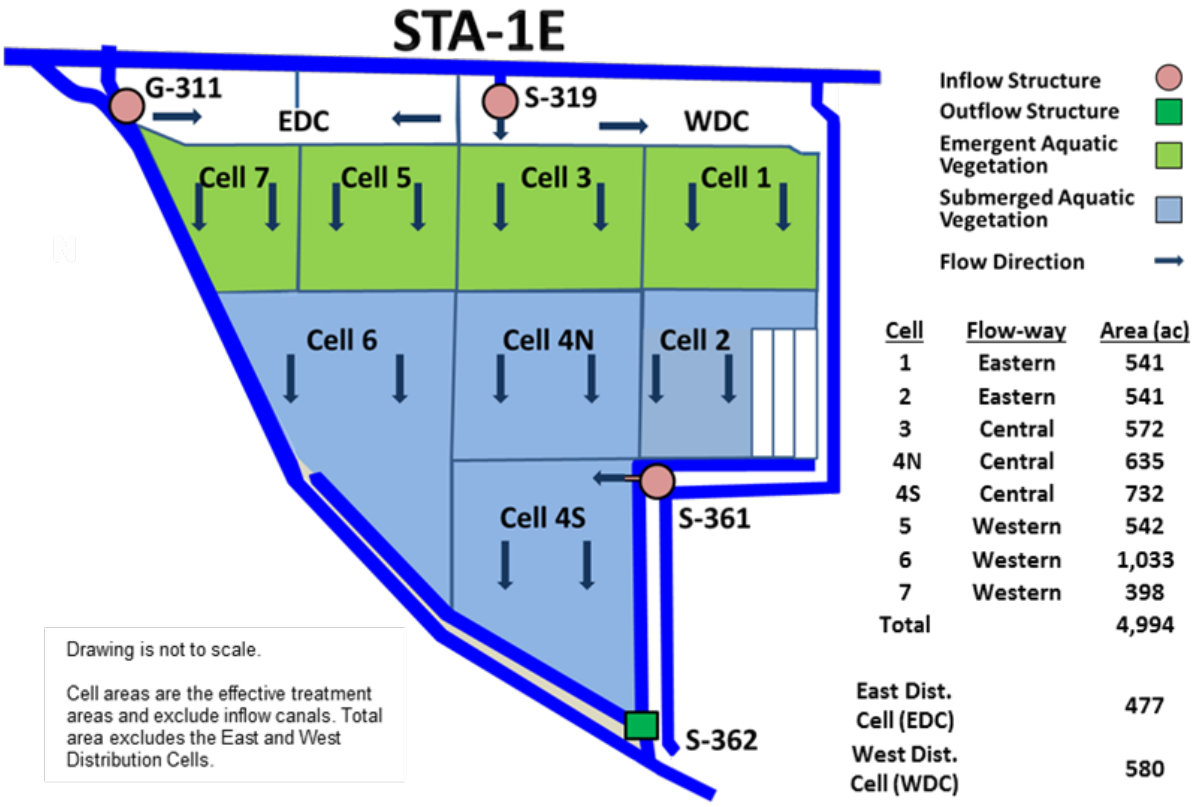
c. BNS: black-necked stilt; RSSP: Restoration Strategies Science Plan; SK: Everglade snail kite; and USACE: United States Army Corps of Engineers.

d. STA operations and maintenance activities modified during WY2018 due to bird nesting are detailed in Appendix 5B-3 of this volume.

STA-1E

STA-1E is located 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. 2014; **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, Lake Okeechobee regulatory releases, and the Rustic Ranches subdivision. In WY2007, STA-1E started receiving runoff from Wellington Acme Basin B. During the dry season, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration in priority cells, i.e., cells dominated by SAV. 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: EDC – East Distribution Cell; Dist. – distribution; and WDC – West Distribution Cell.)

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, an unnamed storm 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), dryout 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 applesnail [*Pomacea maculata*] in July 2013).

STA TREATMENT PERFORMANCE

Over its 14-year POR, STA-1E has treated approximately 1.6 million ac-ft of water and retained 263 t of TP or 78% of the inflow TP load (**Table 5B-1**). The POR inflow FWM TP concentration to this facility is 177 µg/L, while the POR outflow FWM TP concentration is 41 µg/L.

STA-1E received a relatively high inflow water volume during WY2018 (161,000 ac-ft) compared to previous water years (**Figure 5B-5**). Inflow water volumes during June, September, and October 2017 were an order of magnitude greater than inflows in the other months this water year. Of the total inflow water volume in WY2018, approximately 17,100 ac-ft were Lake Okeechobee releases directed to STA-1E via the S-319 and G-311 structures; 10,300 ac-ft of these releases were treated in STA-1E, while 6,800 ac-ft were delivered as supplemental water to maintain the vegetation communities in the STA. Lake Okeechobee water was received in all months this water year except July 2017.

STA-1E retained 81% of the inflow TP load this water year (43 of 53 t; **Table 5B-1**). Percent TP retention has been fairly constant over the past eight water years. Annual inflow and outflow FWM TP concentrations were 265 and 47 µg/L in WY2018, respectively, while the HLR and PLR were 2.7 cm/d and 2.6 $g/m^2/yr$, respectively. STA-1E received its highest annual inflow TP FWM concentration and TP load over its POR this water year (**Figure 5B-5**).

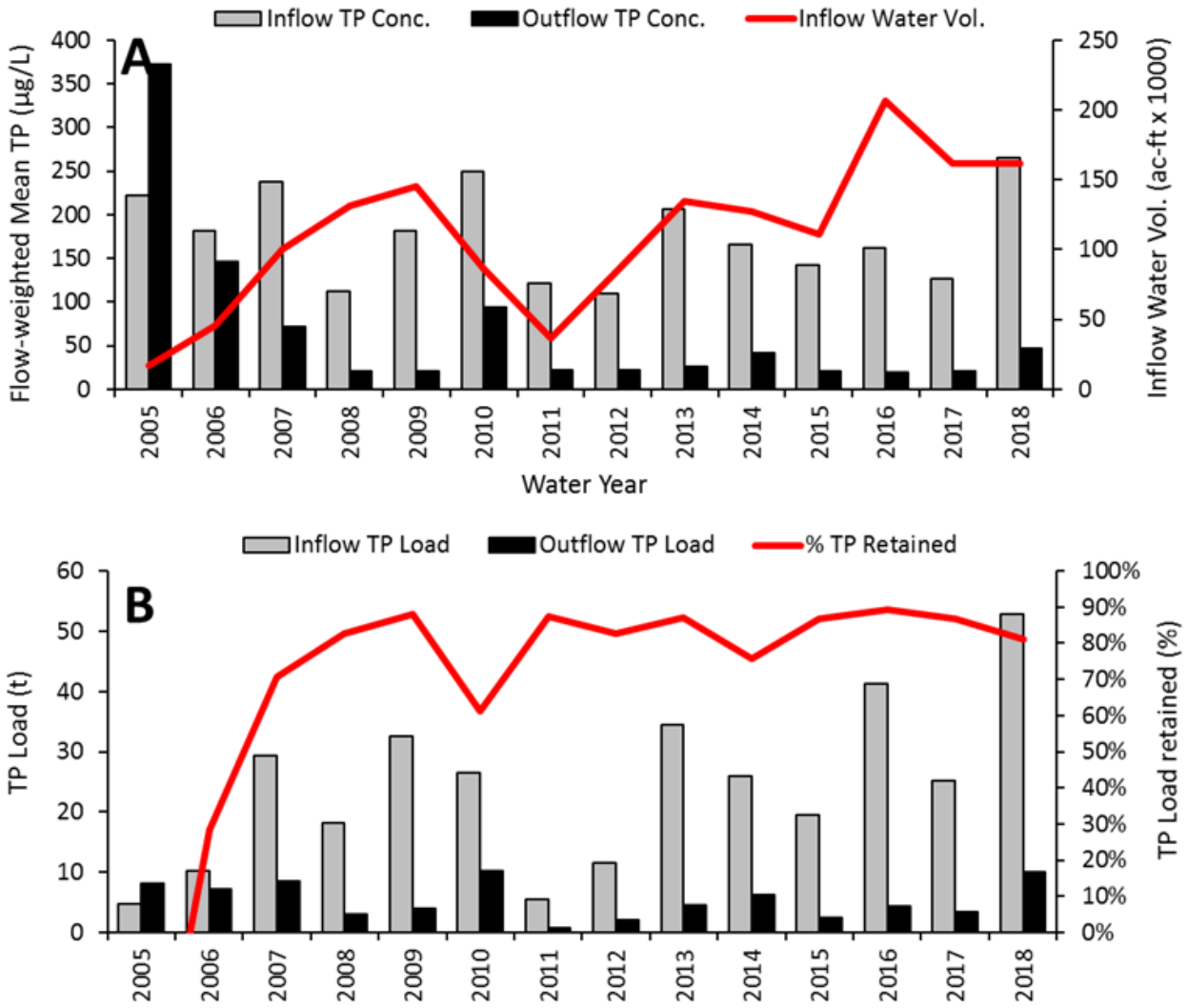


Figure 5B-5. POR time series in STA-1E for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

All three flow-ways in STA-1E were operational throughout WY2018, although each flow-way was ONR during a portion of the water year when stage and/or flow were restricted due to one or more one of the following: presence of nesting Everglade snail kites and black-necked stilts, structure repairs, impacts related to Hurricane Irma, vegetation maintenance activities, or deep water conditions promoted by a steep topographic gradient in the Western Flow-way (**Table 5B-2**).

USACE repairs to water control structures in the Western and Central flow-ways were completed by May 2017. In addition, construction of G-716, a new triple-gated spillway that connects the East and West distribution cells, was completed in June 2017.

An electric power outage due to Hurricane Irma in September 2017 resulted in some structures in STA-1E being inoperable both during and after the storm. As a result, stage within some cells of STA-1E increased to 30 cm or more above target stage for several weeks after the hurricane. All electric power was restored by October 2017 and STA-1E resumed normal operations.

Dryout

All cells in STA-1E were hydrated throughout WY2018.

Migratory Bird and Snail Kite Nesting

Black-necked stilt nests were observed in STA-1E Cells 2, 5, and 7 between May and June 2017. Stilt nests were also observed in Cells 5 and 6 in April 2018. Two active Everglade snail kite nests were present in Cell 4N from May through July 2017. No active Florida burrowing owl nests were observed in STA-1E. Information on STA-1E operational and maintenance adjustments made to protect bird nests during WY2018 is presented in Appendix 5B-3 of this volume.

VEGETATION MANAGEMENT

STA-1E vegetation management activities in WY2018 were largely focused on controlling FAV and preparing impacted cells for future rehabilitation efforts. Approximately 708 ac of FAV were treated in the Eastern and Western distribution cells to prevent non-rooted FAV species from encroaching on water control structures and limit their spread to the downstream treatment cells.

The Eastern Flow-way of STA-1E began normal operation in WY2016 after a planting and grow-in period following decommissioning of the USACE Periphyton-based Stormwater Treatment Area (PSTA) Project; vegetation coverage is continuing to expand in this flow-way. Non-rooted FAV invading Cell 1 was a continuing threat to the establishment of EAV; in response, 116 ac of FAV were treated during the water year. Muskgrass has recolonized Cell 2, although coverage has fluctuated in recent water years due to seasonal die-offs and unplanned cell dry outs. Invasive and nuisance species control in Cell 2 included treating 67 ac of FAV to protect maturing vegetation strips and encourage the spread of SAV.

Vegetation management activities in the Central Flow-way of STA-1E largely focused on removing cattail to increase SAV coverage, repairing vegetation strips, and treating FAV. Willow (*Salix* spp.), primrose willow, and non-rooted FAV coverage continued to expand in Cell 3; in response, 125 ac of primrose willow and 300 ac of FAV were treated to limit their spreading to the downstream SAV cells. In WY2018, SAV coverage continued to expand in Cell 4S but remained unstable in Cell 4N. Four hundred (400) ac of FAV and 100 ac of cattail in Cell 4N and 30 ac of FAV (including 0.5 ac of feathered mosquitofern [*Azolla pinnata*]) and 70 ac of cattail in Cell 4S were treated this water year. Sixteen (16) ac of giant bulrush were planted in Cell 3 to serve as harvest sites for future rehabilitation efforts, 5 ac of giant bulrush were planted to repair vegetation strips damaged by Hurricane Irma, and inoculations of southern naiad were made throughout the flow-way.

In the Western Flow-way of STA-1E, 18 ac of alligator flag and 10 ac of giant bulrush were planted in Cell 5 this water year to repair hydraulic short circuits and as harvest sites to provide plants for more extensive plantings in the future. Willow, primrose willow, and pennywort (*Hydrocotyle umbellata*) occurred throughout this cell and are being controlled before extensive rehabilitation efforts begin; 5 ac of willow, 222 ac of primrose willow, and 450 ac of FAV were treated in WY2018. Most of the cattail in Cell 7 was rooted in surficial soil that delaminated (i.e., separated) from the deeper soil layer during Hurricanes Matthew and Irma and formed floating muck islands. Almost all cattail on these islands subsequently died. Efforts are under way to create conditions that promote cattail with a deeper root system to help to stabilize the soil. To this end, 150 acres of non-rooted FAV were treated, and 34 ac of alligator flag and 44 ac of giant bulrush were planted in strips to buffer this cell from the effects of high wind and flow events. In addition, SAV was inoculated into deeper areas of Cell 7 and small plantings of duck potato, pickerelweed (*Pontederia cordata*), spikerush, and rooted FAV species were made to test the viability of introducing these species into areas of the cell where cattail has failed. Test plantings with multiple species in Cell 7 will continue for the next few years. In Cell 6, 180 acres of FAV were treated and 19 ac of giant bulrush were planted in vegetation strips to repair hydraulic short circuits and at harvest sites.

VEGETATION SURVEYS

Ground Surveys for SAV

Ground SAV surveys were conducted on six occasions in WY2018 to map SAV coverage in STA-1E: in June and November 2017 and February 2018 in Cells 4N and 4S; and in May, June, and October 2017 and February 2018 in Cell 6 (Appendix 5B-4, Figures 1 through 6). The following SAV taxa were identified in STA-1E this water year: coontail; bladderwort (*Utricularia* spp.); hydrilla; muskgrass; southern naiad; and spiny naiad. Hydrilla was the most abundant SAV taxon in Cells 4N and 4S, while southern naiad and coontail were most abundant in Cell 6. Muskgrass, bladderwort, and spiny naiad were present in smaller quantities in STA-1E this water year.

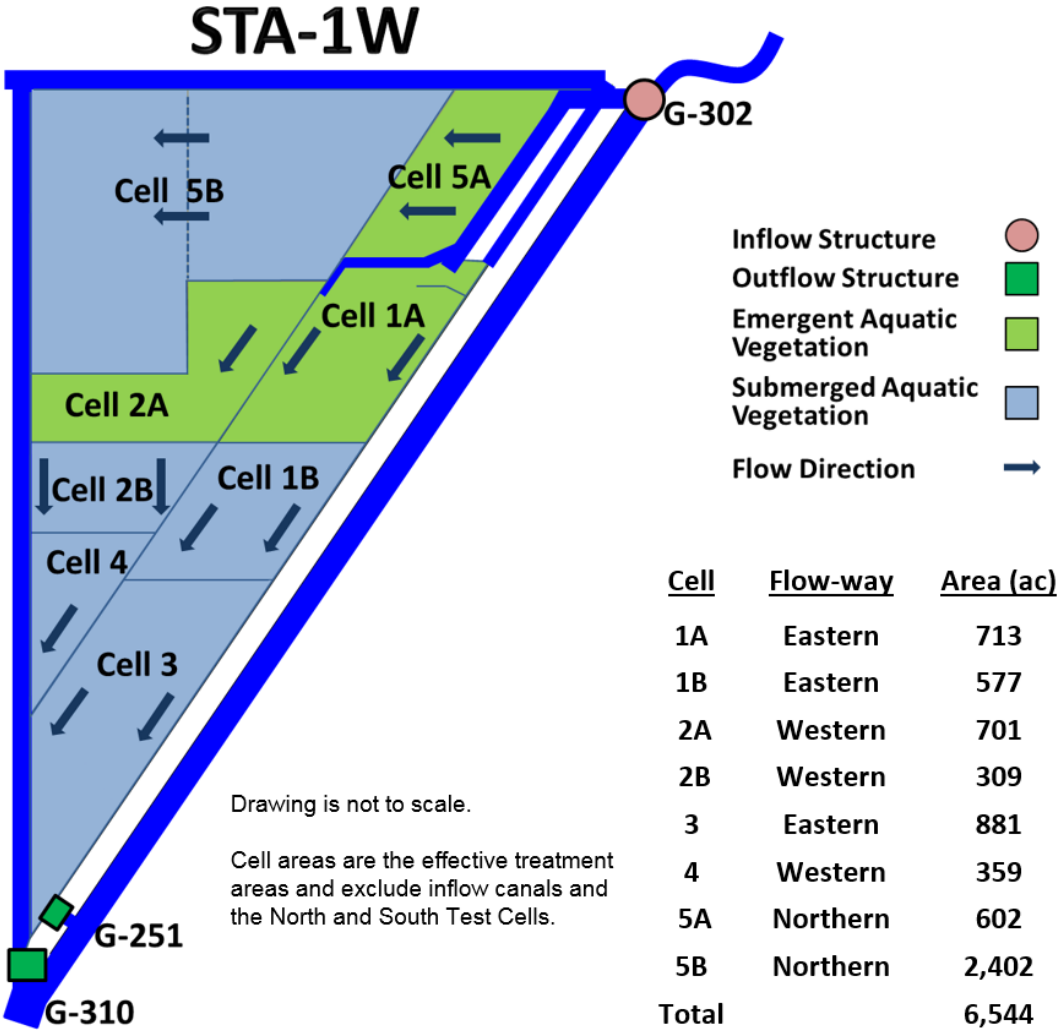
Pre-hurricane total SAV coverage was medium or high at about one-third of the survey sites and absent to medium at the remaining sites. Substantial scouring occurred in Cells 4N and 4S during the hurricane resulting in the loss of much SAV; only a few survey sites had high total SAV coverage following the storm. SAV coverages had not recovered to pre-hurricane levels by the time the last ground SAV survey was conducted in February 2018 (Appendix 5B-4, Figures 1 through 6).

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**). This STA encompasses 6,544 ac of treatment area arranged into three flow-ways with eight treatment cells (Piccone et al. 2014; **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 Cell 2 was completed in 2007 with the construction of two new interior levees that created Cells 1A, 1B, 2A, and 2B. Construction of additional interior levees completed in 2015 completely separated inflow to the Western Flow-way from inflow entering the Eastern Flow-way. This STA receives inflow primarily from the S-5A drainage basin and East Beach Water Control District, as well as Lake Okeechobee regulatory releases. During the dry season, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration in cells dominated by SAV. The flow-way nomenclature for STA-1W is as follows:

- Eastern Flow-way = Cells 1A, 1B, and 3
- Western Flow-way = Cells 2A, 2B, and 4
- Northern Flow-way = Cells 5A and 5B

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 that were damaged by hydraulic overloading in previous water years and restore treatment performance to all cells. Stage in the Eastern Flow-way was lowered in WY2016 as part of a major vegetation rehabilitation effort that included planting depth-tolerant species such as giant bulrush and alligator flag.



Cell	Flow-way	Area (ac)
1A	Eastern	713
1B	Eastern	577
2A	Western	701
2B	Western	309
3	Eastern	881
4	Western	359
5A	Northern	602
5B	Northern	2,402
Total		6,544

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.

STA TREATMENT PERFORMANCE

Over its 24-year POR, STA-1W has treated approximately 4.3 million ac-ft of water and retained 677 t of TP or 73% of the total inflow TP load (**Table 5B-1**). The POR inflow FWM TP concentration is 177 µg/L, while the POR outflow FWM TP concentration is 46 µg/L.

In WY2018, STA-1W treated approximately 195,000 ac-ft of runoff (**Table 5B-1**). Inflow water volumes during June and October 2017 were an order of magnitude greater than inflows in most other months this water year. Of the total inflow water volume in WY2018, approximately 6,700 ac-ft were Lake Okeechobee releases directed to STA-1W via G-302; 5,500 ac-ft of these releases were treated in STA-1W, while 1,200 ac-ft were delivered as supplemental water to maintain the vegetation communities in the STA. Lake Okeechobee water was received this water year in all months except July through September 2017 and January 2018.

STA-1W had an inflow and outflow FWM TP concentrations of 228 and 39 µg/L, respectively, this water year (**Table 5B-1**). STA-1W retained 44 t of TP load or 80% of the inflow TP load (55 t) and had an HLR and a PLR of 2.5 cm/d and 2.1 $g/m^2/yr$, respectively. Treatment performance in STA-1W has fully 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 relatively constant at 80% or greater since WY2009, which is comparable to the level of treatment performance that occurred prior to WY2001.

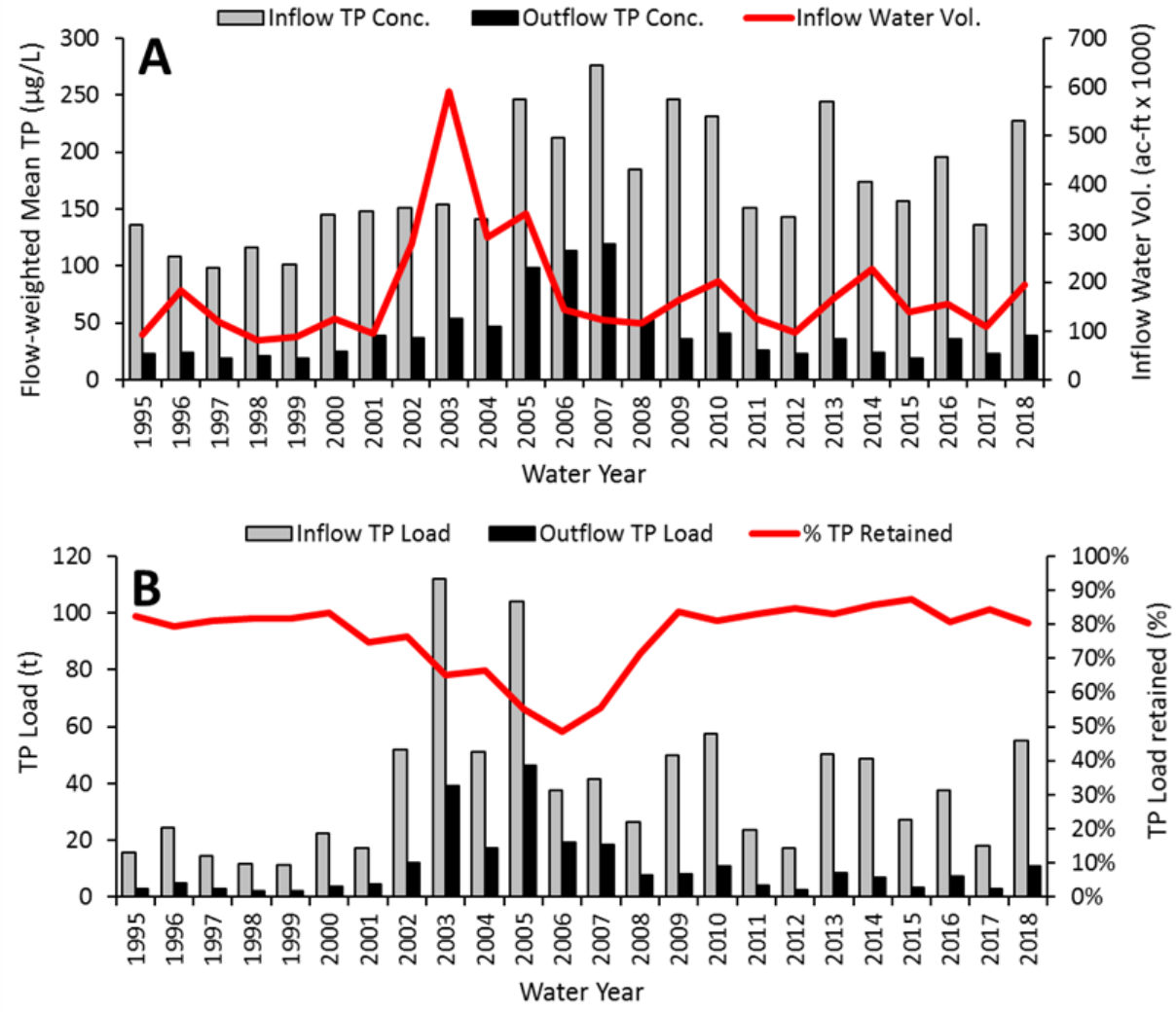


Figure 5B-7. POR time series in STA-1W for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

All three flow-ways in STA-1W were operational throughout WY2018, although each flow-way was ONR during a portion of the water year when stage and/or flow were restricted due to one or more of the following: the presence of nesting black-necked stilts, vegetation maintenance, construction activities associated with the expansion of STA-1W[9], or impacts from an unnamed storm in June 2017 and Hurricane Irma in September 2017 (**Table 5B-2**).

As part of the STA-1W Expansion Area Project, construction of the new G-727A overflow weir on the western levee of Cell 5B was initiated in February 2017 and completed by August 2017. The G-306E–H outflow structures along this levee were closed until the new structure was completed and operation of the Northern Flow-way was restricted during this period. In addition, construction related to the connection of the new discharge canal to the existing STA-1W discharge canal, as well as the improvements to the G-251 embankment, were initiated in February 2018. The G-251 embankment construction was completed by March 2018.

An electric power outage due to Hurricane Irma resulted in some structures in STA-1W being inoperable both during and after the storm. As a result, stage within STA-1W increased from 8 to 46 cm above target stage for several weeks after the hurricane. All electric power was restored by October 2017 and STA-1W resumed normal operations. Hurricane Irma also caused substantial damage to the roof of the G-310 Pump Station. Roof debris was pulled into the pumps, which rendered the pump station inoperable during the storm. Temporary roof repairs were completed within several days after the storm, and the pump station was returned to service. Permanent roof repairs to G-310 began in March 2018 and were completed by September 2018.

Dryout

All cells in STA-1W were hydrated throughout WY2018.

Migratory Bird and Snail Kite Nesting

Black-necked stilts were observed nesting in STA-1W Cells 1B, 4, and 5B in June 2017. No Everglade snail kite or Florida burrowing owl nests were found in STA-1W. Information on STA-1W operational and maintenance adjustments made to protect bird nests during WY2018 is presented in Appendix 5B-3 of this volume.

VEGETATION MANAGEMENT

The primary focus of vegetation management in STA-1W during WY2018 was the rehabilitation of Cells 1A and 5B. These two cells had been impacted in past water years by the spread of primrose willow, non-rooted FAV, and floating cattail tussocks. Herbicide treatments were used to control these undesirable species. This water year, 318 ac of FAV in Cell 1A were treated as a continuation of the rehabilitation effort. Other treatments performed in WY2018 included 80 ac of primrose willow, 1.5 ac of FAV, and 100 ac of cattail in Cell 1B; 85 ac of non-rooted FAV in Cell 2A (to keep the inflow and outflow spreader canals open); 59 ac of non-rooted FAV and 170 ac of Mexican water lily[10] (*Nymphaea mexicana)* in Cell 2B; 66 ac of Mexican water lily, 55 ac of primrose willow, and 30 ac of FAV in Cell 4; and 218 ac of FAV in Cell 5A. Approximately 17 ac in weak spots along vegetation strips in Cell 1B and 30 ac at the inflow region of Cell 5B were planted with alligator flag this water year.

[9] Construction of a 6,500-ac addition to the treatment area in STA-1W (see **Figure 5B-1**) was initiated in April 2015 and is scheduled to be completed by December 2018.

[10] Mexican water lily, a non-native species in Florida, can be invasive and shade out SAV. The District generally favors SAV over FAV in the STAs, so Mexican water lily, like other FAV species, is controlled when it becomes a problem in SAV areas.

VEGETATION SURVEYS

Ground Surveys for SAV

Ground SAV surveys were conducted on eight occasions during WY2018 to map SAV coverage in STA-1W: in August 2017 and February 2018 in Cells 1B and 3; in June and November 2017 and February 2018 in Cells 2B and 4; and in May and October 2017 and March 2018 in Cell 5B (Appendix 5B-4, Figures 7 through14). The SAV communities in Cells 1B, 3 and 4 were dominated by muskgrass, while Cell 5B was dominated by muskgrass and southern naiad. Additionally, the SAV community in Cell 2B was dominated by coontail. Other SAV taxa observed in lesser quantities in STA-1W this water year included hydrilla, spiny naiad, and bladderwort.

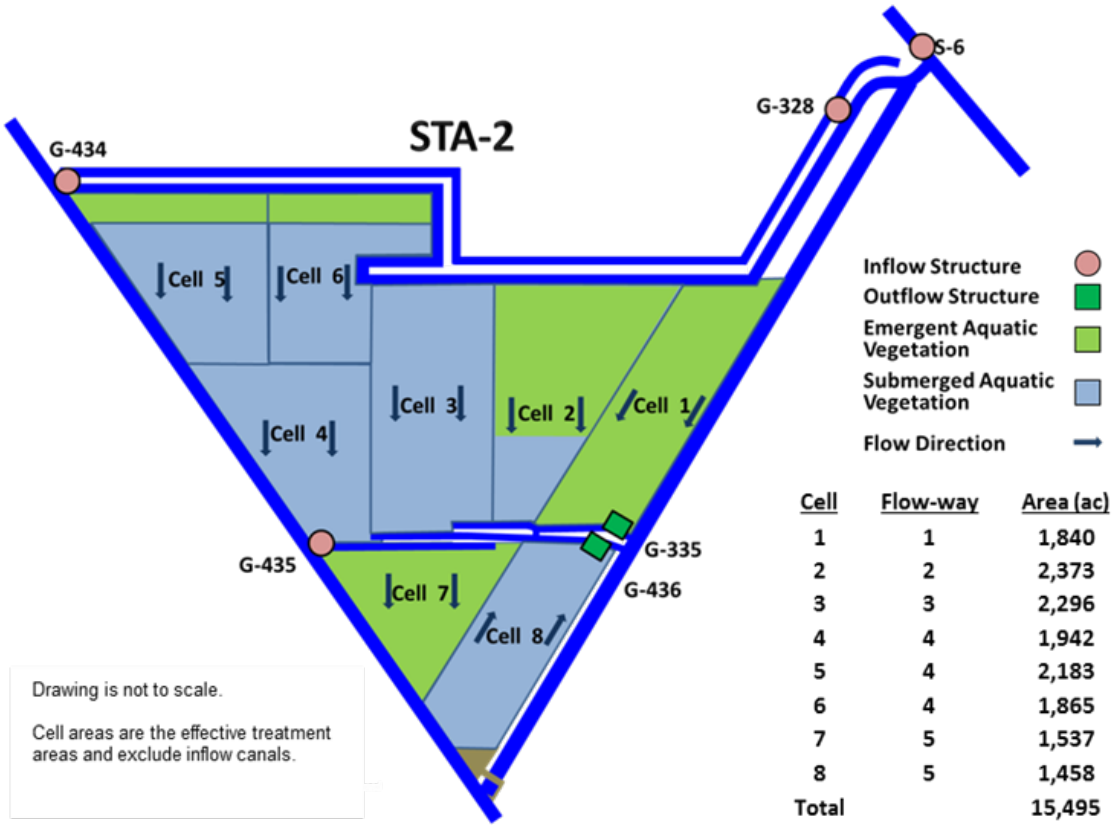
Total SAV coverage was medium to high at 50% or more of survey sites in STA-1W prior to Hurricane Irma. Total SAV coverage declined substantially following the storm, where high coverages were observed at less than 25% of survey sites and low coverages were much more common. SAV coverages had not recovered to pre-hurricane levels by the time the last ground SAV survey was conducted in February 2018 (Appendix 5B-4, Figures 7 through14).

STA-2

STA-2 is located in Palm Beach County immediately west of WCA-2A (**Figure 5B-1**). 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 offline 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 a total treatment area of 15,494 ac (Piccone et al. 2014; **Figure 5B-8**). STA-2 receives agricultural runoff from three 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 and the remaining portion of the S-2 basins. STA-2 also receives runoff from the East Shore Water Control District, the Closter Farms Drainage System, and a portion of the S-5A basin. During the dry season, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration in cells dominated by SAV. 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.



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.

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. Starting in WY2011, as a proactive measure, stage throughout STA-2 was increased to hold more water in the system in advance of the dry season, which has helped minimize dryout. One feature of STA-2 thought partly responsible for its historically good treatment performance is that all of Cell 1 and a portion of Cell 2 were never farmed prior to these areas becoming part of the STA. The hypothesis has been that there is reduced P flux from these unfarmed soils back to the water column, which leads to lower outflow TP concentrations from these cells.

STA Treatment Performance

Over its 17-year POR, STA-2 has treated approximately 5.2 million ac-ft of water and retained 503 t of TP or 77% of the TP load that entered this facility (**Table 5B-1**). The POR inflow FWM TP concentration to this facility is 102 µg/L, while the POR outflow FWM TP concentration is 22 µg/L.

STA-2 treated approximately 445,000 ac-ft of runoff in WY2018, a relatively higher volume compared to prior water years (**Figure 5B-9**). Inflow water volumes during June, September, and October 2017 were an order of magnitude greater than inflows in the other months this water year. Of the total inflow water volume in WY2018, approximately 59,100 ac-ft were Lake Okeechobee releases directed to STA-2 via S-6, G-434, and G-435; 53,500 ac-ft of these releases were treated in STA-2, while 5,600 ac-ft were delivered

as supplemental water to maintain the vegetation communities in STA-2. Lake Okeechobee water was received in May and June 2017 and December 2017–April 2018 this water year.

STA-2 had an inflow and outflow FWM TP concentrations of 158 and 38 µg/L, respectively, this water year (**Table 5B-1**). The facility retained 63 t of TP, or 73% of the inflow TP load (87 t), and had an HLR and PLR of 2.4 cm/d and 1.4 g/m^2/yr, respectively. The treatment performance of STA-2 in WY2018 and previous water years, as measured by the percent TP load retained, has been fairly consistent over the POR (~ 73 to 84%; **Figure 5B-9**). STA-2 received its highest annual inflow TP FWM concentration and TP load this water year; the inflow TP load was approximately 60% greater than the next highest inflow TP load that occurred in WY2016.

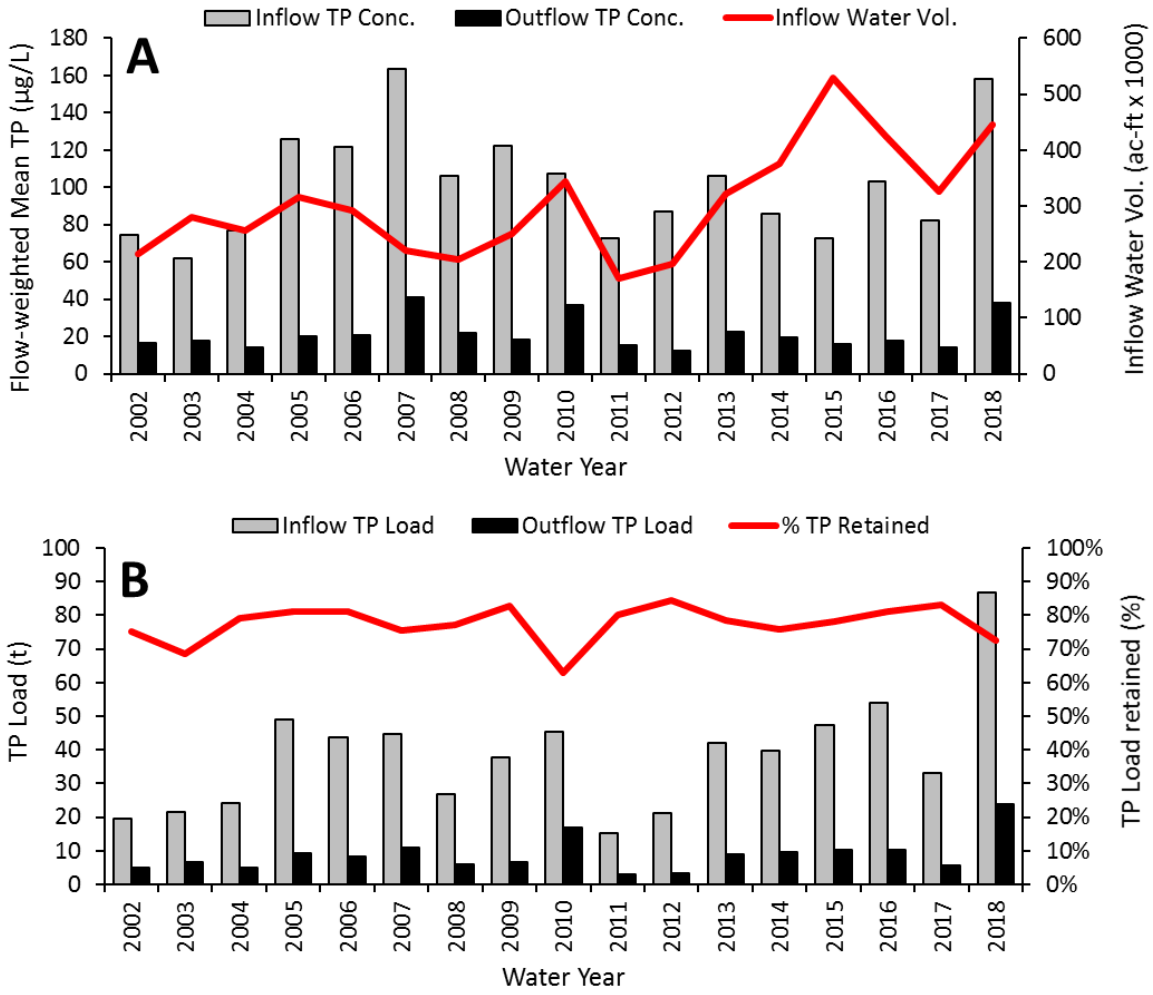


Figure 5B-9. POR time series in STA-2 for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

All five flow-ways in STA-2 were operational throughout WY2018, although Flow-ways 1, 3, 4, and 5 were ONR during a portion of the water year when stage and/or flow were restricted due to the presence of nesting black-necked stilts, STA operation requirements for the P Flux Science Plan research study[11], or impacts from an unnamed storm in June 2017 and Hurricane Irma in September 2017 (**Table 5B-2**).

Electric power outages due to Hurricane Irma resulted in some structures in STA-2 being inoperable both during and after the storm. Correspondingly, stages in STA-2 cells increased up to 60 cm above their target stage following the storm. All electric power was restored by October 2017 and STA-2 resumed normal operations. Hurricane Irma also caused substantial damage to the roof of the G-434 Pump Station. Roof repairs were begun in February 2018 and were completed by September 2018.

Dryout

All cells in STA-2 were hydrated throughout WY2018.

Migratory Bird and Snail Kite Nesting

Black-necked stilts were observed nesting in STA-2, Cell 5 in May 2017 and in Cells 3, 6, and 8 in June 2017. Stilt nests were also observed in Cell 3 in April 2018. No Everglade snail kite or Florida burrowing owl nests were found in STA-2. Information on STA-2 operational and maintenance adjustments made to protect bird nests during WY2018 is presented in Appendix 5B-3 of this volume.

VEGETATION MANAGEMENT

Vegetation management activities in STA 2 during WY2018 largely were focused on preparing Cells 5 and 6 for rehabilitation by treating non-rooted FAV (145 ac in Cell 5 and 120 ac in Cell 6) and 53 ac of floating cattail, 41 ac of floating torpedo grass (*Panicum repens*), and 53 ac of mixed species floating tussocks. In addition, approximately 100 ac of floating cattail were mechanically removed from the north end of Cell 6. In Cell 6 in areas where cattail had floated (north end of Cell 5) were planted with 57 ac of alligator flag, 42 ac of giant bulrush, and 30 ac of alligator flag were planted. Treatments of non-rooted FAV in Cells 1, 2, and 3 increased as more FAV was flushed into these cells than in previous years. To this end, 16 ac of FAV and 1 ac of cattail were treated in Cell 1; 25 ac of FAV were treated in Cell 2; and 90 ac of FAV were treated in Cell 3. Inoculations of muskgrass and southern naiad continued in Cells 2, 3, and 8 as part of converting these cells from EAV to SAV communities.

VEGETATION SURVEYS

Ground Surveys for SAV

Ground SAV surveys were conducted on nine occasions during WY2018 to map SAV coverage in STA-2: in June and October 2017 and February 2018 in Cell 3; in August 2017 and March 2018 in Cell 4; in August 2017 and April 2018 in Cell 5; in October 2017 in Cell 6; and in December 2017 in Cell 8 (Appendix 5B-4, Figures 15 through18, and 20 through 25). Muskgrass was the dominant taxon in the SAV communities, especially in Cells 4 and 6. Southern naiad was also present in dense coverages in Cells 5 and 8, while spiny naiad was present in moderate coverages in Cells 4 and 6. Other SAV taxa observed in lesser quantities in STA-2 this water year included bladderwort, coontail, and pondweed.

Total SAV coverage across STA-2 was highly variable prior to Hurricane Irma. Cell 4 and the outflow regions of Cells 5, 6, and 8 had the highest coverage. No or low SAV coverage was found at survey sites

[11] *Evaluation of Phosphorus Sources, Forms, Flux and Transformation Processes in the Stormwater Treatment Areas* study, otherwise known as the "P Flux Study".

in the other areas of Cells 5, 6, and 8. In contrast, the majority of survey sites in Cell 3 had medium SAV coverage. Post-hurricane impacts to the SAV communities were greatest in Cell 3 where most SAV was lost during the storm and coverage continued to decline by the February 2018 ground SAV survey (Appendix 5B-4, Figure 19).

STA-3/4

STA-3/4 is located in Palm Beach County northeast of the Holey Land Wildlife Management Area and north of WCA-3A (**Figure 5B-1**). This STA became operational in WY2004 and a new interior levee was constructed in WY2006 to create 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. 2014; **Figure 5B-10**). A 445-ac section of Cell 2B is the site of the District's STA-3/4 PSTA Project. The STA-3/4 PSTA Project has been described in past South Florida Environmental Reports (SFERs) and is discussed briefly in Chapter 5C of this volume. STA-3/4 treats stormwater runoff from the S-2/S-7, S-3/S-8, S-236, and C-139 basins, the South Shore Drainage District, and the South Florida Conservancy District, and releases from Lake Okeechobee. During the dry season, supplemental water is delivered from Lake Okeechobee, when available, to maintain hydration in cells dominated by SAV. 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**) is a 15,000-ac aboveground storage reservoir located immediately north of STA-3/4, and a critical component of the *Restoration Strategies Regional Water Quality Plan* (SFWMD 2012). This facility was completed and started operation in WY2016. STA-3/4 began receiving outflows from the reservoir in November 2015. The primary purpose of the A-1 FEB is to temporarily store stormwater runoff and thereby attenuate peak inflows to STA-3/4 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-3/4. See Volume III, Appendix 3-3 for additional information on the A-1 FEB.

Similar to the other STAs, 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 to 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.

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 15-year POR has treated the largest volume of water (6.5 million ac-ft) and retained the most TP (728 t) with the greatest treatment efficiency, based on its percent TP load retained (85%), of all the STAs (**Table 5B-1**). The POR inflow FWM TP concentration STA-3/4 is 107 µg/L, while the POR outflow FWM TP concentration is 16 µg/L, which is the lowest POR outflow TP concentration among the STAs. Based on these metrics, STA-3/4 has been the best performing STA over its POR. The good POR treatment performance of STA-3/4 can be attributed, in part, to its relatively low POR inflow TP concentration (only STA-2 had a lower POR inflow TP concentration [102 µg/L]; 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 among the STAs. A fuller explanation of why treatment performance varies among the STAs is one of the objectives of the ongoing Science Plan study P Flux Study (see Chapter 5C in this volume).

STA-3/4 treated approximately 543,000 ac-ft of runoff in WY2018 (**Table 5B-1**). Of this total inflow water volume, approximately 69,000 ac-ft were Lake Okeechobee releases sent to the STA-3/4-A1 FEB system prior to delivery south to WCA-2A and WCA-3A; 37,800 ac-ft of these releases were treated in STA-3/4, while 31,200 ac-ft were delivered as supplemental water to maintain the vegetation communities in the STA. Lake Okeechobee water was received in May and June 2017 and December 2017–April 2018 this water year.

STA-3/4 had an inflow FWM TP concentration of 128 µg/L and produced an outflow FWM TP concentration of 12 µg/L this water year, which is among the lowest annual outflow concentrations recorded in any STA to date (**Table 5B-1**). This facility retained 74 t of TP, or 90% of the inflow TP load (87 t) and had an HLR and PLR of 2.8 cm/d and 1.3 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 88%; **Figure 5B-11**).

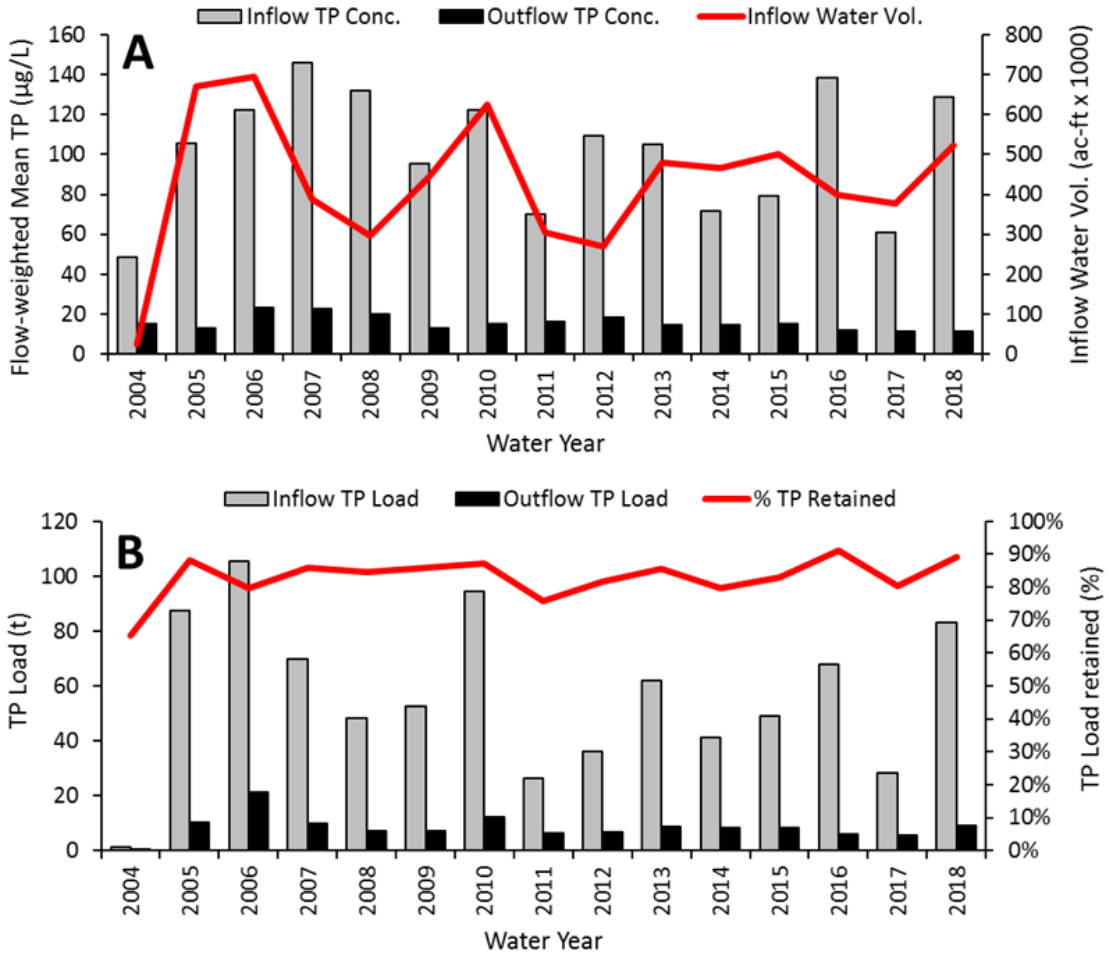


Figure 5B-11. POR time series in STA-3/4 for (A) annual inflow and outflow FWM TP concentrations (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

FACILITY STATUS AND OPERATIONAL ISSUES

All three flow-ways in STA-3/4 were operational in WY2018, although all flow-ways were ONR for a portion of the water year for vegetation maintenance, STA operation requirements associated with the P Flux Study, or impacts from Hurricane Irma (**Table 5B-2**).

In September 2017, electric power outages due to Hurricane Irma resulted in some structures in STA-3/4 being inoperable both during and after the storm. As a result, stage within cells of STA-3/4 increased up to 46 cm above target stage for several weeks after the hurricane. All electric power was restored by October 2017 and STA-3/4 resumed normal operations.

Dryout

All the cells in STA-3/4 were hydrated throughout WY2018.

Migratory Bird and Snail Kite Nesting

Two black-necked stilt nests were observed in STA-3/4 this nesting season. However, no Everglade snail kite or Florida burrowing owl nests were detected.

VEGETATION MANAGEMENT

Most of the vegetation maintenance activities in STA 3/4 during WY2018 were focused on controlling non-rooted FAV and invasive/undesirable species in EAV cells: 423 ac of FAV and 4 ac of floating cattail were treated in Cell 1A; 320 ac of FAV and 18 ac of floating cattail were treated in Cell 2A; 239 ac of FAV and 1 ac of cattail were treated in the Cell 3A; and 12 ac of FAV were treated in Cell 3B.

VEGETATION SURVEYS

Ground Surveys for SAV

Ground SAV surveys were conducted on six occasions during WY2018 to map SAV coverage in STA-3/4: in August 2017 and March 2018 in Cell 1B; in February 2018 in Cell 2B; and in August and November 2017 and March 2018 in Cell 3B (Appendix 5B-4, Figures 26 through 32). The SAV communities in Cells 1B and 3B were dominated by muskgrass, while southern naiad was the dominant taxon in Cell 2B. Other SAV taxa observed in lesser quantities in STA-3/4 this water year included bladderwort, pondweed, spiny naiad, and coontail.

Total SAV coverage was variable in STA-3/4; high coverages were observed at 50% or more of survey sites in Cells 1B and 3B prior to Hurricane Irma. Cell 3B suffered substantial loss of SAV during the storm whereas impacts to Cell 2B were less severe. Cell 3B continued to lose total SAV coverage up through the last ground SAV survey conducted in March 2018 (Appendix 5B-4, Figure 33).

STA-5/6

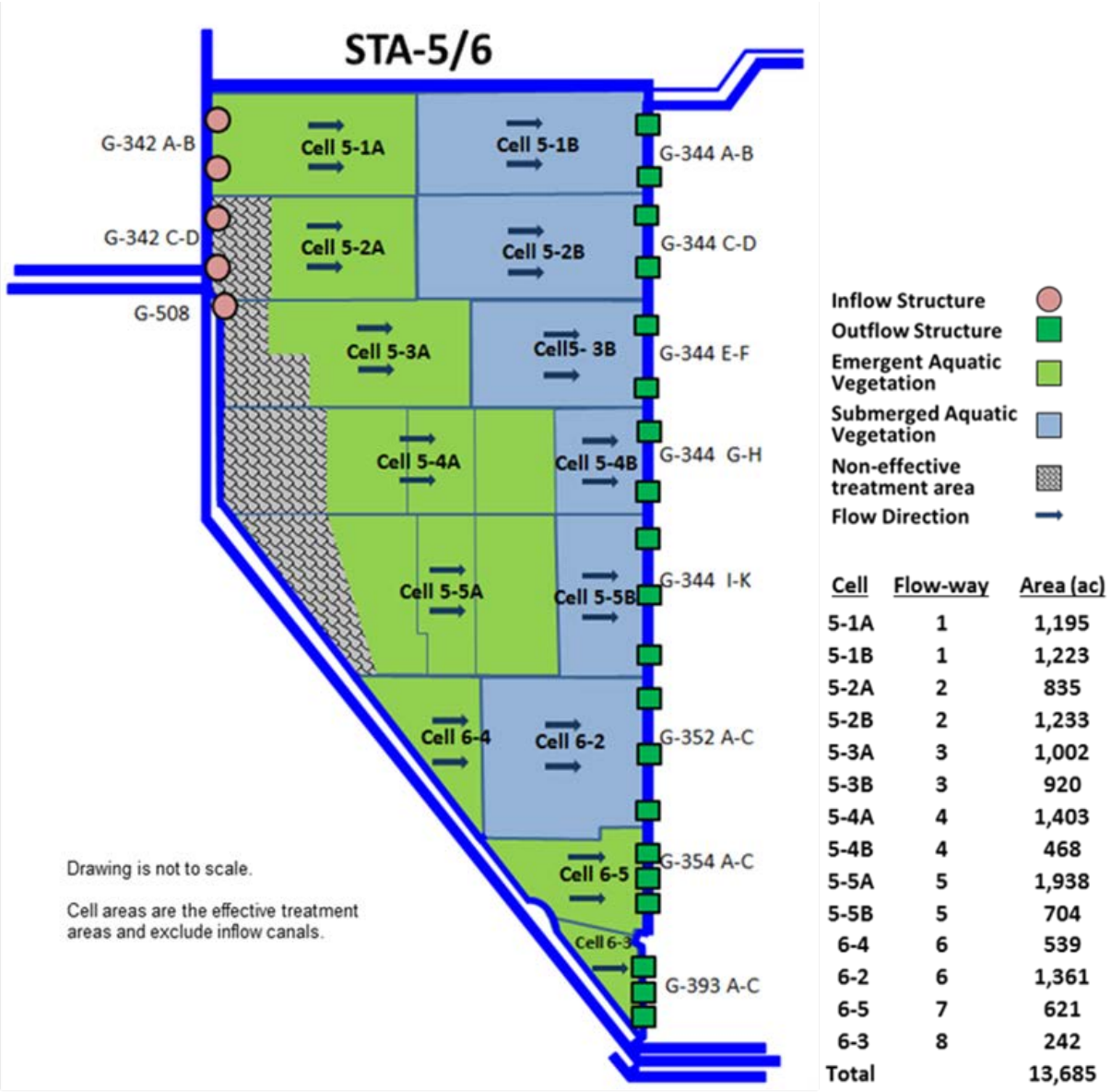
STA-5/6 is located in Hendry County and is bordered by the C-139 and C-139 Annex basins on the west and the Rotenberger Wildlife Management Area on the east (**Figure 5B-1**). This STA was created by merging what had been two separate STAs: STA-5 and STA-6. The original STA-5 (Cells 5-1A, 5-1B, 5-2A, and 5-2B) and STA-6 (Cells 6-3 and 6-5) (**Figure 5B-12**) began operation in 2000 and 1997, 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[12]. 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 now has 14 cells arranged into eight flow-ways with a total treatment area of 13,685 ac (Piccone et al. 2014). 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 in this water year's analysis.

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 STAs, STA-5/6 over its POR has been affected by high inflow TP concentrations and extreme weather events, such as regional droughts and large storms. The EAV cells in this STA have dried out to some extent in almost every dry season, and WY2018 was no exception. High soil P flux has followed rehydration of these cells, usually resulting in temporary spikes in outflow TP concentration.

[12] 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	835
5-2B	2	1,233
5-3A	3	1,002
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		13,685

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.

STA TREATMENT PERFORMANCE

STA-5/6 over its combined 21-year POR has treated approximately 2.7 million ac-ft of water and retained 433 t of TP or 69% of the total inflow TP load (**Table 5B-1**). The POR inflow FWM TP concentration is 189 µg/L, while the POR outflow FWM TP concentration is 64 µg/L. Based on its POR outflow FWM TP concentration and percent TP load retained, STA-5/6 has been the poorest performing STA. However, treatment performance in recent water years prior to WY2018 had improved substantially (see below).

STA-5/6 treated approximately 271,000 ac-ft in WY2018 and retained 49 t of TP, which corresponded to 62% of the inflow TP load (78 t) (**Table 5B-1**). The inflow FWM TP concentration this water year was 234 µg/L while the outflow FWM TP concentration was 74 µg/L. STA-5/6 had the lowest HLR (1.7 cm/d) and one of the lowest PLRs (1.4 g/m^2/yr) compared to the other STAs this water year (**Figure 5B-3**). Going back to WY2013, STA-5/6 consistently has had some of the lowest HLRs and PLRs of all the STAs, which is attributed, in large measure, to the increase in STA-5/6 treatment area once Flow-ways 3, 4, and 5 came online. Discounting this water year, the percent TP load retained in STA-5/6 since WY2013 (~ 86 to 91%), has been comparable with the best treatment performance observed in the other STAs (**Figure 5B-13**).

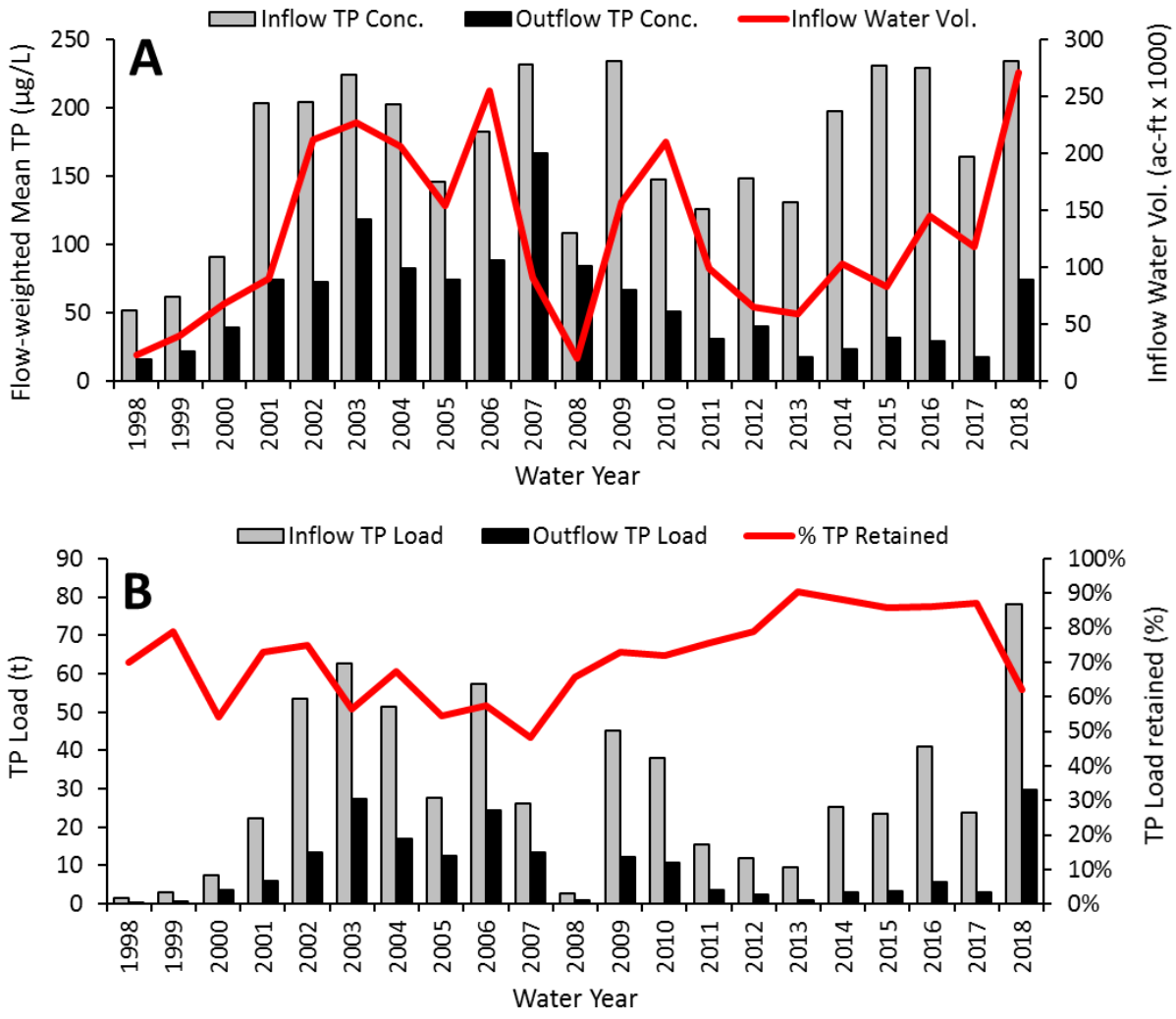


Figure 5B-13. POR time series in STA-5/6 for (A) annual inflow and outflow FWM TP concentration (Conc.) with corresponding inflow water volumes (Vol.) and (B) annual inflow and outflow TP loads with the percent TP load retained.

Due to conveyance limitations of the regional canal system, STA-5/6 cannot receive Lake Okeechobee regulatory releases. Supplemental water can be pumped from the STA-5/6 discharge canal and delivered as needed through the G-305B, G-507, G-509, and G-510 structures into Cells 1B, 2B, 3B, and 4B to keep these cells flooded during dry conditions.

FACILITY STATUS AND OPERATIONAL ISSUES

All eight flow-ways in STA-5/6 were operational during WY2018, although all flow-ways were ONR for a portion of the water year due to the presence of nesting Everglade snail kites and black-necked stilts, or cell dryout (**Table 5B-2**). Stage within STA-5/6 was up to 53 cm above target stage during and immediately after Hurricane Irma. Conversely, all the EAV cells in this STA were dry for a portion of the water year, while supplemental water pumped from the STA-5/6 discharge canal was used to keep most of the SAV cells hydrated for part of WY2018. However, stage recession was allowed to occur in SAV cells during the latter part of the water year in preparation for vegetation rehabilitation efforts.

Dryout

The District declared that dryout conditions existed in a number of cells in STA-5/6 in WY2018: Cells 5-1A, 5-2A, 5-3A, 5-4A, 5-5A, 6-2, 6-3, 6-4, and 6-5 from May through June 2017; Cells 6-3 and 6-5 in March 2018; and Cells 5-1A, 5-2A, and 5-3A in April 2018. The District notified FDEP of these developments accordingly. All other cells in STA-5/6 were hydrated throughout WY2018 and had no dryout impacts.

Migratory Bird and Snail Kite Nesting

Black-necked stilts were observed nesting in STA-5/6 Cells 5-4A, 5-5B, and 6-2 between May and June 2017. Stilt nests were also observed in Cells 5-3A, 5-3B, 5-4A, 5-4B, and 5-5B in April 2018. No Everglade snail kite or Florida burrowing owl nests were found in STA-5/6 this water year. Information on STA-5/6 operational and maintenance adjustments made to protect bird nests during WY2018 is presented in Appendix 5B-3 of this volume.

VEGETATION MANAGEMENT

Historically, STA-5/6 has had chronic problems with willow and primrose willow encroachment in EAV cells and non-rooted FAV invasion and expansion in all cells. The District treated a combined 1,201 ac of FAV in Cells 5-1A, 5-1B, 5-2A, 5-2B, 5-3A, 5-4A, 5-4B, 5-5A, 6-2, 6-3, 6-4, and 6-5. Vegetation rehabilitation work this water year consisted of inoculating Cell 2B with southern naiad and muskgrass. Nursery plots of alligator flag and giant bulrush started in previous years throughout STA-5/6 have become established and will serve as sources of planting material for this STA in the future.

VEGETATION SURVEYS

Ground Surveys for SAV

Ground SAV surveys were conducted on eight occasions during WY2018 to map SAV coverage in STA-5/6: in September 2017 and March 2018 in Cell 5-1B; in September 2017 and April 2018 in Cell 5-2B; in October 2017 and March 2018 in Cell 5-3B; and in December 2017 and April 2018 in Cells 5-4B and 5-5B (Appendix 5B-4, Figures 33 through 40). Total SAV coverage was generally low or absent throughout Cell 5-2B; low to medium at 50% or more of survey sites in Cells 5-1B, 5-3B, and 5-4B; and medium to high at most survey sites in Cell 5-5B. Hydrilla and coontail were the dominant taxa in STA-5/6, though southern naiad was present in medium coverages. Other SAV taxa observed in lesser quantities this water year included bladderwort and pondweed. Substantial loss of SAV was noted in STA-5/6 following Hurricane Irma.

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