Chapter 8D: Caloosahatchee River Watershed Protection Plan Annual Progress Report

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SUMMARY

The Northern Everglades and Estuaries Protection Program (NEEPP), which is mandated in Section 373.4595, Florida Statutes (F.S.), promotes a comprehensive approach to protecting Lake Okeechobee and the Caloosahatchee and St. Lucie rivers and estuaries. The primary goal of the legislation is to restore and protect surface water resources by addressing water quality, quantity, timing, and distribution of water to the natural system. NEEPP directs the South Florida Water Management District (SFWMD or District), in cooperation with the other coordinating agencies—Florida Department of Environmental Protection (FDEP) and Florida Department of Agriculture and Consumer Services (FDACS)—and local entities, to complete a watershed protection plan (WPP) for each of the three watersheds within NEEPP: Lake Okeechobee Watershed (LOW), St. Lucie River Watershed (SLRW), and Caloosahatchee River Watershed (CRW). WPPs are unique to each watershed and receiving water body and are coordinated in recognition of the connectivity of these watersheds. WPPs are science-driven plans that include two components: (1) a Research and Water Quality Monitoring Program (RWQMP) and (2) a Watershed Construction Project and Programs (WCP). This chapter along with Chapter 8A of this volume provides the annual progress report for the Caloosahatchee River Watershed Protection Plan (CRWPP).

CALOOSAHATCHEE RIVER ESTUARY

To represent current and historical ecological conditions in the Caloosahatchee River Estuary (CRE), this report summarizes monitoring data for precipitation, freshwater inflow, salinity, total phosphorus (TP), total nitrogen (TN), chlorophyll *a*, and benthic habitat indicators such as *Crassostrea virginica,* the eastern oyster, and submerged aquatic vegetation (SAV):

- In Water Year 2021 (WY2021; May 1, 2020–April 30, 2021), the total freshwater inflow to the CRE was 2,196 x 10^3 acre-feet (ac-ft) of which approximately 49% (1,066 x 10^3 ac-ft) was from the Caloosahatchee Basins, 17% (377 x 10^3 ac-ft) from the Tidal Basin, and 34% (753 x 10^3 ac-ft) from Lake Okeechobee. Total freshwater inflow in WY2021 was higher than the average for the period of record (POR; WY1997–WY2021).
- Mean concentrations of TP in the CRE in WY2021 were lower than the long-term average POR (WY2000–WY2021) concentrations.

- Mean concentrations of TN in the CRE in WY2021 were similar to the long-term average for the POR (WY2000–WY2021) at the upper (CES04) and middle estuary (CES06) stations but were 0.09 milligrams per liter (mg/L) higher at the lower estuary (CES08) station.
- The upper (CES04) and middle (CES06) estuary stations exhibited lower mean chlorophyll *a* concentrations than the long-term average POR (WY2000–WY2021) in WY2021 while the mean chlorophyll *a* concentration at the lower estuary station (CES08) was similar to the long-term average.
- The percentage of days that the 14-day moving average was within the optimum salinity envelope (10 to 25) for *C. virginica* in the lower estuary was 58% at both the Cape Coral and Shell Point stations in WY2021. In WY2021, the percentage of days when the 14-day moving average was in the stressed salinity envelope was 12% at Cape Coral (5 to 10) and 42% at Shell Point (>25). The percentage of days in the damaging salinity envelope (< 5) in WY2021 was 30% at Cape Coral and 0% at Shell Point. Stressed and damaging salinity percentages were similar to the long-term averages at both stations.
- Mean live *C. virginica* densities were similar during the dry seasons of WY2021 (170 ± 81 oysters per square meter [oysters/m^2]) and WY2020 (164 ± 157 oysters/m^2) at the more upstream Iona Cove station. At Bird Island, mean live *C. virginica* densities during the dry season declined from 515 ± 227 oysters/m^2 in WY2020 to 340 ± 232 oysters/m^2 in WY2021. Mean larval recruitment rates at Iona Cove in WY2021 were similar to those recorded in WY2020 but those at Bird Island were substantially lower. Prevalence of dermo (*Perkinsus marinus*, a protozoan parasite infection in *C. virginica* was moderate at both Iona Cove and Bird Island where WY2021 rates were 58% and 47%, respectively. Despite the moderate infection rates, infection intensity remained low in *C. virginica* from both stations (very light to light infection severity).
- Species of SAV in the CRE varied spatially and temporally along the salinity gradient from upstream to downstream. Typically, freshwater SAV such as *Vallisneria americana* (tape grass) and *Ruppia maritima* (widgeon grass) occurred farthest upstream, followed by a mixture of *R. maritima* and *Halodule wrightii* (shoal grass) through the middle estuary, and an exclusively marine seagrass community of up to five seagrass species in the lower estuary.
- In WY2021, the percentage of days that the 14-day moving average was within the optimum salinity envelope (< 10) for *V. americana* was 100% at the upper estuary salinity recording station (Val I-75) and 90% at the Ft. Myers salinity recording station. At the Shell Point salinity monitoring station, the percentage of days that the 14-day moving average was within the optimum salinity envelope (15 to 45) for *H. wrightii* was 99% in WY2021.

CALOOSAHATCHEE RIVER WATERSHED

To quantify and assess relative inputs of fresh water and nutrients to the CRE, the CRW is divided into three contributing areas: Lake Okeechobee, Caloosahatchee Basins, and Tidal Basin. The Caloosahatchee Basins (representing 69% of the watershed) include the East Caloosahatchee, West Caloosahatchee, and S-4 basins. The Tidal Basin (representing 31% of the watershed) includes all areas draining to the CRE downstream of S-79 (W.P. Franklin Lock and Dam).

- Average annual rainfall across the CRW in WY2021 was 56.1 inches with 70% occurring in the wet season and 30% occurring in the dry season. This was higher than the annual average (52.2 inches) for the POR (WY1997–WY2021).

- In WY2021, the percent contribution of TP loads to the CRE was 60% from the Caloosahatchee Basins (194 metric tons [t]), 15% from the Tidal Basin (50 t), and 25% from Lake Okeechobee (82 t).
- The percent contribution of TN loads in WY2021 were 56% from the Caloosahatchee Basins (2,064 t), 13% from the Tidal Basin (487 t), and 31% from Lake Okeechobee (1,143 t).
- Lake Okeechobee contributed 34% of total flow, 25% of TP load, and 31% of TN load in WY2021.
- The percent contributions from the WY2017–WY2021 period from the Caloosahatchee Basins were 46% of total flow, 58% of TP load, and 51% of TN load; all of which were greater than the contributions from the Tidal Basin or Lake Okeechobee. Within the Caloosahatchee Basins, the West Caloosahatchee basin had the largest contribution to total flow (34%), TP load (37%), and TN load (33%) over the WY2017–WY2021 period.

CALOOSAHATCHEE RIVER WATERSHED CONSTRUCTION PROJECT

In Fiscal Year 2021 (FY2021; October 1, 2020–September 30, 2021), three Watershed Protection Plan projects were operational in the CRW: Mudge Ranch Dispersed Water Management (DWM) project, Boma Interim Storage project, and Lake Hicpochee Hydrologic Enhancement (Phase I) project. Construction on the Comprehensive Everglades Restoration Plan (CERP) Caloosahatchee River (C-43) West Basin Storage Reservoir (C-43 Reservoir) continued and is expected to be complete by FY2024. The C-43 Reservoir Water Quality Component, Lake Hicpochee Hydrologic Enhancement Expansion (Phase II), Boma Flow Equalization Basin (FEB), and C-43 Water Quality Treatment and Testing Facility (C43-WQTTP) – Phase II, Test Cells projects are all currently in the design stage. In addition, the following was accomplished during the reporting period:

- Amendments to Chapter 40E-61, Florida Administrative Code (F.A.C.), became effective on April 11, 2021. The rules were expanded to encompass the entirety of the three Northern Everglades watersheds and provide for a monitoring program for those under a basin management action plan (BMAP) not implementing best management practices (BMPs). The program requires nonpoint source dischargers not implementing BMPs to submit a SFWMD-approved water quality monitoring plan and regularly report associated monitoring data.
- Water quality monitoring is ongoing including the expansion of the existing upstream monitoring program in response to the Governor's Executive Order 19-12: Achieving More Now for Florida's Environment, as described in Appendix 8D-1 of this volume.
- Basin-specific detailed assessments within focus areas are underway as described in Appendix 8D-2 of this volume. The purpose of the detailed assessments is to identify areas for the highest priority for action, gather information to pinpoint the nutrient sources contributing to the water quality problems, recognize the existing programs that have the potential to impact those sources and their status, consider existing and planned projects and their expected impact to water quality, determine what remains to be done to improve water quality, and recommend strategic actions for future planning in collaboration with the coordinating agencies.

INTRODUCTION

As required by Subsection 373.4595(6), F.S., this chapter, in conjunction with Chapters 8A, 8B, and 8C of this volume, fulfills the specific reporting requirements outlined in NEEPP for the annual progress report. This chapter provides an annual review for the CRWPP, which was initiated by SFWMD in WY2021 and is critical to maintaining transparency and accountability in the BMAP process, and for assisting to progressively move towards the achievement of total maximum daily loads (TMDLs).

The CRW and CRE are in southwestern Florida and span portions of Lee, Hendry, Charlotte, Glades, and Collier counties. The CRW is comprised of five basins that drain to the Caloosahatchee River (C-43 Canal) and eventually to the CRE. The primary land use type[1] within the CRW based on 2014–2016 land use data is natural area (45%) followed by agricultural (35%) and non-agricultural (20%). To calculate inputs of fresh water and nutrients to the system, the CRW was divided into three primary contributing areas: Lake Okeechobee, the Caloosahatchee Basins (also collectively known as the C-43 Basins), and the Tidal Basin (**Table 8D-1** and **Figure 8D-1**; Buzzelli et al. 2017). The Caloosahatchee Basins include the S-4, East Caloosahatchee, and West Caloosahatchee basins. Inputs of fresh water and nutrients are quantified at four major water control structures: S-77 (Moore Haven Lock and Dam), S-78 (Ortona Lock and Dam), S-79 (W.P. Franklin Lock and Dam), and S-235. The drainage area downstream of these major structures comprises the Tidal Basin, for which flow and nutrient loads are estimated using the Linear Reservoir (Lin Res) model (Wan and Konyha 2015). The Tidal Basin discharges directly into the estuary, and the mouth of the estuary opens to San Carlos Bay near Shell Point. The Coastal Basin does not directly contribute runoff to the CRE.

Table 8D-1. Major contributing areas of the CRW.

Contributing Areas	Basins	Basin Acreage (% of Watershed)	Flows & Loads
Lake Okeechobee	Not applicable	Not applicable	Calculated [a]
Caloosahatchee Basins (or C-43 Basins)	East Caloosahatchee West Caloosahatchee S-4	204,095 (23.7%) 350,116 (40.7%) 42,146 (4.9%)	Measured Measured Measured
Tidal Basin	Tidal Caloosahatchee	264,706 (30.7%)	Modeled

a. Lake Okeechobee releases to the CRE are calculated via the measured flows and loads at the S-77, S-78, and S-79 water control structures.

[1] The agricultural land use category includes pasture, row crops, citrus groves, and other similar land uses. The non-agricultural land use category includes residential, institutional, and urban land uses. The natural areas land use category includes wetlands, water bodies, and forested areas, among others.

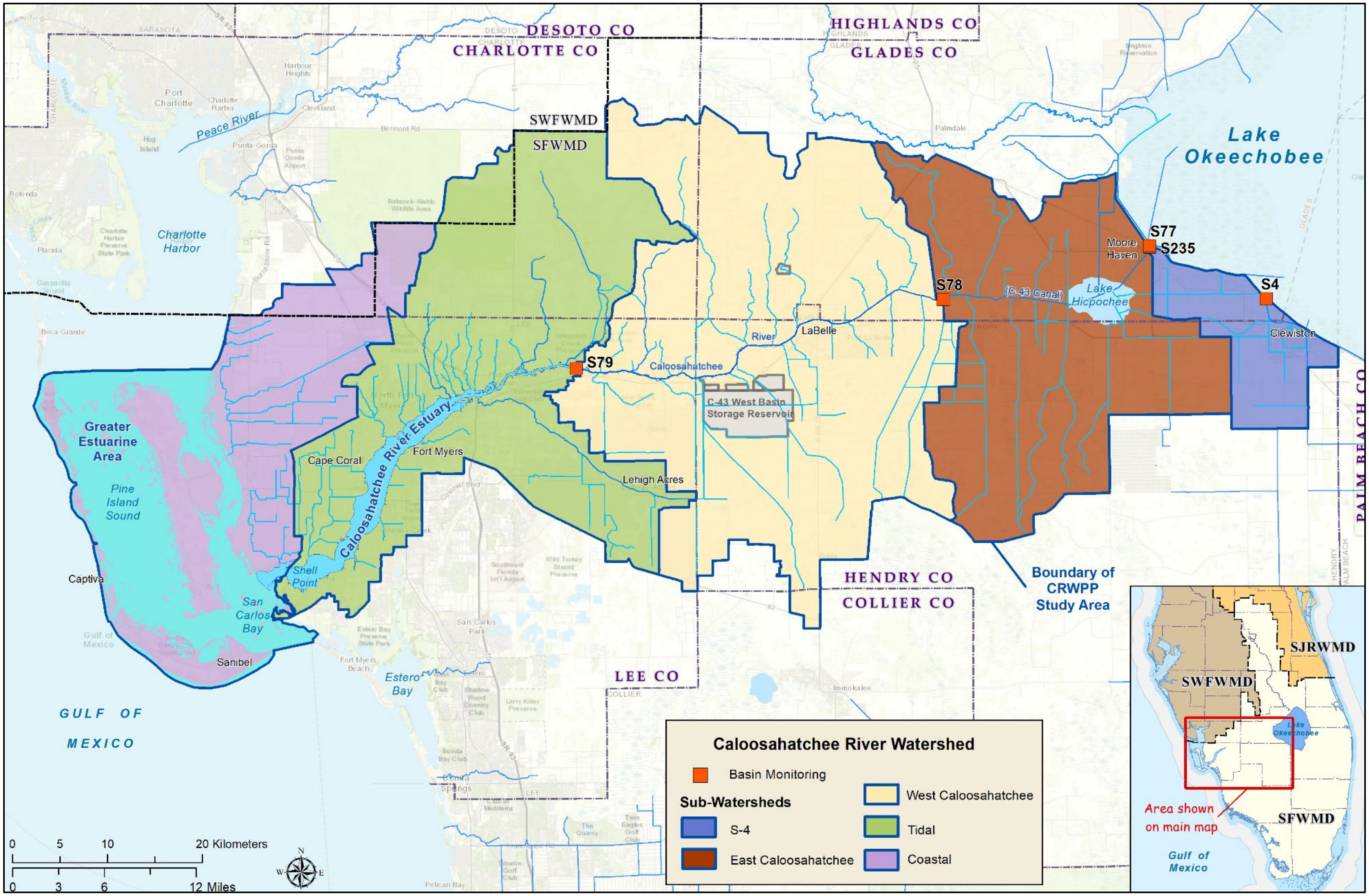

Figure 8D-1. The Caloosahatchee River Watershed with its basins and major water control structures. Modeled basin areas are also depicted.

The Caloosahatchee River (C-43 Canal) is the primary conveyance transporting local basin runoff and regulatory releases from Lake Okeechobee to the CRE. The Caloosahatchee River historically originated near a geological formation called Lake Flirt, which is located ~2 miles (3.2 kilometers [km]) east of La Belle at Fort Thompson. During the wet season, the historic river had rapids moving downstream from this point and was also fed with sheetflow from the east by the overflowing waters of Lake Okeechobee. The river contained many oxbows (~102), and water flow and depth varied greatly between wet and dry seasons (Antonini et al. 2002). Straightening and dredging to deepen the river channel began in the 1880s, and in 1887, a channel from Lake Flirt to Lake Okeechobee was cut. Dredging alterations continued through the 1930s with additional canals and control structures including the Ortona and Moore Haven Lock and Dam structures (USACE 1957, Section 6.B.6). While tidal influence of the estuary at that point extended upstream to Ft. Denaud, the structures at Olga (i.e., W.P. Franklin Lock and Dam or S-79) were constructed in the 1960s to prevent saltwater intrusion and assure a freshwater supply. Relative to historic conditions, these modifications reduced river length by 8.2 miles (13.2 km) and resulted in a loss of 76 river bends (Antonini et al. 2002). The C-43 Canal currently spans 44 miles (70 km) from S-77 at Lake Okeechobee to the S-79 structure where the CRE begins and extends 26 miles (42 km) downstream to Shell Point where it empties into San Carlos Bay (**Figure 8D-1**). The surface area of the CRE is 21.6 square miles (55.9 square km [km^2] or 13,824 acres [ac] or 5,594 hectares [ha]) with an average depth of 8.9 feet [ft] (2.7 meters [m]). Flushing time ranges from 60 days during periods of very low inflow volumes to four days at high inflow volumes, with an average of around 20 days (Wan et al. 2013, Buzzelli et al. 2013a, 2014b).

Fresh water entering the tributaries and estuary is affected by modifications to the natural system from anthropogenic impacts of land use changes in the watershed, coastal development, hydrological alterations through water management, hardened shorelines, and channelization (Rumbold and Doering 2020). The volume and source of freshwater inflow to tributaries and the estuary directly affect the water quality conditions, such as salinity, light attenuation, and nutrients (Paczkowska et al. 2020). Changes in freshwater inflows and resultant changes to the habitat have been shown to affect the distribution and dynamics of many estuarine taxa and communities, including primary producers such as phytoplankton, benthic microalgae (Mortazavi et al. 2000, Phlips et al. 2012, Shangguan et al. 2017, Paczkowska et al. 2020), seagrass (Doering and Chamberlain 2000, Doering et al. 2002, Kahn et al. 2013), and oysters (Parker and Radigan 2020, Volety et al. 2010, Volety and Haynes 2014).

FDEP has identified the CRE and several tributaries in the CRW as impaired water bodies and has established TMDLs for the CRE and tributaries. The CRE TMDL was adopted in 2009 and requires a 23% reduction in TN loading to the CRE (Bailey et al. 2009). The Caloosahatchee Tributaries TMDL was adopted in 2019 and establishes TN, TP, and biochemical oxygen demand (BOD) reduction targets for five freshwater tributaries, including the (1) S-4 Basin, (2) C-19 Canal, (3) Lake Hicpochee, (4) Long Hammock Creek, and (5) Townsend Canal (Albright et al. 2019). The FDEP-adopted *Caloosahatchee River and Estuary Basin Management Action Plan* (BMAP) is a multifaceted approach designed to achieve the TMDL nutrient load reductions within the CRW (FDEP 2020).

In support of the BMAPS, NEEPP directs SFWMD, along with FDEP and FDACS and local entities, to complete a WPP for each of the three watersheds within the NEEPP: LOW, SLRW, and CRW. WPP are unique to each watershed and receiving water body and are coordinated in recognizing the connectivity of these watersheds. WPPs are science-driven plans that include two components: (1) RWQMP and (2) WCP. The RWQMP builds upon existing research and monitoring to inform decisions, develop future restoration efforts, and assess and modify existing plans such as BMAPs. In this chapter, the RWQMP is presented in two parts: Part I: CRE, in which estuary water quality, salinity, and benthic habitat are indicators; and Part II: CRW, in which watershed characteristics are described with a focus on loading from the CRW basins. The WCP provides a comprehensive strategy consisting of constructed facilities and programs implemented for improving water quality, quantity, timing, and distribution of surface water in the Northern Everglades ecosystem. The WCP also summarizes the current and future water quality improvement projects and programs designed to assist in achieving TMDL reductions.

RESEARCH AND WATER QUALITY MONITORING PROGRAM PART I: CALOOSAHATCHEE RIVER ESTUARY

Inflows to the CRE exhibit intra- and interannual variability depending on the source and magnitude of those inflows due to changes in water management, weather, and climate, and their subsequent effects on water quality and ecology (Doering and Chamberlain 1999, Buzzelli et al. 2013a, 2014a, Rumbold and Doering 2020). Estuaries naturally exhibit gradients in water quality parameters from upstream to downstream. However, anthropogenically-impacted estuarine systems with modified hydrology have diminished natural components, which can reduce the predictability and stability of this intrinsic variation. Resulting conditions could reduce acclimation time for estuarine organisms to adjust to environmental fluctuations prolonging the period outside an organism's optimum environmental envelope, thereby promoting mortality or negatively impacting reproduction strategies (Gunter 1961, Doering and Chamberlain 2000, Barletta et al. 2005, Kahn and Durako 2008, Volety et al. 2009, Petes et al. 2012).

The volume and source of freshwater inflow to the tributaries and the estuary directly affect water quality within the CRE and can alter salinity conditions, nutrient concentration, and light availability. Higher volumes of freshwater inflows decrease salinity levels and can alter the concentration and form of nutrients (such as TP and TN), the levels of colored dissolved organic matter (CDOM or color), and the amount of suspended solids in the water column (Wan et al. 2012, Buzzelli et al. 2013a, 2014a, 2014b, Hanisak and Davis 2018, Paczkowska et al. 2020, Rumbold and Doering 2020). Increased levels of CDOM in the system are a major contributing light extinction coefficient in the estuary (Doering and Chamberlain 1999, Chen et al. 2015, Chen and Doering 2016, Rumbold and Doering 2020), which reduces the amount of light available for biological processes such as photosynthesis. Higher nutrient levels can lead to increased populations of primary production and microalgae. These increased populations together with suspended solids further reduce light availability in the water column, which can negatively impact seagrass growth (Buzzelli et al. 2013b, Paczkowska et al. 2020). Freshwater inflows influence the water quality parameters that shape phytoplankton community growth responses and determine the residence time for nutrient consumption and biomass accumulation (Shangguan et al. 2017, Geyer et al. 2018). Changes in water quality and flushing rate due to the timing, duration, and volume of freshwater delivery can also affect the abundance, distribution and health of key benthic indicator species such as seagrass and oysters (Lirman and Cropper 2003, La Peyre et al. 2003, Borja and Tunberg 2011, Parker et al. 2013, McKeon et al. 2015), as well as other benthic macrofauna, fish, and shellfish populations in the CRE (Tolley et al. 2010, Simpendorfer et al. 2011, Stevens et al. 2013, Olin et al. 2014, Palmer et al. 2016, Doering and Wan 2018).

Analyses of long-term monitoring data conclude that primary drivers of water quality and ecological responses of the system are precipitation, watershed land use, and the resultant inflow from the Caloosahatchee Basins (also known as the C-43 Basin) rather than Lake Okeechobee contributions. Also, contributing waters vary in characteristics, e.g., Caloosahatchee Basins inflows have relatively higher TN and CDOM than freshwater contributions from Lake Okeechobee (Doering and Chamberlain 1999, Julian and Osborne 2018, Rumbold and Doering 2020).

To represent current and past ecological conditions in the CRE, this report summarizes monitoring data for the following water quality parameters and benthic habitat indicators at select sites in the estuary: salinity, TP, TN, chlorophyll *a*, *Crassostrea virginica* (eastern oysters), and SAV (**Figure 8D-2**).

Figure 8D-2. CRE monitoring locations for water quality (CES04, CES06, and CES08), salinity recording stations (Val I-75, Ft. Myers, Cape Coral, and Shell Point), seagrass, and *C. virginica* (eastern oysters). Seagrass cover data are based on aerial photography conducted in 2014 of the lower estuary, Estero Bay, Pine Island Sound, and Matlacha Pass to the border of Lee county, and *C. virginica* cover data are based on data from the 2019 sidescan-sonar mapping results for oyster substrate, which includes live oysters and oyster shell.

HYDROLOGY

Precipitation

Daily Next Generation Radar (NEXRAD) rainfall data from the long-term POR (WY1997–WY2021) for each basin of the CRW were downloaded from SFWMD's environmental database, DBHYDRO, accessible at http://my.sfwmd.gov/nexrad2/nrdmain.action. The cumulative amount of rainfall across the watershed was computed using area weighting, which accounts for the different sizes of the basins.

Total rainfall in WY2021 in the CRW was 56.1 inches (142.5 centimeters [cm]) and was 23% higher than WY2020 and 8% higher than the long-term average for the POR (**Figure 8D-3**). In WY2021, 75% of the annual rainfall occurred during the wet season (May 1–October 31) and 25% in the dry season (November 1–April 30), similar to the long-term average for the POR (79 and 21%, respectively; **Figure 8D-3**). WY2021 wet season rainfall (42.3 inches or 107.4 cm) was higher than the wet season of the previous two water years and the long-term average for the POR (**Figure 8D-3**). Tropical Storm Sally and Tropical Storm Eta (NHC 2021a, 2021c) made landfall in South Florida in September and November 2020 resulting in higher rainfall observed throughout most of Florida in WY2021. During WY2021, it rained 244 days (66.8%) in the CRW, with seven days having rainfall > 1.0 inch (2.5 cm).

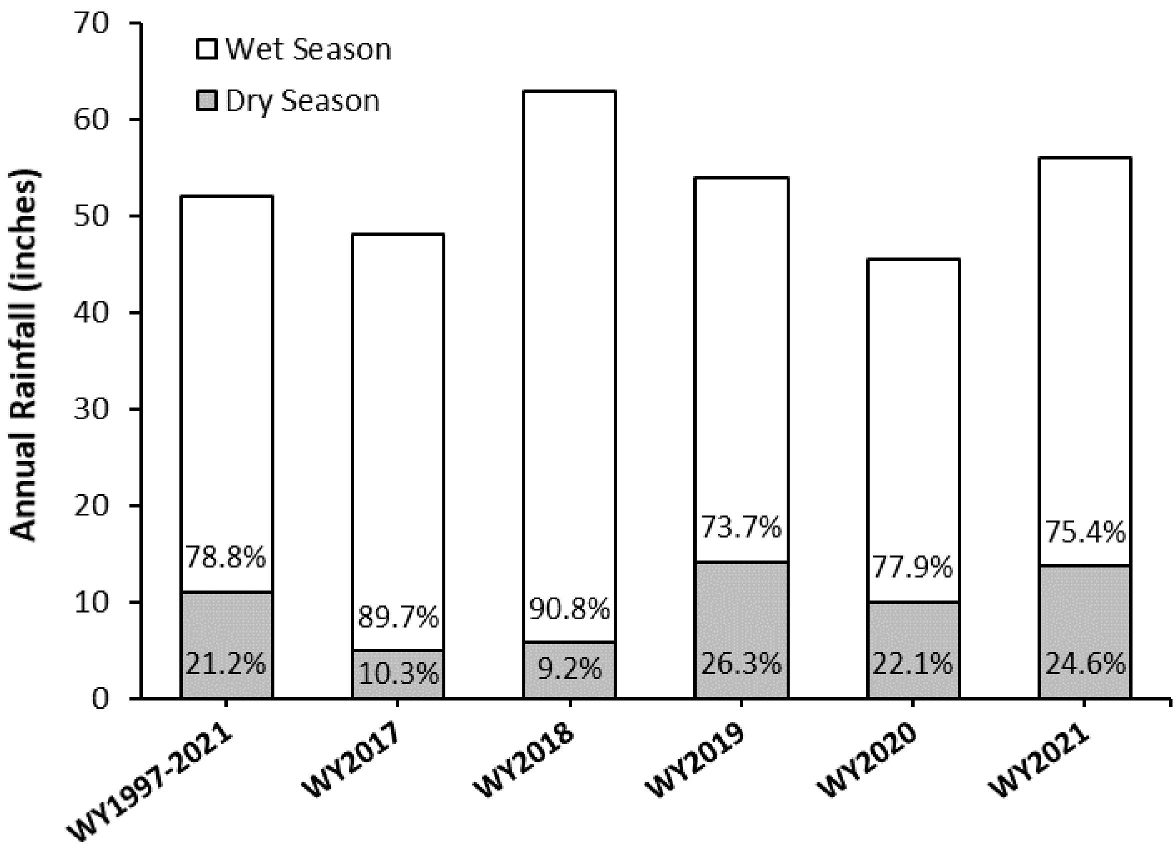

Figure 8D-3. Total annual rainfall for the CRW by water year from most recent 5-year period (WY2017–WY2021) and the long-term average for the POR (WY1997–WY2021) with percent contributed by season.

Spatial distribution patterns of rainfall across the watershed in WY2021 were similar to those observed in WY2020 and the long-term average for the POR, with the most rainfall occurring in the Tidal Basin (**Figure 8D-4**). Spatial distribution patterns of rainfall across the watershed in WY2021 were similar to those observed in WY2020 and over the long-term average for the POR, with the most rainfall occurring in the Tidal Basin (**Figure 8D-4**).

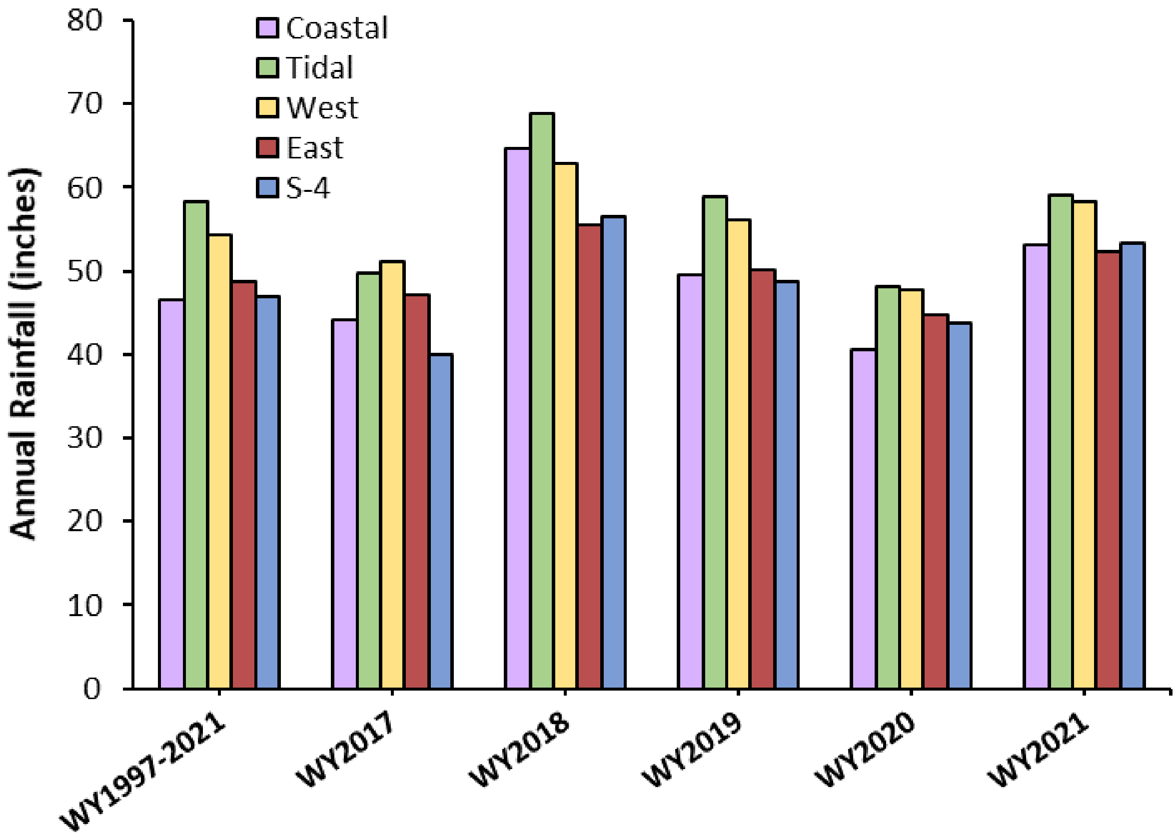

Figure 8D-4. Total annual rainfall by basin in the CRW by water year from the most recent 5-year period (WY2017–WY2021) and the long-term average for the POR (WY1997–WY2021). See **Figure 8D-1** for basin locations.

Freshwater Inflow

Freshwater inflow to the CRE was estimated from the three main contributing areas in the CRW: Lake Okeechobee, the Caloosahatchee Basins, and the Tidal Basin and tributaries (**Figure 8D-1** and **Table 8D-1**). Flows were measured at S-77 (Lake Okeechobee), S-235 (S-4 Basin), S-78 (East Caloosahatchee Basin) near the City of LaBelle, and S-79 (West Caloosahatchee Basin) at the upstream boundary of CRE. All freshwater flows were measured except those from the Tidal Basin, which were simulated by application of the Linear Reservoir (Lin Res) model (Wan and Konyha 2015). Flows from the Coastal Basin (**Figure 8D-1**) were not incorporated as contributing to the Tidal Basin flows as they do not discharge into CRE proper (Wan and Konyha 2015). Average daily inflows from WY1997 through WY2021 were used to evaluate intra- and interannual variations in flows, quantify total inflow to the CRE, and assess relative contributions of basins to total inflow (see **Table 8D-11** in Part II of this chapter). **Figure 8D-5** presents the percent contribution of inflow from these three main contributing areas, and **Figure 8D-6** provides additional detail on relative contributions of each of the Caloosahatchee basins.

Total freshwater inflow from the CRW in WY2021 was 2,196.2 x 10^3 ac-ft, of which 49% was from the Caloosahatchee Basins, 34% from Lake Okeechobee, and 17% from the Tidal Basin (**Figure 8D-5**). The total inflow in WY2021 was 17% higher than the long-term average for the POR inflow, 76% higher than WY2020 and 2% lower than WY2019. This higher volume of freshwater inflow that occurred in WY2021 was largely a result of the heavy rainfall that occurred during Tropical Storm Sally and Tropical Storm Eta in September and November 2020 (NHC 2021a, 2021c). In WY2021, the Lake Okeechobee contribution (752.6 x 10^3 ac-ft, 34%) was higher than WY2020 (170.3 x 10^3 ac-ft, 14%) and the long-term average for the POR (616.7 x 10^3 ac-ft, 33%) (**Figure 8D-5**). Inflow from the Caloosahatchee Basins in WY2021 (1,066.2 x 10^3 ac-ft, 49%) was slightly higher than the long-term average for the POR (47%). The relative contribution of the Tidal Basin in WY2021 (377.4 x 10^3 ac-ft, 17.0%) was lower than in WY2020 (349.8 x 10^3 ac-ft, 28%) and over the long-term average for the POR (20%; **Figure 8D-5**).

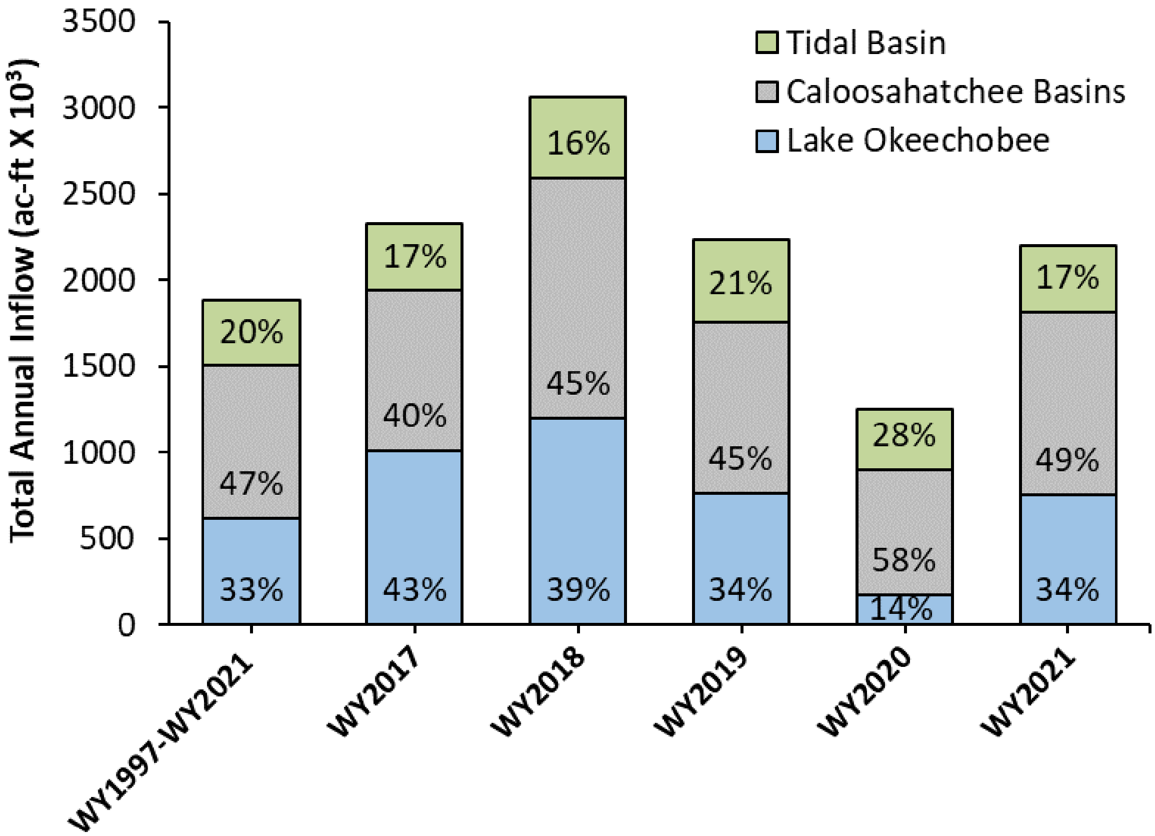

Figure 8D-5. Total annual freshwater inflow to the estuary for each contributing area by water year for the most recent 5-year period (WY2017–WY2021) and the long-term average for the POR (WY1997–WY2021) with relative percent contribution to total.

In WY2021, the West Caloosahatchee, East Caloosahatchee, and S-4 basins contributed 37%, 9%, and 3%, respectively, to the total inflow (**Figure 8D-6** and **Table 8D-11** in Part II of this chapter). These were lower than WY2020 percent contributions from the West Caloosahatchee and East Caloosahatchee basins (42% and 15%, respectively) and slightly above the long-term average relative contributions for the West Caloosahatchee Basin to total inflow (33%; **Figure 8D-6** and **Table 8D-11** in Part II of this chapter).

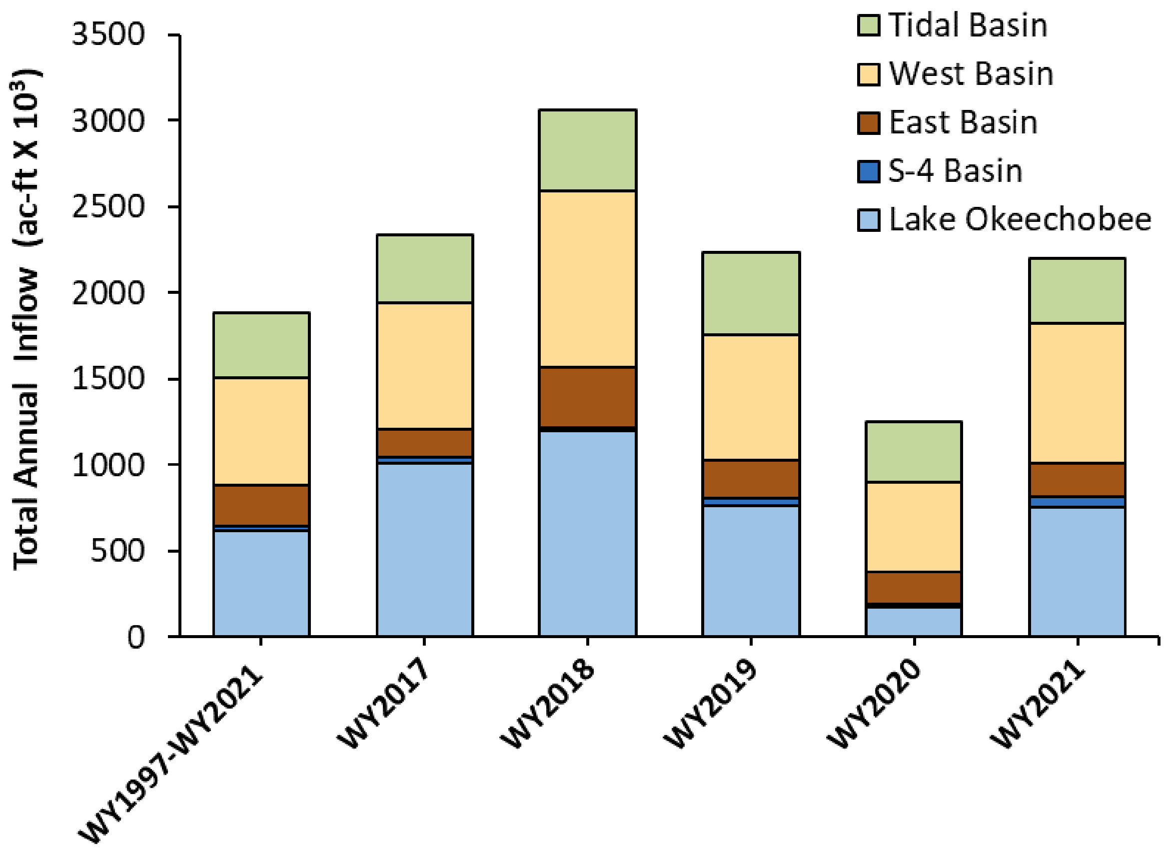

Figure 8D-6. Total annual inflow for the CRW and inflow from contributing basins, Lake Okeechobee, and the Tidal Basin by water year for the most recent 5-year period (WY2017–WY2021) and the long-term average for the POR (WY1997–WY2021).

SALINITY

Salinity, defined as the quantity of grams of salt per kilogram of water, is computed from conductivity and temperature field measurements and is reported as dimensionless values (Fofonoff and Millard 1983). Salinity is a conservative property of the water body and therefore is useful to connect the sources of freshwater inflow, circulation, mixing, and biological indicators (Wilber 1992, Jassby et al. 1995, Hagy and Murrell 2007, Pollack et al. 2011). Surface and bottom salinity measurements were recorded every 15 minutes at six stations in the CRE: S-79, Val I-75, Ft. Myers, Cape Coral, Shell Point, and Sanibel Island Bridge (**Figure 8D-2**). Data analyses for this report focused on the annual averages for the most recent five water years and the long-term average for the POR. The POR was WY2007–WY2021 for Val I-75, WY2001–WY2021 for Ft. Myers, and WY2003–WY2021 for Cape Coral and Shell Point (based on the best available data set). Salinity conditions at Val I-75 and Ft. Myers were used to examine the oligohaline to mesohaline region of the estuary, and Cape Coral and Shell Point for the downstream, polyhaline region of the CRE (**Figure 8D-2**). To relate salinity conditions to ecological indicator responses in CRE, the optimum salinity envelopes developed for the CERP Restoration Coordination and Verification Program (RECOVER) salinity performance measure update (RECOVER 2020; **Table 8D-2**) were applied for *Vallisneria americana* (tape grass), *Crassostrea virginica* (eastern oysters), and *Halodule wrightii* (shoal grass) using the 14-day moving average salinity (as a percent of time during a given period) within optimum, stressed, and damaging salinity envelopes for each indicator species (**Table 8D-2**).

Table 8D-2. Salinity envelopes for ecological indicator species in CRE based on the CERP RECOVER salinity performance measure update (RECOVER 2020).

	Salinity Envelope		
	Optimum	**Stress**	**Damaging**
V. americana	< 10	10 to 15	> 15
C. virginica	10 to 25	5 to 9; > 25	< 5
H. wrightii	15 to 45	5 to 15; > 45	< 5
Description of Envelope	Yielding highest response variables (e.g., growth, density, recruitment, and photosynthesis).	Decline in some response variables (e.g., growth) but tolerable. Survivability and persistence possible or likely for a time.	Significant declines in all response variables. Survivability and persistence low, and loss over the long-term likely.

The Val I-75 and Ft. Myers salinity monitoring stations are primarily fresh water and located in the upstream portion of the CRE. Surface salinity from these stations was used to evaluate salinity conditions for *V. americana*. Mean daily surface salinity in WY2021 ranged from 0.2 to 8.7 at Val I-75 and from 0.2 to 17.2 at Ft. Myers (**Figure 8D-7**). The percentage of days when the 14-day moving average of surface salinity was within the optimum salinity envelope (< 10) for *V. americana* was 100% at Val I-75 in WY2021, the same as the previous four water years, and higher than long-term average (WY2007–WY2021) of 90% (**Table 8D-3**). At Ft. Myers, this percentage was 90%, substantially higher than the 56% in WY2020, and higher than the long-term average (WY2001–WY2021) of 72%. The percentage of days with stressful salinities (14-day moving average of 10 to 15) for *V. americana* at Val I-75 was 0% in WY2021 and lower than the long-term average of 6%. At Ft. Myers, the WY2021 percentage of days in the stressful envelope was 8%, substantially lower than the 44% in WY2020 and lower than the long-term average of 16%. The percentage of days with damaging salinities (14-day moving average > 15) for *V. americana* in WY2021 was 2% at Ft. Myers, which was lower than the long-term average of 12%, and 0% at Val I-75, which was the same as the previous four years. The salinity exceedance of 2% at Ft. Myers occurred in late May 2020 for seven consecutive days (**Figure 8D-7**). Further discussion relating *V. americana* metrics to salinity conditions is presented in the *Aquatic Habitat* subsection of this chapter.

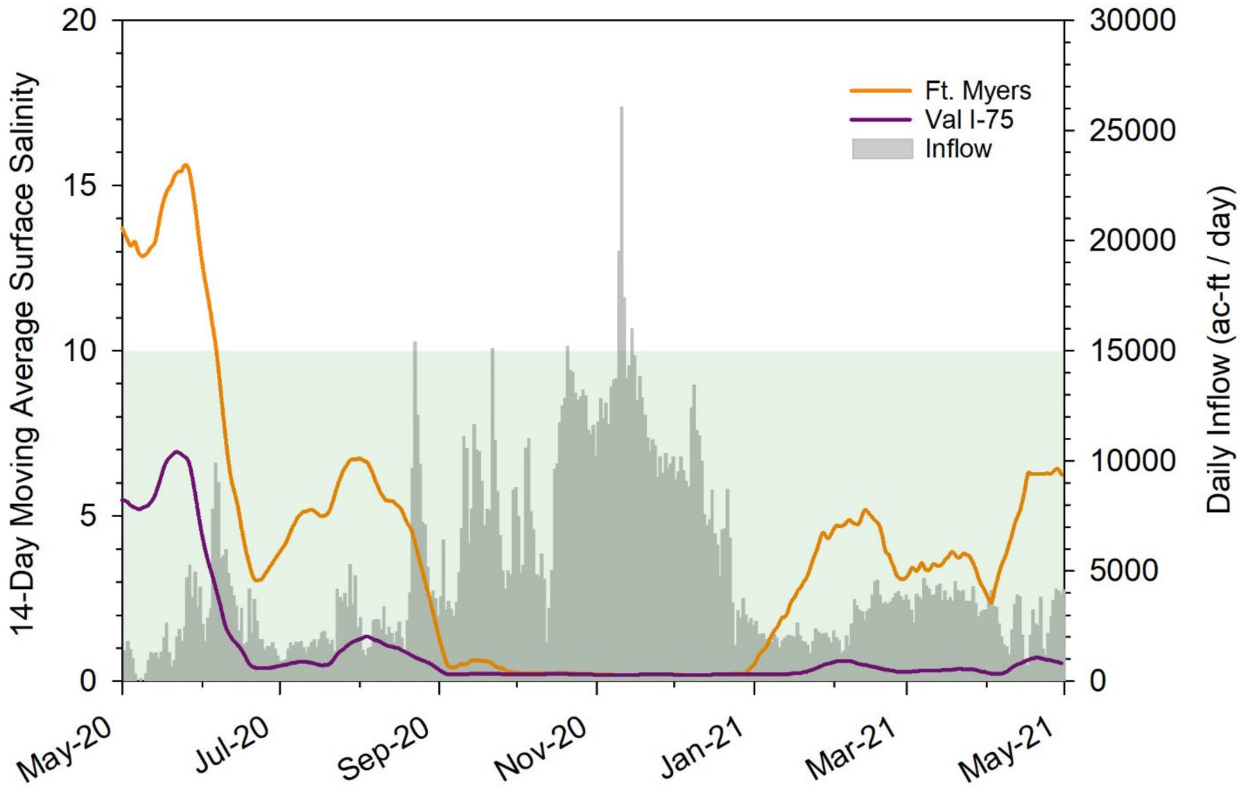

Figure 8D-7. Time series of the 14-day moving average surface water salinity at the Val I-75 (purple) and Ft. Myers (orange) salinity monitoring stations and daily freshwater inflow (gray) at S-79 for WY2021. Green shading indicates the optimum salinity envelope (< 10) for *Vallisneria americana.*

Table 8D-3. Percent of days for the most recent 5-year period and the POR when 14-day moving average surface salinity was in the different salinity envelopes for *V. americana* at the Val I-75 and Ft. Myers salinity monitoring stations. Long-term POR is WY2007–WY2021 for Val I-75 and WY2001–WY2021 for Ft. Myers.

***V. americana* 14-Day Moving Average of Surface Salinity**						
Period	**Days with Optimum Salinity < 10 (%)**		**Days with Stressed Salinity 10 to 15 (%)**		**Days with Damaging Salinity > 15 (%)**	
	Val I-75	**Ft. Myers**	**Val I-75**	**Ft. Myers**	**Val I-75**	**Ft. Myers**
WY2001/ WY2007–WY2021	90%	72%	6%	16%	4%	12%
WY2017	100%	75%	0%	23%	0%	2%
WY2018	100%	69%	0%	23%	0%	8%
WY2019	100%	94%	0%	6%	0%	0%
WY2020	100%	56%	0%	44%	0%	0%
WY2021	100%	90%	0%	8%	0%	2%

Water column salinity was measured at Cape Coral and Shell Point stations to evaluate salinity conditions for *C. virginica*. Mean daily water column salinity in WY2021 ranged from 0.3 to 26.3 at Cape Coral (**Figure 8D-8**). The percentage of days when the 14-day moving average of water column salinity was within the optimum salinity envelope (10 to 25) for *C. virginica* at Cape Coral was 58% in WY2021, significantly lower than the 82% in WY2020 but similar to the long-term average for the POR (WY2003–WY2021) of 52% (**Table 8D-4**). The percentage of days with stressful salinities for *C. virginica* (14-day moving average 5 to 10) was 12% in WY2021, higher than the previous two years and similar to the long-term POR of 14%. The percentage of days with damaging salinities for *C. virginica* (14-day moving average < 5) was 30% in WY2021, higher than the 16% in WY2020 but similar to the long-term POR average of 26%. The Cape Coral salinity station is the furthest upstream salinity station monitored for *C. virginica*; salinities measured are rarely > 25 (stressed salinity envelope).

Mean daily water column salinities ranged from 3.0 to 33.3 at Shell Point (**Figure 8D-8**). The percentage of days when the 14-day moving average of water column salinity was within the optimum salinity envelope (10 to 25) for *C. virginica* was 58% in WY2021, substantially higher than the 26% in WY2020 and higher than the long-term average for the POR (WY2003–WY2021) of 41% (**Table 8D-4**). The percentage of days with 14-day moving average salinities of < 10, encompassing both the stressful and damaging envelopes for *C. virginica*, was 0% in WY2021. The percentage of days with stressful salinities for *C. virginica* (14-day moving average > 25) was 42% in WY2021, substantially lower than the 74% observed in WY2020 and lower than the long-term POR average of 55%. Further discussion relating *C. virginica* metrics to salinity conditions is presented in the *Aquatic Habitat* subsection of this chapter.

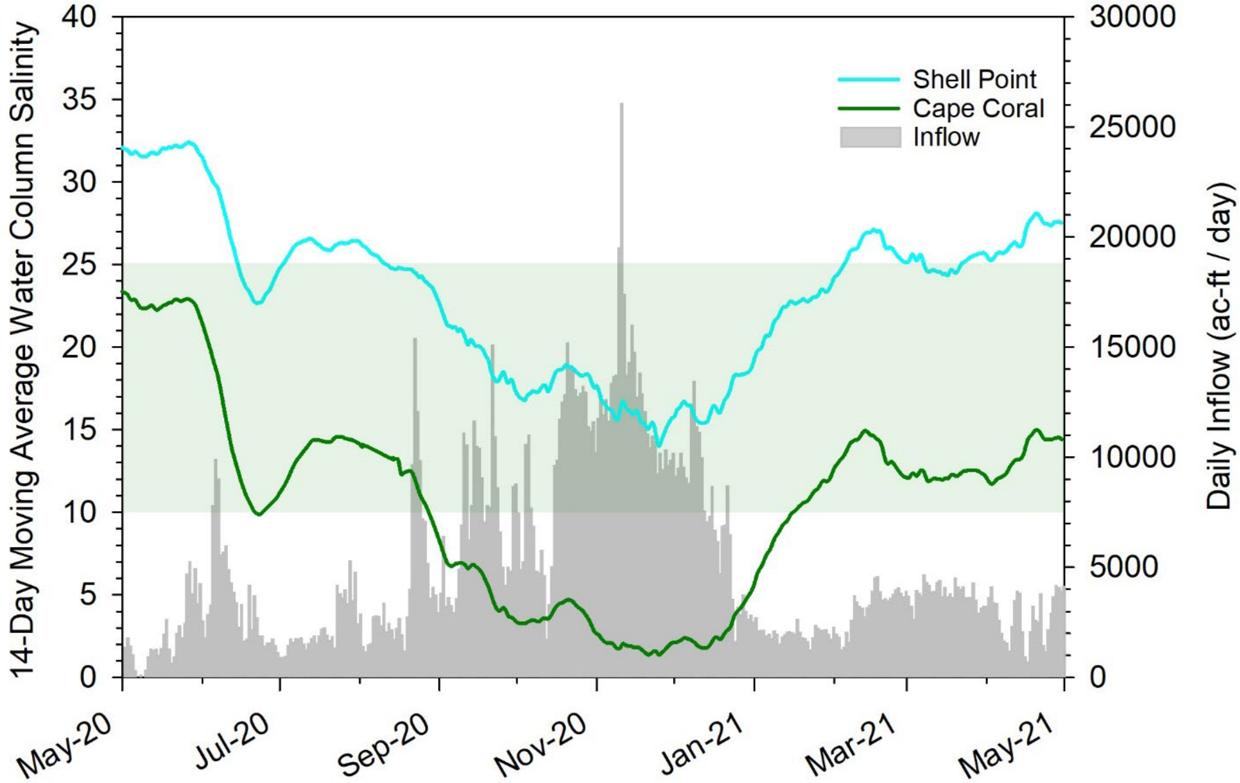

Figure 8D-8. Time series of the 14-day moving average water column salinity at the Cape Coral (green) and Shell Point (teal) salinity monitoring stations and daily freshwater inflow (gray) at S-79 for WY2021. Green shading indicates the optimum salinity envelope (10 to 25) for *Crassostrea virginica.*

Table 8D-4. Percent of days for the most recent 5-year period and the POR when the 14-day moving average salinity in the water column was in the different salinity envelopes for *C. virginica* at the Cape Coral and Shell Point salinity monitoring stations.

Crassostrea virginica **14-Day Moving Average Water Column Salinity**								
Period	**Days with Damaging Salinity < 5 (%)**		**Days with Stressed Salinity 5 to 10 (%)**		**Days with Optimum Salinity 10 to 25 (%)**		**Days with Stressed Salinity > 25 (%)**	
	Cape Coral	**Shell Point**	**Cape Coral**	**Shell Point**	**Cape Coral**	**Shell Point**	**Cape Coral**	**Shell Point**
WY2003–WY2021	26%	0%	14%	4%	52%	41%	8%	55%
WY2017	39%	0%	14%	5%	47%	55%	0%	40%
WY2018	40%	3%	17%	20%	43%	43%	0%	37%
WY2019	33%	0%	6%	2%	61%	68%	0%	29%
WY2020	16%	0%	2%	0%	82%	26%	0%	74%
WY2021	30%	0%	12%	0%	58%	58%	0%	42%

Water column salinities measured at Shell Point and Sanibel were used to evaluate salinity conditions for *H. wrightii* (**Figure 8D-9**). The percentage of days that mean water column salinities at Shell Point were within the optimum envelope (15 to 45) for *H. wrightii* was 99% in WY2021, slightly higher than the 96% in WY2020 and higher than the long-term average of 89% (**Table 8D-5**). The percentage of days with stressed salinities (14-day moving average 5 to 15) was 1% in WY2021, lower than the 4% in WY2020 and the long-term POR of 11%. The percentage of days with damaging salinities for *H. wrightii* (14-day moving average < 5) was 0% in WY2021, the same as the long-term average for the POR as well as the previous few years except WY2018 when this percentage was 3%. A 14-day moving average salinity of > 45 has not occurred at this station during the entire POR.

Mean daily water column salinity in WY2021 at the Sanibel station ranged from 20.0 to 35.4 (**Figure 8D-9**). The percentage of days that mean water column salinities were within the optimum envelope (15 to 45) for *H. wrightii* was 100% in WY2021, the same as the previous four water years and the long-term average for the POR (**Table 8D-5**). There were no excursions above or below the optimum salinity envelope for *H. wrightii* at Sanibel. Further discussion relating *H. wrightii* to salinity conditions is presented in the *Aquatic Habitat* subsection of this chapter.

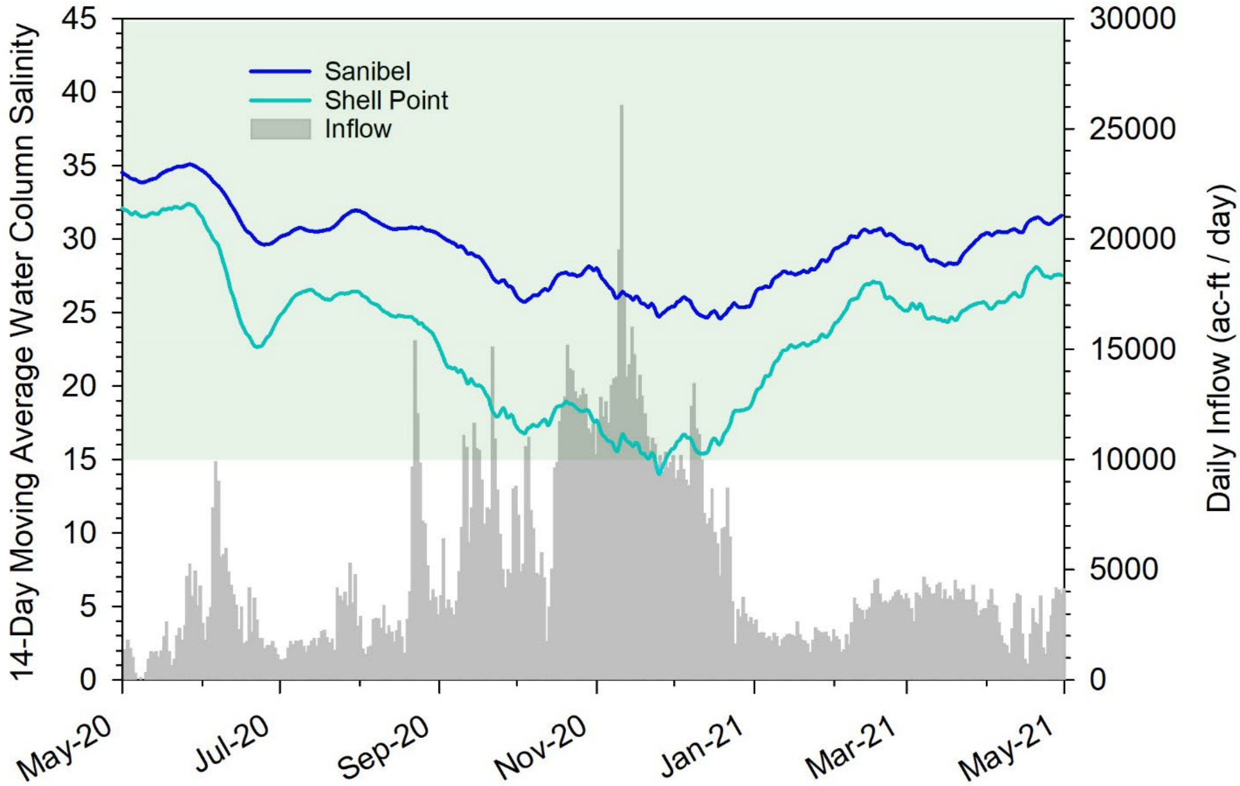

Figure 8D-9. Time series of the 14-day moving average water column salinity at the Shell Point (teal) and Sanibel (blue) salinity monitoring stations and daily freshwater inflow (gray) at S-79 for WY2021. Green shading indicates the optimum salinity envelope (15 to 45) for *Halodule wrightii.*

Table 8D-5. Percent of days for the most recent 5-year period and the POR when the 14-day moving average salinity in the water column was in the different salinity envelopes for *H. wrightii* at the Shell Point and Sanibel salinity monitoring stations.

***H. wrightii* 14-Day Moving Average Water Column Salinity**								
Period	**Days with Damaging Salinity < 5 (%)**		**Days with Stressed Salinity 5 to 15 (%)**		**Days with Optimum Salinity 15 to 45 (%)**		**Days with Stressed Salinity > 45 (%)**	
	Shell Point	**Sanibel**	**Shell Point**	**Sanibel**	**Shell Point**	**Sanibel**	**Shell Point**	**Sanibel**
WY2003–WY2021	0%	0%	11%	0%	89%	100%	0%	0%
WY2017	0%	0%	26%	0%	74%	100%	0%	0%
WY2018	3%	0%	30%	0%	67%	100%	0%	0%
WY2019	0%	0%	29%	0%	71%	100%	0%	0%
WY2020	0%	0%	4%	0%	96%	100%	0%	0%
WY2021	0%	0%	1%	0%	99%	100%	0%	0%

WATER QUALITY

Water samples were collected via grab sample at a depth of 0.5 m from the surface of the water at eight stations in the CRE ranging from approximately 1 mile downstream of S-79 in the upper estuary to just upstream of the Sanibel Causeway in the lower estuary as part of the RWQMP. Water samples were collected at monthly intervals and processed according to the SFWMD *Field Sampling Manual* (SFWMD 2020a) and *Quality Manual* (SFWMD 2020b). The stations with the most complete records (CES04, CES06, and CES08) were selected to characterize water quality along the estuarine gradient (**Figure 8D-2**). This assessment focuses on summarizing TP, TN, and chlorophyll *a* concentrations annually and for the long-term POR (WY2000–WY2021) available for each station. Annual and seasonal concentrations for the last five water years (WY2017–WY2021) are presented as average (Avg) and standard deviation (SD) for each parameter (**Tables 8D-6** through **8D-8**). Temporal trends over the last five water years are presented in a time series and compared to total monthly flow for TP, TN and chlorophyll *a* represented by the monthly values for these parameters (**Figures 8D-10** through **8D-12**).

Total Phosphorus

In WY2021, TP concentrations were highest at CES04 (upper estuary) station, where mean water year values were 0.124 mg/L (**Table 8D-6**). TP concentrations were moderate at CES06 (middle estuary) station and lowest at the lower estuary station (CES08), where the mean water year values were 0.095 and 0.055 mg/L, respectively. WY2021 wet and dry season values followed the same pattern, with concentrations decreasing from the upstream to downstream station. In the WY2021 wet season, mean values ranged from 0.147 to 0.059 mg/L. WY2021 dry season means ranged from 0.102 to 0.051 mg/L. Comparisons of TP concentrations to the long-term POR (WY2000–WY2021) revealed that values were slightly lower at all three stations in WY2021. The greatest difference occurred at CES08 in the WY2021 wet season when the mean annual value (0.059 mg) was substantially lower than the POR (0.092 mg/L).

Peak TP concentrations in WY2021 occurred during different months at each of the CRE stations. The highest mean monthly concentrations were measured in July 2020 at CES04 (0.190 mg/L), in September 2020 at CES05 (0.171 mg/L), and in November 2020 at CES08 (0.076 mg/L; **Figure 8D-10**). These higher TP values may be a result of the increased rainfall and volume of freshwater inflow to the estuary due to a very active tropical storm/hurricane season (NHC 2021a, 2021b, 2021c). The lowest TP concentrations were recorded in January and February 2021 when mean monthly values ranged from 0.074 mg/L at CES04 to 0.038 mg/L at CES08.

Table 8D-6. Annual average (Avg) and standard deviation (SD) TP concentrations presented for three stations in the CRE for the most recent 5-year period (WY2017–WY2021) and the POR. (Note: wet season: May–October and dry season: November–April).

Total Phosphorus (mg/L)						
CES04 (Upper Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	0.153	0.082	0.109	0.047	0.131	0.070
WY2017	0.115	0.016	0.099	0.023	0.105	0.021
WY2018	0.196	0.083	0.130	0.023	0.163	0.068
WY2019	0.150	0.043	0.108	0.016	0.129	0.038
WY2020	0.137	0.038	0.156	0.100	0.146	0.069
WY2021	0.147	0.032	0.102	0.026	0.124	0.036
CES06 (Middle Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	0.126	0.078	0.081	0.038	0.104	0.065
WY2017	0.106	0.027	0.072	0.004	0.085	0.023
WY2018	0.170	0.063	0.098	0.026	0.134	0.060
WY2019	0.153	0.054	0.087	0.009	0.120	0.051
WY2020	0.117	0.045	0.082	0.023	0.101	0.040
WY2021	0.116	0.029	0.074	0.022	0.095	0.033
CES08 (Lower Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	0.092	0.095	0.059	0.030	0.075	0.071
WY2017	0.056	0.019	0.044	0.004	0.049	0.012
WY2018	0.123	0.075	0.066	0.020	0.094	0.060
WY2019	0.088	0.018	0.050	0.007	0.067	0.023
WY2020	0.074	0.040	0.052	0.014	0.064	0.032
WY2021	0.059	0.012	0.051	0.014	0.055	0.013

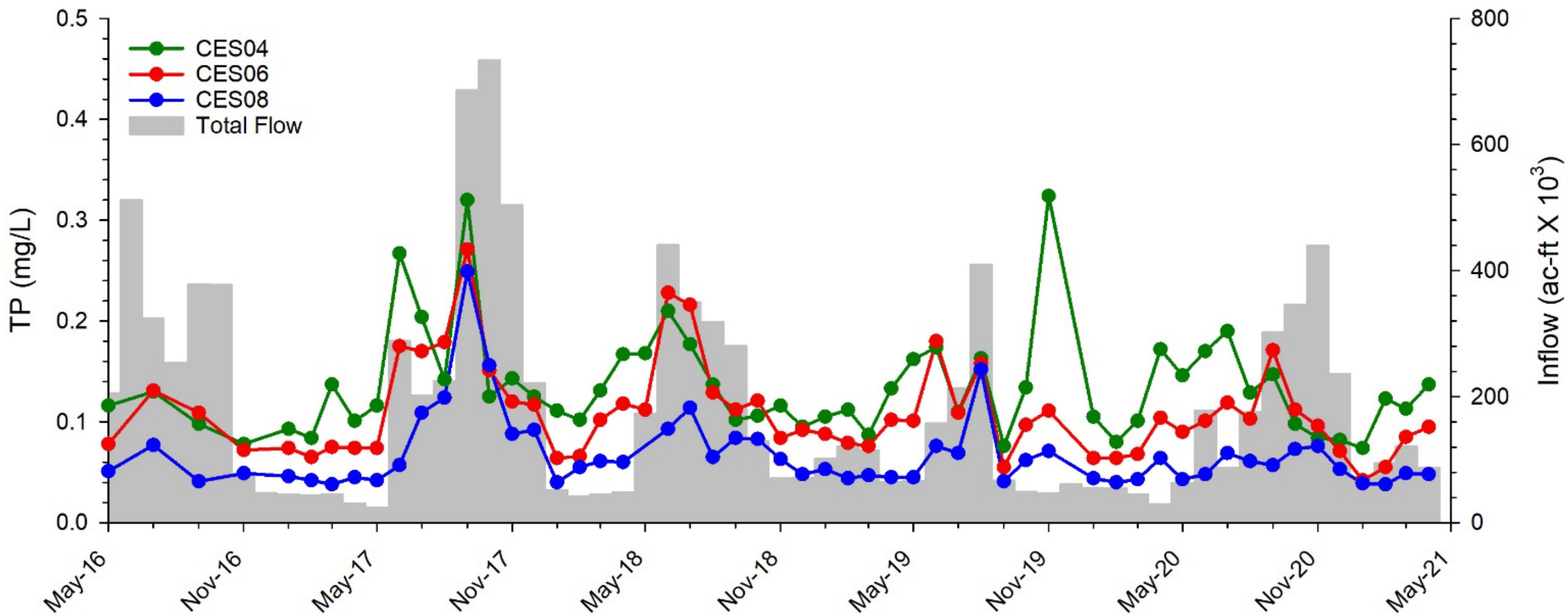

Figure 8D-10. Mean monthly TP concentrations for the most recent 5-year period (WY2017–WY2021) at stations in the upper estuary (CES04), middle estuary (CES06), and lower estuary (CES08) of the CRE with total monthly inflow including the Tidal Basin (gray bars).

Total Nitrogen

In WY2021, TN concentrations were highest at the CES04 (upper estuary) station where the mean water year value was 1.23 mg/L (**Table 8D-7**). TN concentrations at the middle estuary station (CES06) were slightly lower with a mean value of 0.98 mg/L. The lowest TN concentrations were recorded in the lower estuary (CES08) where the mean water year value was 0.58 mg/L. WY2021 wet and dry season values followed the same pattern, with concentrations decreasing from the upstream to downstream station. In the WY2021 wet season, mean values ranged from 0.130 to 0.57 mg/L. WY2021 dry season means ranged from 1.17 to 0.58 mg/L. Mean values in WY2021 at CES04 were similar to the long-term POR as well as the WY2021 wet and dry seasons. At CES06, the overall WY2021 mean value was similar to the POR, but the wet season mean was lower and the dry season mean was higher than the POR. The overall WY2021 mean at CES08 (0.58 mg/L) was higher than the POR (0.49 mg/L). This difference was likely due to the increased TN concentrations measured during the WY2021 dry season when the mean value (0.58 mg/L) was substantially higher than the POR (0.41 mg/L).

In WY2021, peak TN concentrations were measured during the fall (October–November 2020) at CES04, CES06 and CES08 when mean monthly values were 1.59, 1.48, and 0.95 mg/L, respectively (**Figure 8D-11**). These higher TN values may be a result of the increased rainfall and volume of freshwater inflow to the estuary (Paczkowska et al. 2020) observed during Tropical Storm Eta and other active storms (NHC 2021a, 2021b, 2021c). At CES04, there was an additional peak TN concentration earlier in the water year (June 2020) when the mean monthly value reached 1.50 mg/L. The lowest TN concentrations were recorded in May 2020 when mean monthly values were 0.960 mg/L at CES04, 0.670 mg/L at CES06 and 0.360 mg/L at CES08.

Table 8D-7. Annual average (Avg) and standard deviation (SD) TN concentrations presented for three stations in the CRE for the most recent 5-year period (WY2017–WY2021) and the POR. (Note: wet season: May–October and dry season: November–April).

Total Nitrogen (mg/L)						
CES04 (Upper Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	1.29	0.33	1.12	0.41	1.20	0.38
WY2017	1.18	0.09	1.01	0.07	1.08	0.11
WY2018	1.34	0.21	1.25	0.31	1.30	0.25
WY2019	1.34	0.15	1.14	0.20	1.24	0.20
WY2020	1.20	0.18	1.32	0.65	1.26	0.43
WY2021	1.30	0.24	1.17	0.09	1.23	0.19
CES06 (Middle Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	1.11	0.41	0.80	0.30	0.96	0.39
WY2017	0.99	0.21	0.73	0.13	0.83	0.20
WY2018	1.16	0.29	0.88	0.29	1.03	0.31
WY2019	1.26	0.34	0.80	0.06	1.03	0.33
WY2020	0.86	0.29	0.71	0.05	0.80	0.23
WY2021	1.02	0.35	0.94	0.23	0.98	0.29
CES08 (Lower Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	0.58	0.36	0.41	0.23	0.49	0.31
WY2017	0.50	0.11	0.42	0.07	0.45	0.09
WY2018	0.86	0.41	0.60	0.25	0.74	0.36
WY2019	0.67	0.17	0.49	0.04	0.58	0.15
WY2020	0.65	0.36	0.44	0.07	0.56	0.29
WY2021	0.57	0.16	0.58	0.23	0.58	0.19

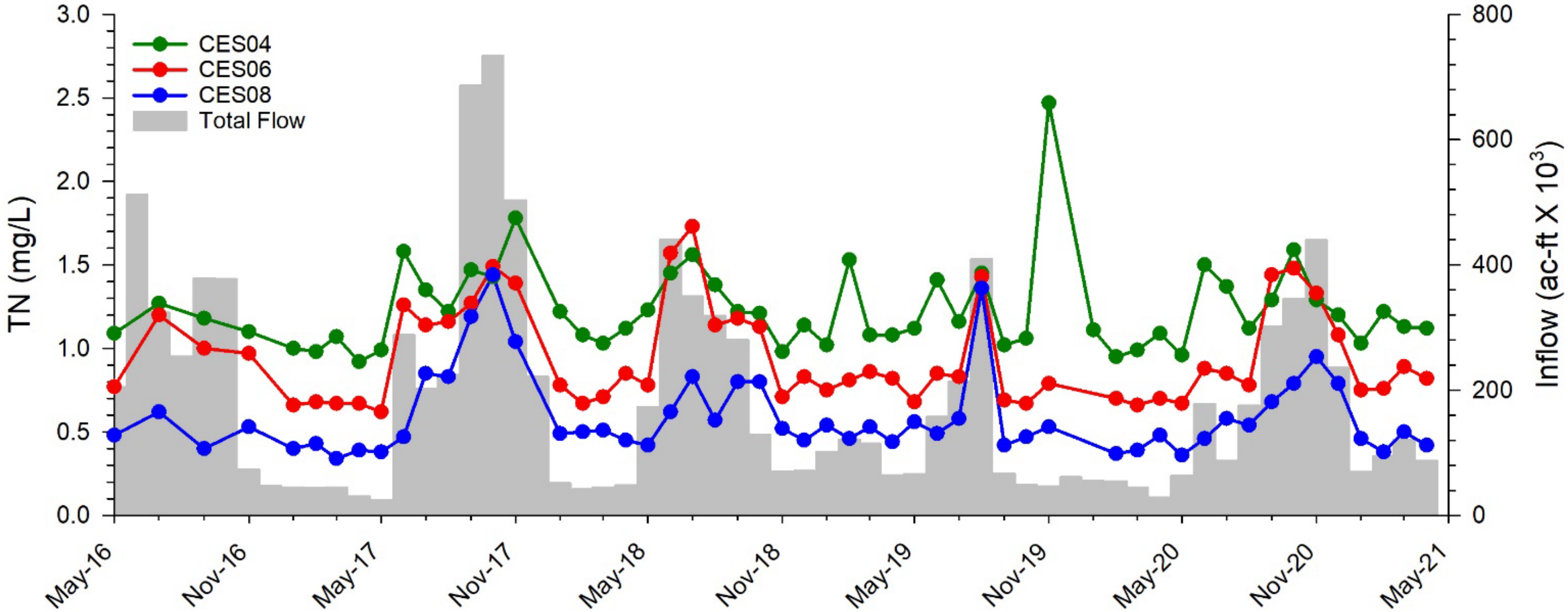

Figure 8D-11. Mean monthly TN concentrations for the most recent 5-year period (WY2017–WY2021) at stations in the upper estuary (CES04), middle estuary (CES06), and lower estuary (CES08) of the CRE with total monthly inflow including the Tidal Basin (gray bars).

Chlorophyll *a*

In WY2021, chlorophyll *a* concentrations were highest at the upper estuary station (CES04) where the mean water year value was 7.5 micrograms per liter (µg/L; **Table 8D-8**). Chlorophyll *a* concentrations were moderate (4.5 µg/L) at the middle estuary (CES06) station and lowest (3.6 µg/L) at the lower estuary (CES08) station in WY2021. Mean WY2021 wet season chlorophyll *a* concentrations were highest at CES04 (6.3 µg/L) and lower but similar at CES06 (4.5 µg/L) and CES08 (4.7 µg/L). As with the overall water year values, WY2021 dry season chlorophyll *a* concentrations decreased from the upstream to downstream station; mean concentrations were 8.6 µg/L at CES04 and 2.6 µg/L at CES08. Mean concentrations at CES04 were similar to the long-term POR in the dry season but were substantially lower in the wet season (6.3 µg/L WY2021 versus 10.0 µg/L POR). At CES06, the WY2021 mean concentrations for total, wet season, and dry season were all 4.5 µg/L and were all lower than the long-term POR values. Mean concentrations for WY2021 at CES08 were similar to POR values.

Peak chlorophyll *a* concentrations occurred in different months at all three CRE stations in WY2021 (**Figure 8D-12**). At CES04, the highest mean monthly concentration (17.6 µg/L) was measured in February 2020. Peak concentrations at CES06 (9.2 µg/L) and CES08 (7.1 µg/L) occurred in July 2020 and August 2020, respectively. The lowest chlorophyll *a* concentrations (< 1.4 µg/L) were measured in September 2020 at CES04 and CES06. At CES08, the lowest chlorophyll *a* concentrations (1.8 µg/L) occurred in May 2020.

Table 8D-8. Annual average (Avg) and standard deviation (SD) chlorophyll *a* concentrations presented for three stations in the CRE for the most recent 5-year period (WY2017–WY2021) and the POR. (Note: wet season: May–October and dry season: November–April).

Chlorophyll *a* (µg/L)						
CES04 (Upper Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	10.0	15.6	8.8	11.1	9.4	13.5
WY2017	8.3	6.0	4.1	1.8	5.7	4.1
WY2018	5.2	4.0	6.4	4.8	5.8	4.2
WY2019	2.8	0.7	6.7	2.7	4.7	2.8
WY2020	8.8	6.6	37.4	54.5	20.2	35.1
WY2021	6.3	4.9	8.6	5.4	7.5	5.1
CES06 (Middle estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	10.9	14.2	6.5	6.6	8.7	11.3
WY2017	3.6	0.8	5.5	2.3	4.8	2.0
WY2018	9.7	6.2	7.2	7.7	8.5	6.8
WY2019	8.5	7.6	4.7	2.3	6.5	5.4
WY2020	3.5	1.4	5.4	6.5	4.3	4.0
WY2021	4.5	3.5	4.5	1.9	4.5	2.6
CES08 (Lower Estuary)						
Period	**Wet Season**		**Dry Season**		**Total**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
WY2000–WY2021	4.5	3.6	2.3	1.9	3.3	3.0
WY2017	3.7	2.2	1.7	0.8	2.4	1.7
WY2018	5.6	5.2	2.3	0.6	3.9	3.9
WY2019	5.8	5.3	1.7	0.4	3.6	4.0
WY2020	3.1	1.2	2.0	1.1	2.7	1.2
WY2021	4.7	2.0	2.6	0.4	3.6	1.7

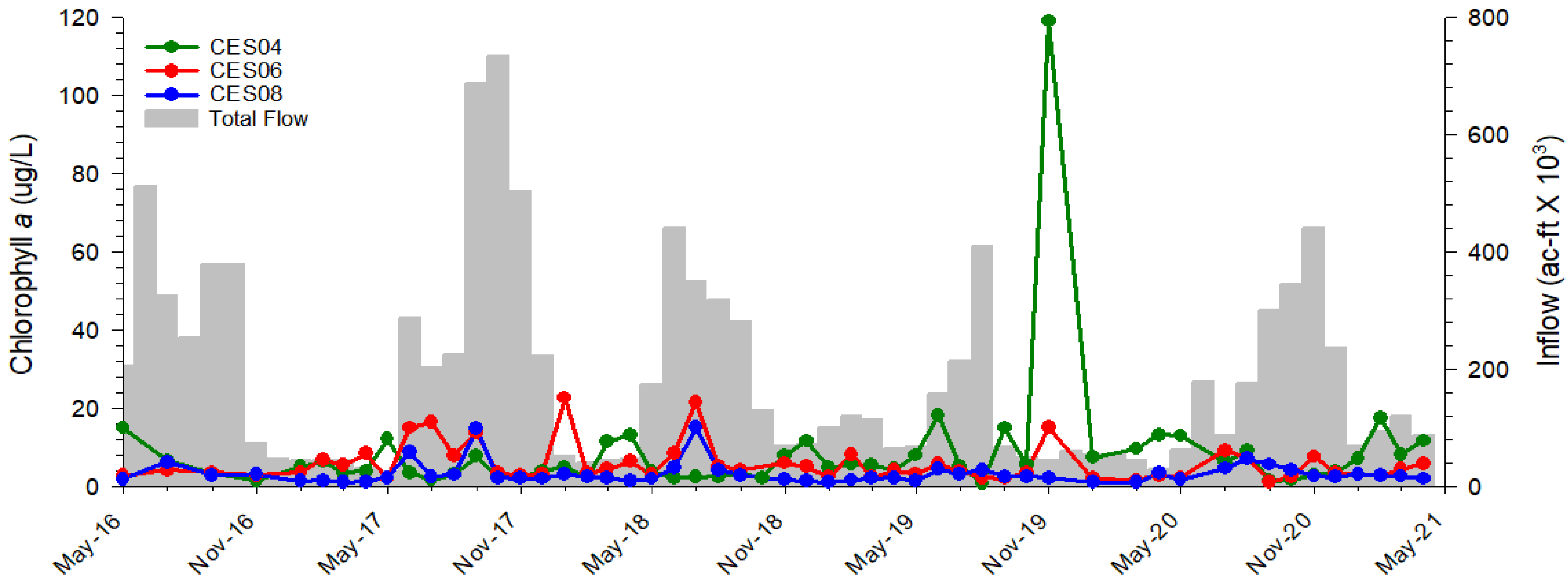

Figure 8D-12. Mean monthly Chlorophyll *a* concentrations for the most recent 5-year period (WY2017–WY2021) at stations in the upper estuary (CES04), middle estuary (CES06), and lower estuary (CES08) of the CRE with total monthly inflow including the Tidal Basin (gray bars).

AQUATIC HABITAT

Crassostrea virginica

Crassostrea virginica (eastern oysters) are benthic, sessile, filter-feeding organisms that contribute valuable ecosystem services by filtering phytoplankton and suspended particles from the water column and providing food, shelter, and habitat for other estuarine organisms. This makes them an ideal indicator species for assessing the effects of water quality restoration on estuarine ecosystems (Volety 2008). *C. virginica* population monitoring in the CRE was initiated in 2000 and is supported by the CERP RECOVER program. This long-term monitoring program measures the effects of CERP restoration efforts on *C. virginica* population health and distribution. *C. virginica* density, recruitment and disease prevalence and intensity were monitored at two sites, Iona Cove and Bird Island, in the CRE (**Figure 8D-2**). Results from the last five water years (WY2017–WY2021) are presented in this section.

Salinity

The health, survivorship, and distribution of *C. virginica* populations are greatly influenced by water quality. Changes in salinity, high temperatures, low dissolved oxygen concentrations, and siltation can all be stressors (Parker 2015, Parker and Radigan 2020). Temperature and salinity are two of the most influential environmental factors affecting *C. virginica* populations (Shumway 1996) but the magnitude, timing, and frequency of salinity fluctuations are the major driving force behind changes in *C. virginica* health and abundance in the CRE. *C. virginica* can tolerate a wide range of salinities, 1.2 to 36.6 in Apalachicola Bay, Florida (Menzel et al. 1966), but the optimum salinity range is much narrower. RECOVER recently published an updated salinity performance measure defining the optimum salinity envelope for *C. virginica* as 10 to 25 (**Table 8D-2**; RECOVER 2020). Salinities outside of this range are considered stressful (5 to 9; > 25) or damaging (< 5) to *C. virginica*. Mean daily water column salinity at the Cape Coral station, located upstream of the Iona Cove *C. virginica* monitoring site (**Figure 8D-2**), ranged from 0.1 to 27.5 over the last five water years (WY2017–WY2021) and the 14-day moving average salinity was within the optimum salinity envelope 58% of the days in WY2021 (**Table 8D-4**). At the Shell Point station, located near the Bird Island *C. virginica* monitoring site (**Figure 8D-2**), mean daily water column salinity ranged 0 to 35.3 from WY2017–WY2021. The 14-day moving average salinity at Shell Point was within the optimum salinity envelope for *C. virginica* 58% of the days in WY2021 (**Table 8D-4**).

Live Crassostrea virginica Density

Live *C. virginica* densities were measured biannually (fall and spring) using methods adapted from Lenihan and Peterson (1998) and Grizzle et al. (2005) survey methodologies at the Iona Cove and Bird Island sites. At each site, 15 replicate 0.25-square meter (m^2) quadrats were haphazardly deployed, and all live *C. virginica* were collected and counted. At Iona Cove, mean *C. virginica* densities ranged from 2 oysters/m^2 during the WY2018 dry season (post Hurricane Irma; NHC 2018) to 523 oysters/m^2 during the WY2020 wet season (**Figure 8D-13**). At the downstream Bird Island site, mean densities ranged from 248 oysters/m^2 during the dry season of WY2021 to 2,107 oysters/m^2 during the WY2017 wet season WY2017 (**Figure 8D-14**). *C. virginica* densities at Bird Island illustrate that estuarine salinities at that location were favorable for successful larval recruitment and survival (Volety and Haynes 2014). Despite favorable conditions, *C. virginica* densities at Bird Island have shown a decline since September 2019 possibly due to predation and disease from prolonged high (> 25) salinities.

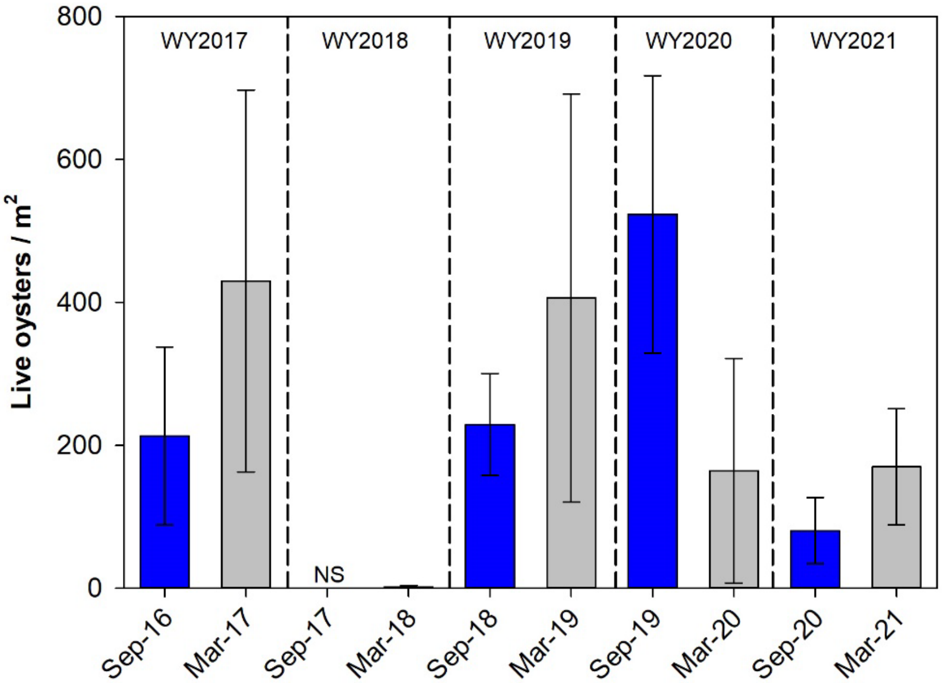

Figure 8D-13. Mean live *C. virginica* density (± SD) at the Iona Cove site in the CRE for WY2017–WY2021. Blue bars represent wet season and gray bars represent dry season sampling events. No samples (NS) were collected in September 2017 due to water quality conditions after Hurricane Irma.

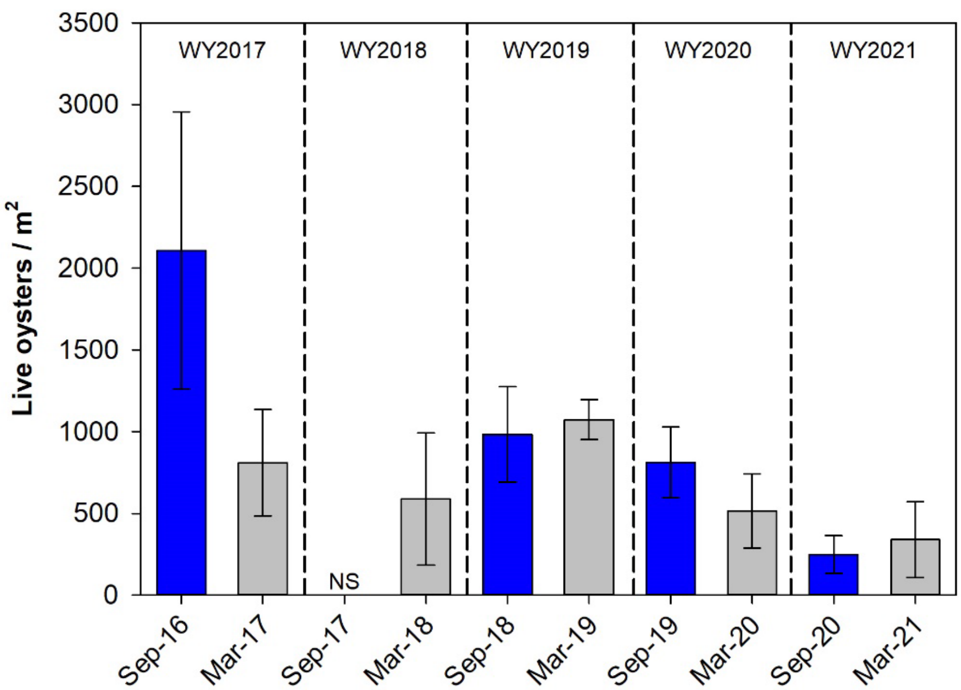

Figure 8D-14. Mean live *C. virginica* density (±SD) at the Bird Island site in the CRE for WY2017–WY2021. Blue bars represent wet season and gray bars represent dry season sampling events. No samples (NS) were collected in September 2017 due to water quality conditions after Hurricane Irma.

Recruitment

Juvenile recruitment was measured by counting settled *C. virginica* spat (permanently attached *C. virginica*) from the underside of shells strung on three replicate arrays deployed at the Iona Cove and Bird Island sites in the CRE. Recruitment rates were determined by dividing the number of spat per shell by the number of days the shell was deployed and then standardizing to a 28-day month. Spawning and larval settlement typically occurred during the wet season months. In the CRE, the first spring recruits were most commonly detected in May with recruitment continuing through the summer months before peaking in late fall (Parker and Radigan 2020). Mean monthly recruitment rates ranged from 0 to 37.1 spat/shell/month at the Iona Cove site during WY2017–WY2021 with the highest rate occurring in September 2018 (**Figure 8D-15**). Mean wet season recruitment rates at Iona Cove ranged from 0.8 to 10.7 spat/shell/month and mean dry season values ranged from 0.01 to 1.0 spat/shell/month.

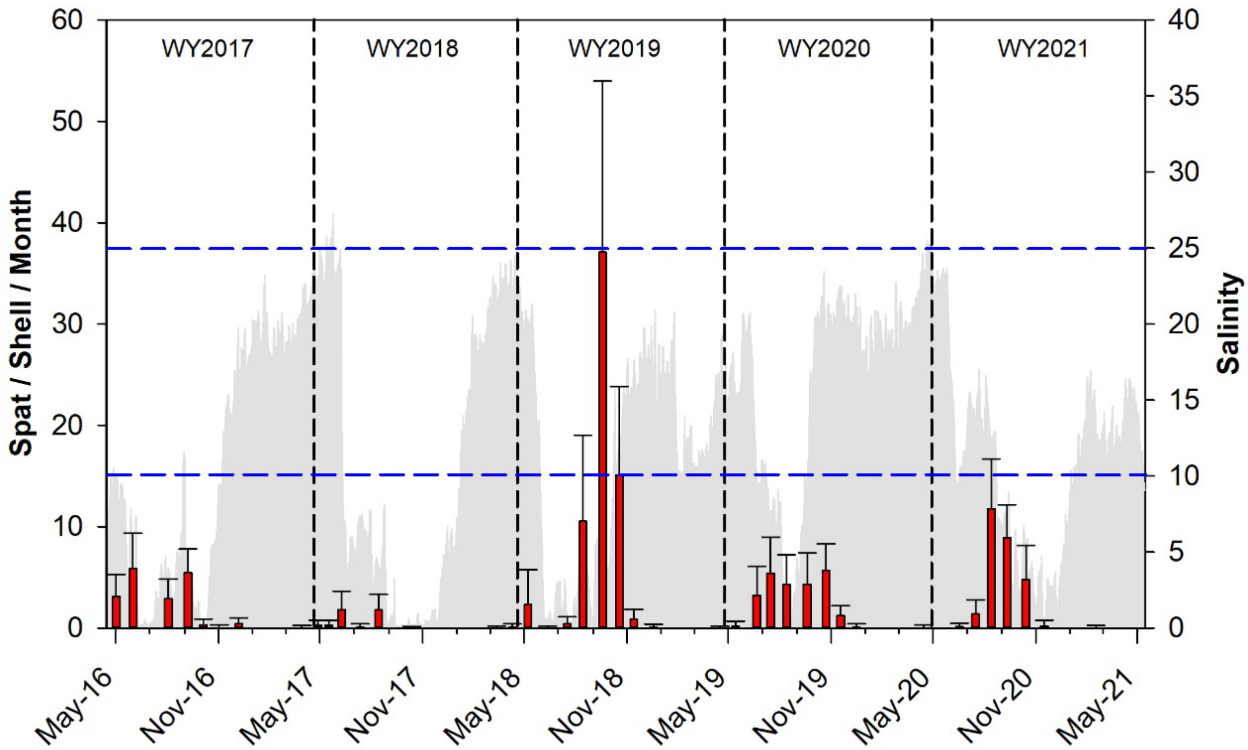

Figure 8D-15. Mean monthly spat recruitment (± SD; red bars) at the Iona Cove site in the CRE during WY2017–WY2021 and mean daily salinity (gray) at Cape Coral. The optimum salinity envelope (10 to 25) is indicated by the blue dashed lines.

At Bird Island, mean monthly recruitment rates ranged from 0 to 108 spat/shell/month during WY2017–WY2021 (**Figure 8D-16**). As with Iona Cove, the highest recruitment rate at Bird Island was also recorded in September 2018. During the wet season, mean recruitment rates at Bird Island ranged from 7.1 to 40.0 spat/shell/month. Mean dry season recruitment rates ranged from 0.1 to 10.2 spat/shell/month. For the most recent 5-year period (WY2017–WY2021), mean overall recruitment rates were substantially greater at the more downstream Bird Island site where downstream flows concentrated larvae and salinities were generally higher, allowing for successful settlement of those larvae. Mean recruitment rates were also higher at both Iona Cove and Bird Island during the wet season (4.3 and 22.2 spat/shell/month, respectively) than during the dry season (0.3 and 2.3 spat/shell/month, respectively).

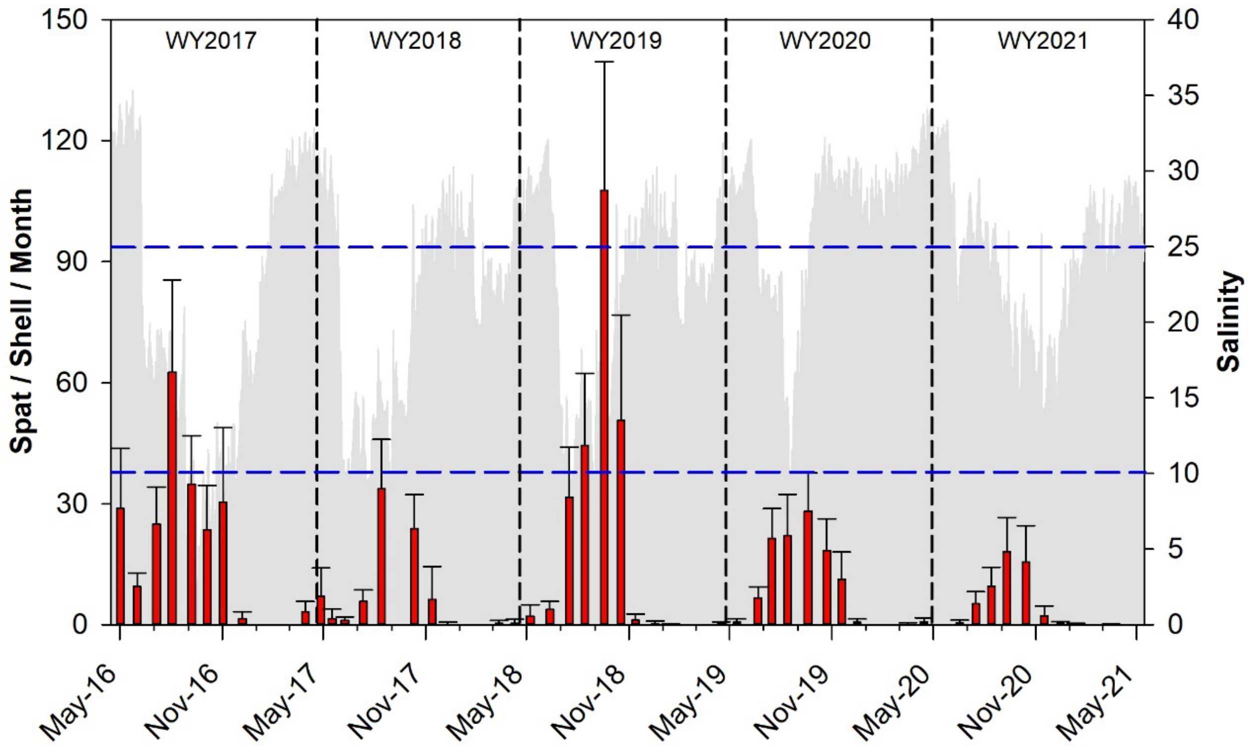

Figure 8D-16. Mean monthly spat recruitment (± SD; red bars) at the Bird Island site in the CRE during WY2017–WY2021 and mean daily salinity (gray) at Shell Point. The optimum salinity envelope (10 to 25) is indicated by the blue dashed lines.

Dermo Infection Prevalence and Intensity

Dermo (*Perkinsus marinus*) is a marine protozoan parasite that infects oysters. The dermo parasite favors high salinity and high temperature environments so infections often decline when estuarine salinities fall below the optimum range for oysters. Dermo infection prevalence (% infected) and intensity (severity of infection) were assessed by examining mantle and gill tissues from 15 *C. virginica* individuals collected monthly from the Iona Cove and Bird Island sites. Mean monthly dermo prevalence ranged from 0 to 100% at Iona Cove during the WY2017–WY2021 period. Mean wet season prevalence at Iona Cove ranged from 20.0 to 61.3% and mean dry season values ranged from 10.0 to 76.0% (**Table 8D-9**). The percentage of infected *C. virginica* was highest at Iona Cove during the WY2020 dry season when salinities exceeded the optimum range for *C. virginica* for a prolonged period (**Figure 8D-15**). Dermo infection intensity was scored according to the Mackin scale (Mackin 1962) with mean monthly values ranging from 0 (no infection) to 2 (light to moderate infection) during WY2017–WY2021. Mean wet season infection intensities ranged from 0.05 to 0.64 and were slightly lower than those measured during the dry season when values ranged from 0.04 to 1.06 (**Table 8D-9**). At Bird Island, mean monthly prevalence also ranged from 0 to 100% during WY2017–WY2021. Mean wet season prevalence at Bird Island ranged from 31.1 to 60.0% and mean dry season values ranged from 23.8 to 76.0% during WY2017–WY2021 (**Table 8D-9**). Despite the high percentage of infected *C. virginica* at Bird Island, mean dermo intensity was low with values ranging from 0.23 to 0.87 in the wet season and 0.20 to 1.00 in the dry season during WY2017–WY2021.

Table 8D-9. Mean prevalence (% infected) and intensity (0 to 5 based on the Mackin scale with 0 = no infection and 5 = heavy infection; Mackin 1962) of *C. virginica* infected with dermo (*Perkinsus marinus)* from the Iona Cove and Bird Island sites in the CRE during WY2017–WY2021.

Water Year	Season	Dermo Prevalence Mean (%)		Dermo Intensity Mean (0 to 5)	
		Iona Cove	Bird Island	Iona Cove	Bird Island
WY2017	Wet	61.3% [a]	55.6%	0.63	0.60
	Dry	53.3% [b]	55.6% [b]	0.48	0.50
WY2018	Wet	60.0% [c]	31.1% [c]	0.52	0.23
	Dry	60.0% [c]	23.8%	0.20	0.20
WY2019	Wet	20.0% [d]	38.3%	0.05	0.35
	Dry	10.0%	48.6%	0.04	0.45
WY2020	Wet	36.7%	60.0%	0.28	0.87
	Dry	76.0% [e]	76.0% [e]	1.00	1.00
WY2021	Wet	46.7%	40.0%	0.64	0.32
	Dry	72.0%	56.0%	1.06	0.76

a. No *C. virginica* were sampled in September 2016.

b. No *C. virginica* were sampled in January 2017.

c. No live *C. virginica* were available for collection from September 2017 through April 2018 at Iona Cove or September 2017 at Bird Island due to mortalities associated with low estuarine salinities following Hurricane Irma.

d. No live *C. virginica* were available for collection in June 2018.

e. No *C. virginica* were sampled in April 2020 due to COVID-19 restrictions.

Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) communities, which include both seagrasses and freshwater aquatic plants, are monitored within the CRE using a modified Braun-Blanquet coverage and abundance scale (BBCA; **Table 8D-10**), which provides an effective estimate of variability in seagrass coverage and abundance for seagrass meadows (Furman et al. 2018).

Table 8D-10. Braun-Blanquet cover and abundance scores and corresponding percent cover interpretations.

Braun-Blanquet Score	Cover Interpretation
0	Species absent from quadrat
0.1	<5 %; species represented by a single shoot
0.5	< 5%; a few solitary shoots
1	< 5%; many shoots
2	5 to 25%
3	26 to 50%
4	51 to 75%
5	76 to 100%

An estuary-wide BBCA survey was conducted once during each wet and dry season (June and December, respectively) at approximately 30 sites in each of the four segments depicted in **Figure 8D-17**. Sites were selected by overlaying a hexagonal grid on a map of the CRE segments and randomly selecting points using a stratified random sampling design (Hall et al. 1999). Eight randomly thrown 0.25-m^2 quadrats were scored at each site. Recorded BBCA scores were used to calculate SAV spatial extent index (SE), abundance index, and relative species composition (RSC) according to Madden et al. (2009). These metrics provide standardized comparisons to quickly evaluate SAV community health. SAV SE gives the proportion of seagrass bottom cover per segment and was calculated from the frequency of observations within a segment where SAV occurs then divided by the total number of all quadrats sampled. SE ranges from 0.0 (no SAV observed) to 1.0 (SAV recorded in every quadrat). The higher the SE value, the more widespread SAV distribution is supported within a segment.

A comparison of SAV SE for each segment in the CRE is provided in **Figure 8D-18** in the next subsection. The SAV abundance index represents the average density of SAV cover only within areas supporting SAV within each segment, and it does not average the abundance over the entire segment. Higher abundance of SAV indicate a higher standing biomass of SAV, which enhances sediment stabilization and provides a source of food and habitat (Orth et al. 2006).

A comparison of SAV abundance index for each segment in the CRE is provided in **Figure 8D-19** in the next subsection. RSC was calculated by dividing the abundance of a single SAV species by the sum of abundance values for all SAV species present in the segment. RSC provides the proportion each SAV species contributes to total SAV abundance within a segment and serves as an index of species diversity. RSC is provided for each segment and discussed in the each of the segment sections below.

In addition to estuary-wide monitoring, SAV cover and abundance were assessed more frequently at a community-scale through BBCA surveys along fixed transects that are monitored at an upper, middle and lower estuary site (CRE 2, CRE 5, and CRE 8, respectively; **Figure 8D-2**). At each permanent transect site, SAV cover and abundance were assessed within a 0.25-m^2 quadrat along three fixed, parallel 100-m transects at 10-m increments. BBCA scores were then converted to percent cover according to van der Maarel (2007). Mean percent cover for each site was summarized for wet season monitoring, which occurs monthly (CRE 2 and 8) or every other month (CRE 5) from May to October, and dry season monitoring, which occurs in November, March, and April of each water year. Permanent transect monitoring was initiated in the WY2019 wet season at the start of the revised Northern Estuaries SAV Ecosystem Assessment project (NESEA).

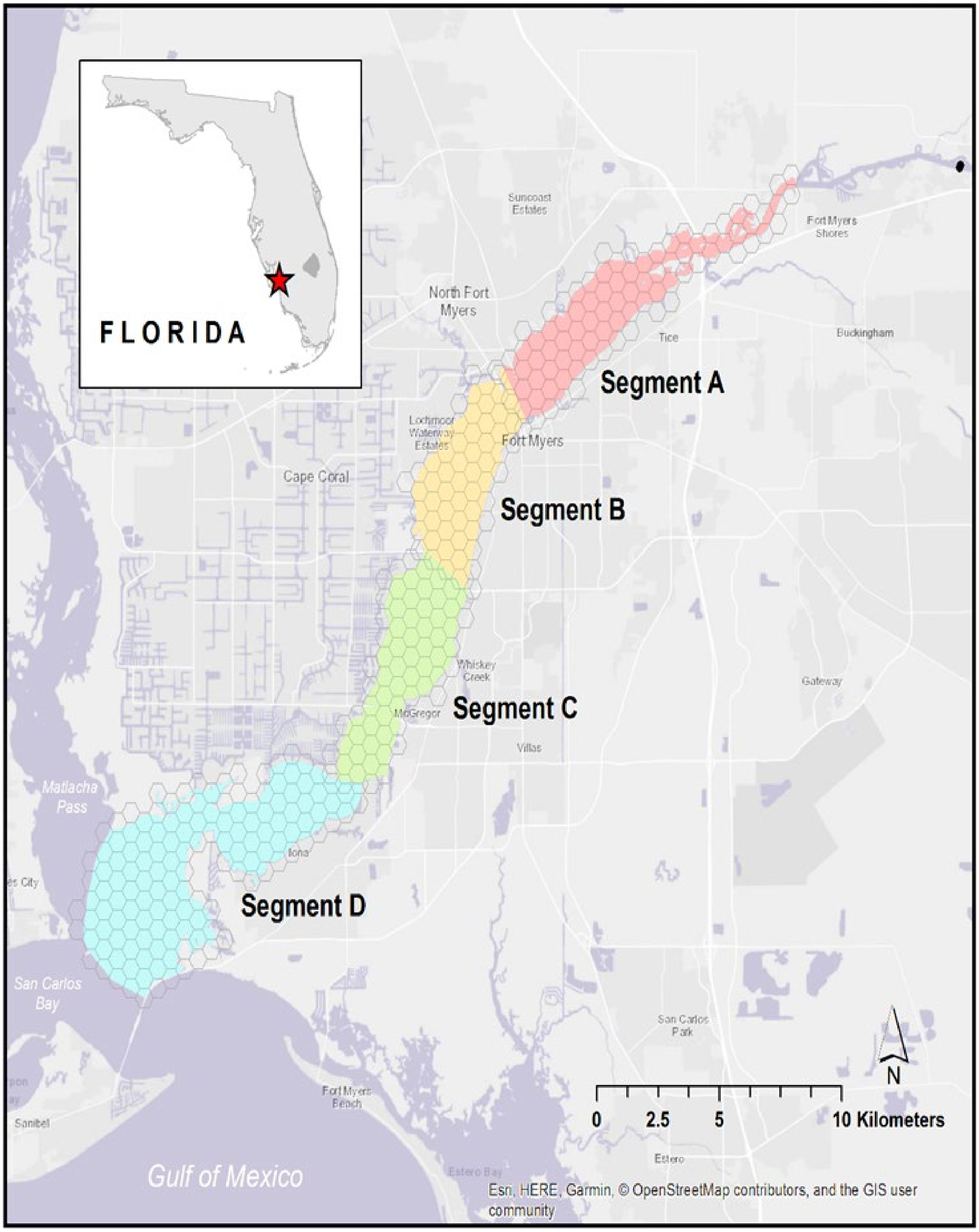

Figure 8D-17. The four segments of the CRE used for ecosystem-scale monitoring of SAV with example overlay of hexagons used in the stratified random sampling design.

Upper Estuary – Segments A and B, CRE 2

The SAV communities in the upstream, low salinity environment of Segments A and B were historically comprised of freshwater species *Ruppia maritima* (widgeon grass) and *Vallisneria americana* (tape grass). *V. americana* growth and survival is impeded at salinity > 10, while salinity < 10 is considered within its optimum range (Haller et al. 1974, Doering et al. 2001, 2002, French and Moore 2003, Boustany et al. 2010, Lauer et al. 2011). *V. americana* was abundant in the CRE in 1998 and has since had periods of recovery followed by severe decreases due to high salinity events, the most recent of which occurred in 2017 (reviewed in Douglass et al. 2020). *R. maritima* is a salt-tolerant freshwater species with growth reported in salinities of 0 to 70 (Kantrud 1991). Despite a broad tolerance to salinity, *R. maritima* is often absent or present only in low abundance in the CRE (Douglass et al. 2020). The ecosystem-scale monitoring in CRE Segments A and B indicates SAV communities in the upper estuary are characterized by low SE and abundance (**Figures 8D-18** and **8D-19**).

Spatial extent of SAV in Segment A ranged from zero in the WY2019 dry season to a maximum value of 0.14 in the WY2020 wet season resulting in SAV occurrence in 14% of recorded observations. Within Segment B, the minimum SE of SAV occurred in the WY2020 dry season when SAV was absent in 98% of observations. The highest SE of SAV in Segment B occurred in the WY2021 wet season when 22.4% of observations contained SAV (**Figure 8D-18**). The average percent ± SD of SAV occurrence over the reported period was slightly lower in Segment A than Segment B (5.5 ± 4.6 and 6.5 ± 7.2%, respectively).

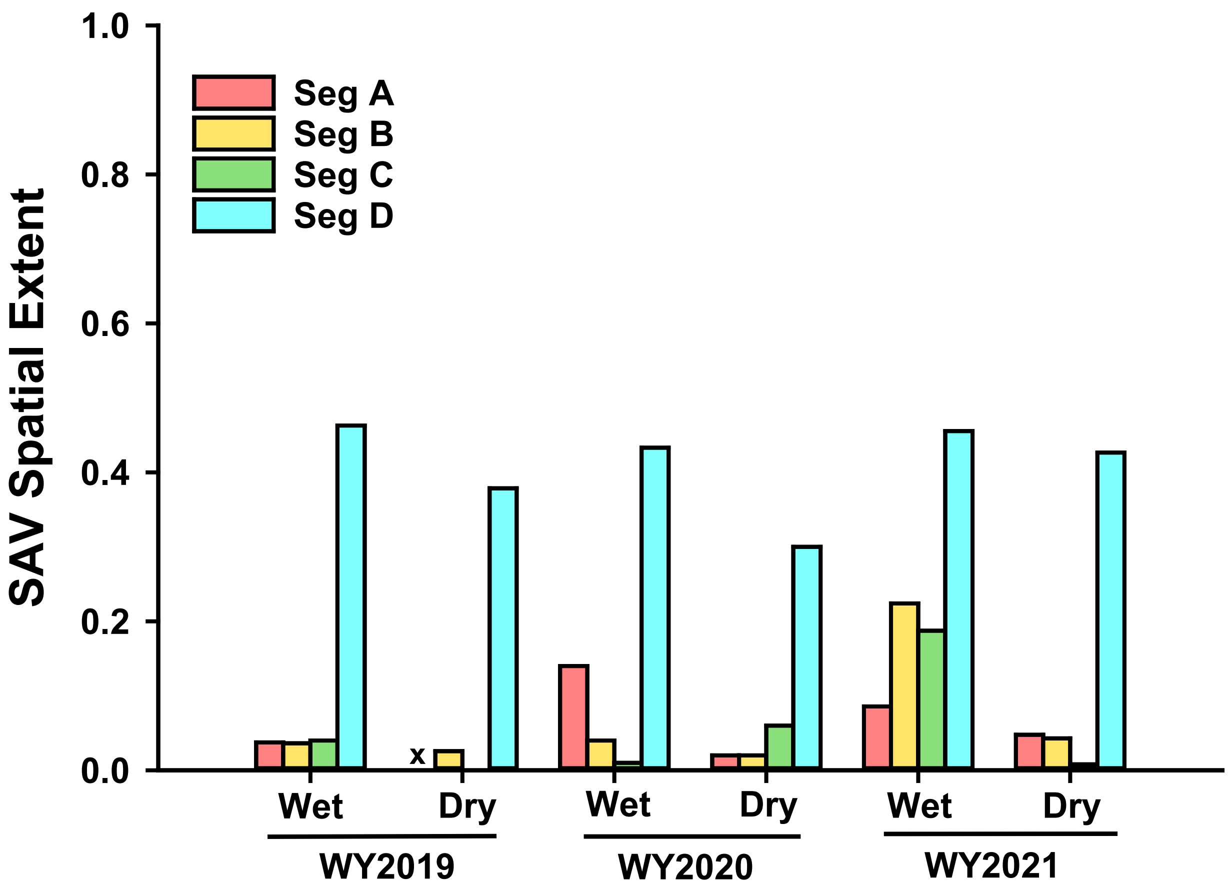

Figure 8D-18. SAV spatial extent in the four CRE segments (A through D) by season for WY2019–WY2021. A lowercase x indicates a zero-value.

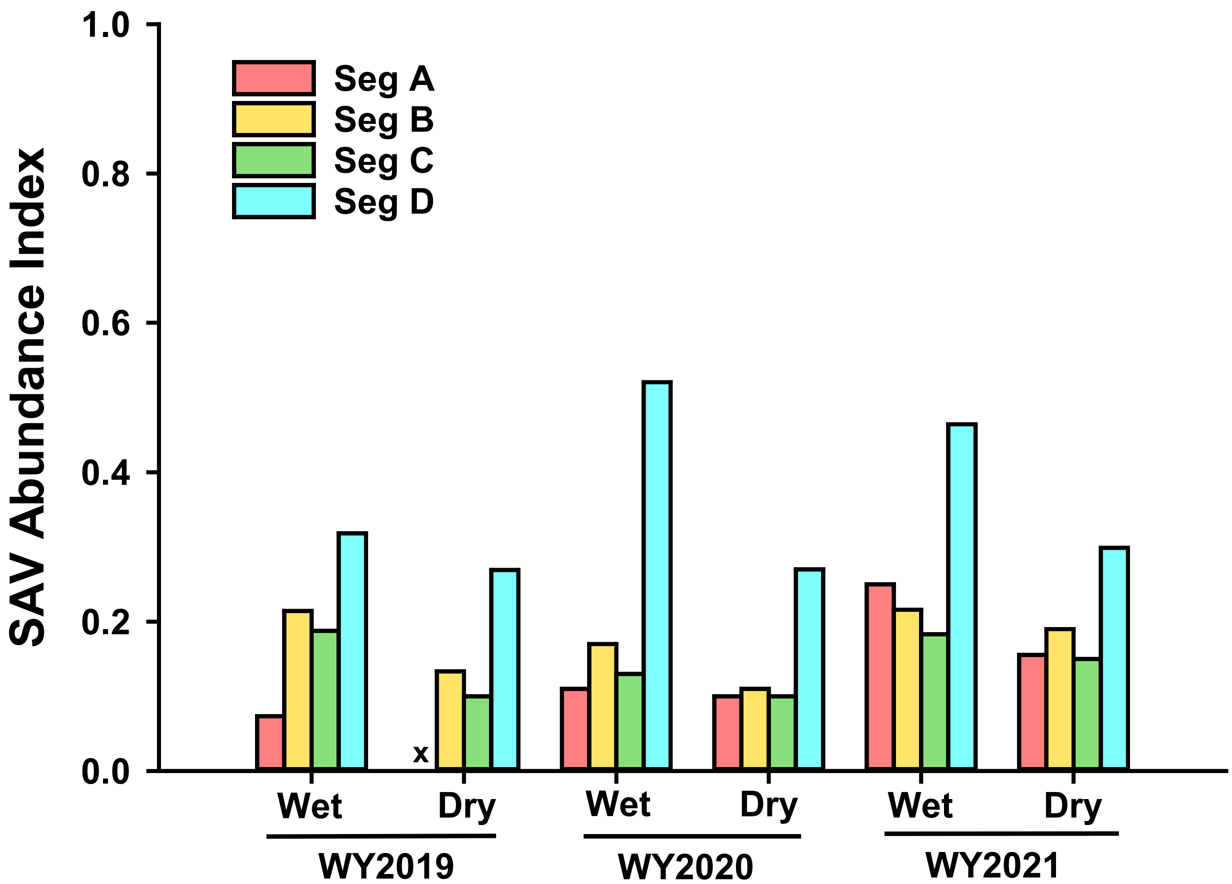

Figure 8D-19. SAV abundance index in the four CRE segments (A through D) by season for WY2019–WY2021. A lowercase x indicates a zero-value.

Similarly, average SAV abundance index was slightly lower in Segment A compared to Segment B (0.12 ± 0.08 and 0.17 ± 0.04, respectively). Maximum abundance of SAV in Segment A occurred in the WY2021 wet season (0.25) while a minimum value of zero occurred in the WY2019 dry season (**Figure 8D-19**). For Segment B, maximum abundance of SAV also occurred in the WY2021 wet season (0.22), but this was nearly equal to the WY2019 wet season value of 0.21 (**Figure 8D-20**).

The number of SAV species and their relative ratios were more variable among water years and seasons in Segment A than B (**Figures 8D-20** and **8D-21**). The RSC of SAV in Segment A included *V. americana* and *R. maritima* over the study period. Only *V. americana* occurred in the WY2019 wet season with no SAV observed the following dry season (WY2019). *R. maritima* was first recorded in the WY2020 wet season but did not occur in the following dry season (WY2020). Sparse *R. maritima* was again observed in the WY2021 wet season and in the following dry season (WY2021). *R. maritima* and *V. americana* occurred at nearly equal abundances with RSC values of 50.5% for *R. maritima* and 49.5% for *V. americana* in WY2021. These two species were also observed over the reported period in Segment B; however, the community was monotypic each season as *R. maritima* was the sole SAV species in Segment B in five out of six monitored seasons with the exception of the WY2020 dry season when *H. wrightii* was the only SAV species observed (**Figure 8D-21**).

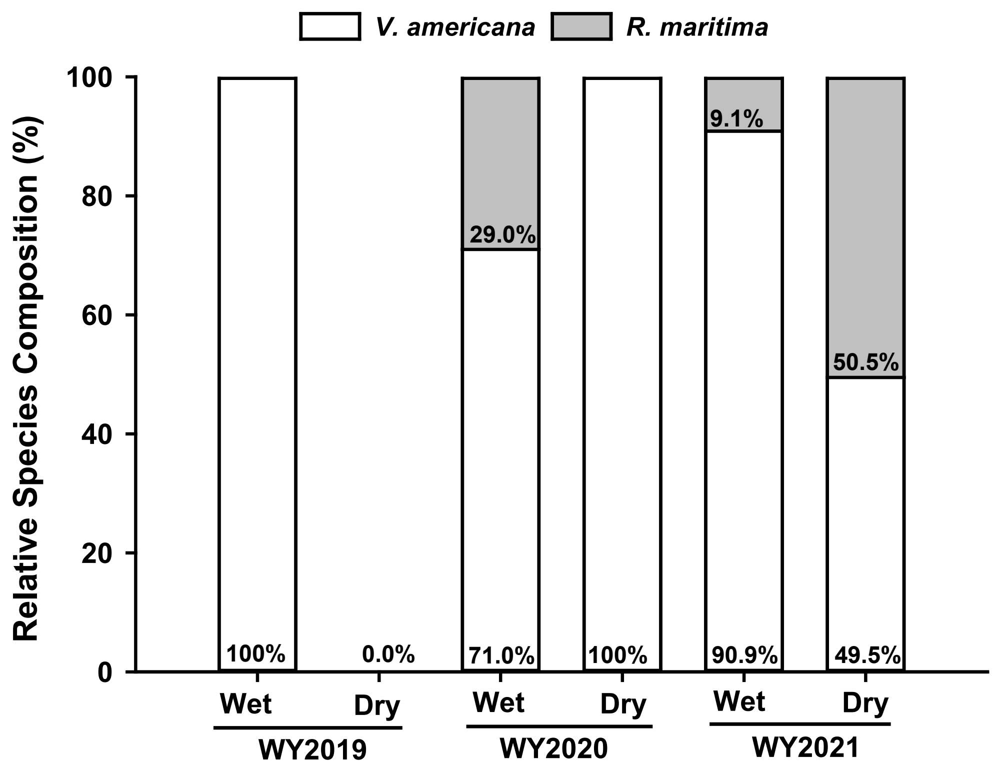

Figure 8D-20. Relative species composition in CRE Segment A by season for WY2019–WY2021 including *V. americana* (white) and *R. maritima* (grey).

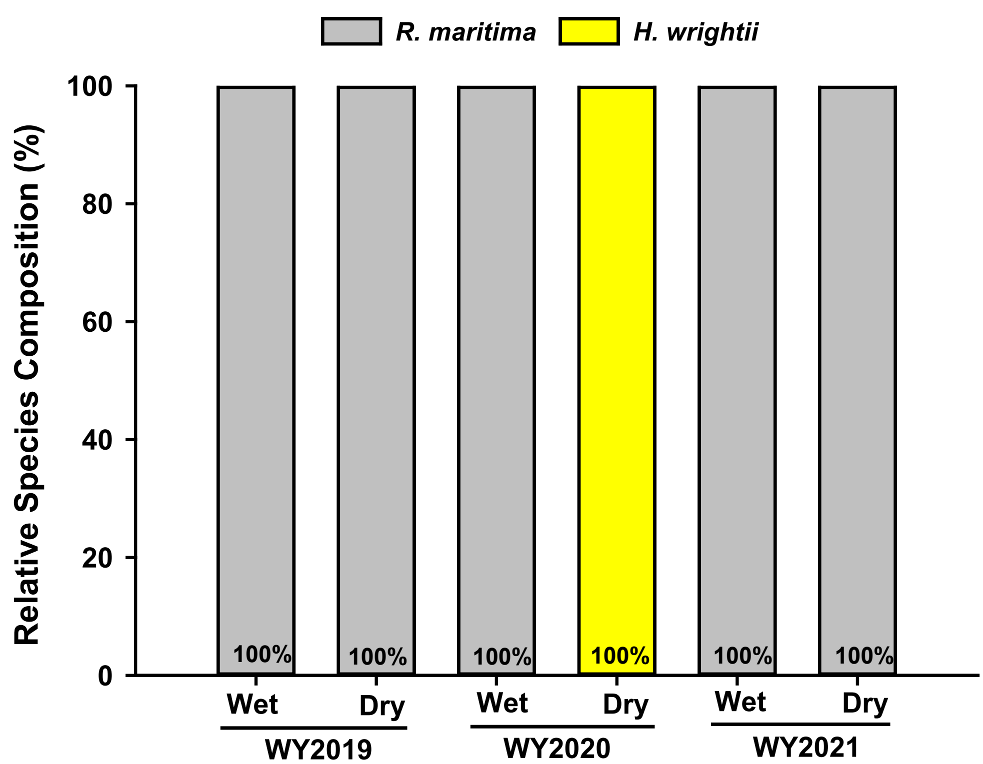

Figure 8D-21. Relative species composition in CRE Segment B by season for WY2019–WY2021 including *R. maritima* (grey) and *H. wrightii* (yellow).

For the upper estuary permanent monitoring site CRE 2, *R. maritima* was the sole SAV species recorded and it was first observed in the WY2019 dry season with a low average percent cover of 0.8% ± 3.6. Sparse amounts of *R. maritima* persisted during the rest of this monitoring period with a maximum average percent cover of 1.1% ± 3.3 (**Figure 8D-22**). Data from the Val I-75 salinity monitoring station up-stream of CRE 2 (**Figure 8D-7**) indicated the 14-day moving average surface salinity remained in the optimum salinity envelope (< 10) for *V. americana* from WY2017 through WY2021 (**Table 8D-3**). At the more downstream salinity station, Ft. Myers, the 14-day moving average of salinity < 10 occurred 90% of the days in WY2021, an improvement from 56% in WY2020 and similar to 94% observed in WY2019. The percentage of days with the 14-day moving average of salinity > 15 was 2% in WY2021, slightly higher than the 0% that occurred in WY2019 and WY2020. Therefore, the persistent absence of *V. americana* at CRE 2, particularly in WY2019, is unlikely to be primarily driven by unfavorable salinity conditions. Similarly, salinity was unlikely to have had a negative impact on *R. maritima* coverage and abundance at this site over this monitoring period, as it has a broad tolerance to salinity.

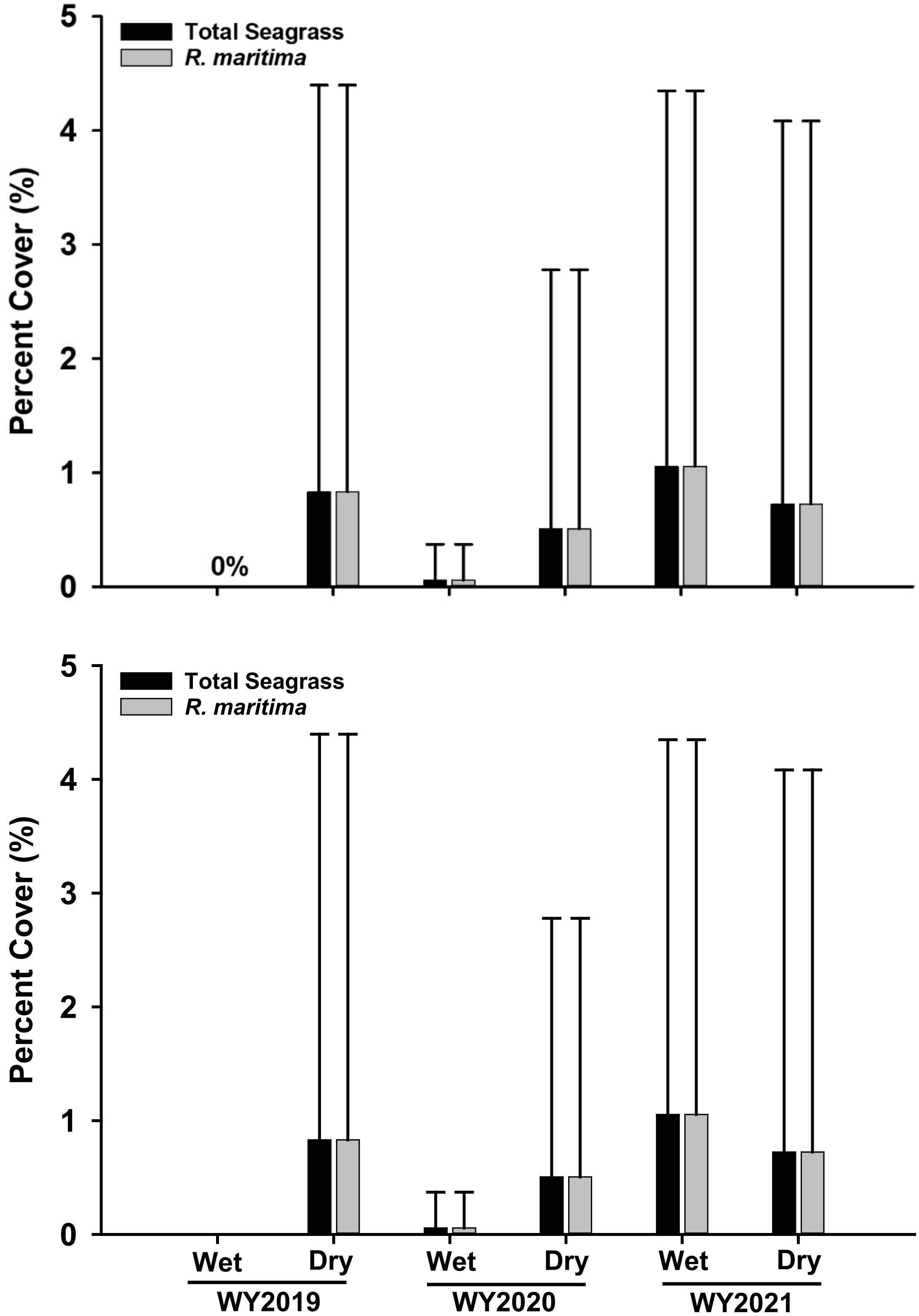

Figure 8D-22. Average percent cover ± SD of SAV (black) and *R. maritima* (grey) for CRE 2 transect monitoring site by season for WY2019–WY2021. Note: the WY2019 wet season was monitored with a value of 0.0%.

Middle Estuary – Segment C, CRE 5

The middle estuary of the CRE, Segment C, traditionally supports sparse *H. wrightii* and a low abundance of seasonally transient *R. maritima* (Douglass et al. 2020). Monitoring results generally agreed with this precedent, as SAV abundance was low with limited SE (**Figures 8D-18** and **8D-19**). Additionally, SAV species consisting of *H. wrightii* occurred throughout the study period while *R. maritima* occurred in the WY2019 and WY2021 wet seasons (**Figure 8D-23**). An exception to typical species composition occurred in the WY2021 wet season when *Thalassia testudinum* (turtle grass) occurred in limited abundance (**Figure 8D-23**). The greatest SE (0.19) and abundance index (0.18) values for SAV occurred in the WY2021 wet season and were driven primarily by an increase in occurrence and abundance of *R. maritima*, rather than an increase in abundance of *H. wrightii* (**Figure 8D-23**).

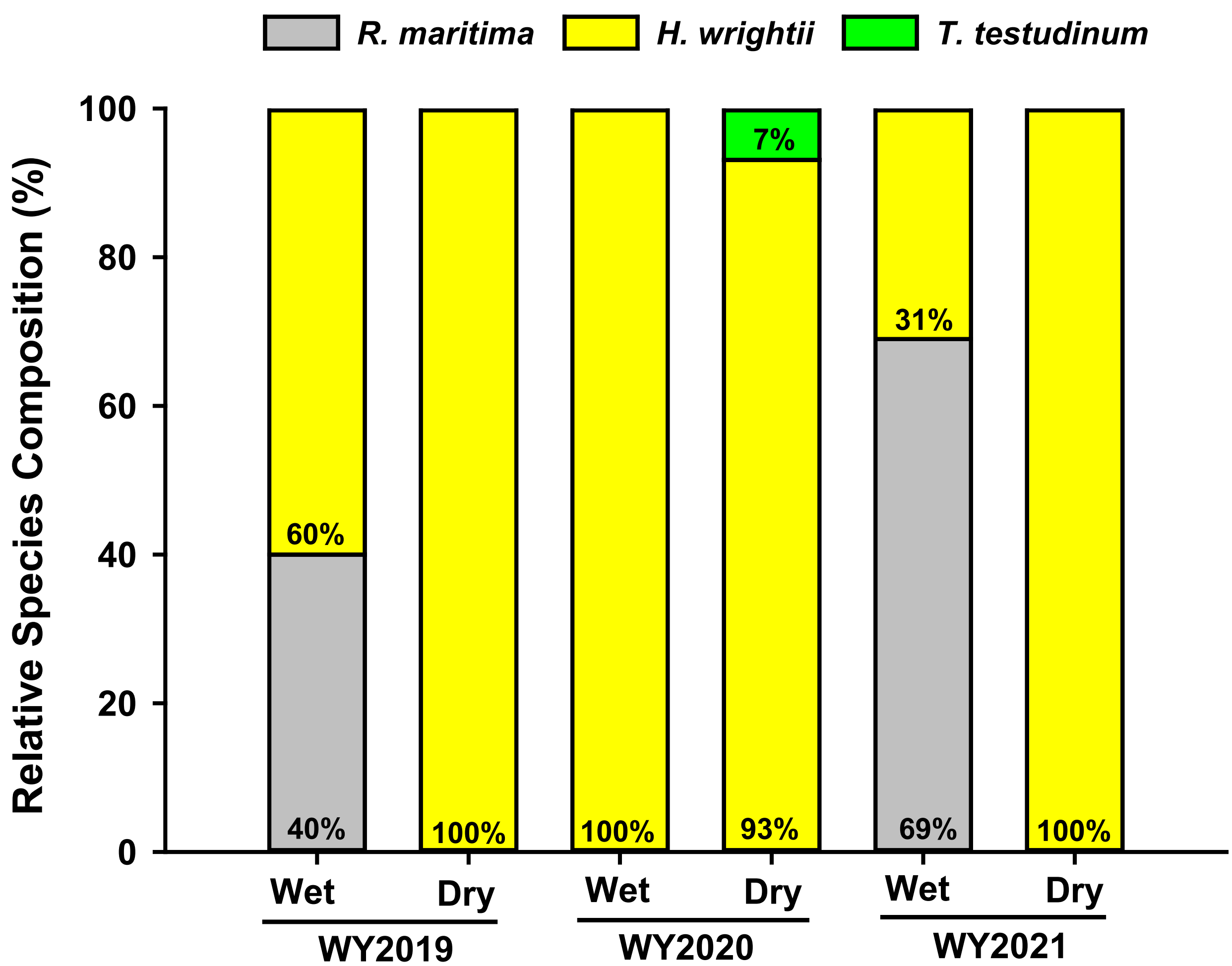

Figure 8D-23. Relative species composition in CRE Segment C by season for WY2019–WY2021 including *R. maritima* (grey), *H. wrightii* (yellow) and *T. testudinum* (green).

The middle estuary SAV monitoring site, CRE 5, has a seagrass meadow comprised almost exclusively of *H. wrightii* with occurrence of *T. testudinum* in one monitored period (WY2021 wet season; **Figure 8D-24**). When present, *T. testudinum* average percent cover was extremely low (0.01% ± 0.1), providing a minimal contribution to total seagrass percent cover. The nearby (4 km) downstream salinity recording station at Shell Point was used to calculate the percentage of days the 14-day moving average salinity was within the optimum salinity envelope (15 to 45) for *H. wrightii* (RECOVER 2020; **Table 8D-2**). The percentage of days the 14-day moving average salinity was within the optimum salinity envelope for *H. wrightii* increased from 71% in WY2019 to 96% in WY2020 and up to 99% in WY2021. Respectively, the percentage of days the 14-day moving average salinity was in the stressed salinity envelope (5 to 15) decreased from 29% in WY2019 to 4% in WY2020 and 1% in WY2021. Over this monitoring period, the minimum average *H. wrightii* percent cover of 2.6% ± 3.0 was recorded in the WY2019 dry season with increases in subsequent seasons to a peak of 10.0% ± 11.2 in the WY2021 wet season (**Figure 8D-24**). The trend of increased percent cover of *H. wrightii* from the WY2019 dry season through the WY2021 wet season may, in part, be due to recovery from low salinity conditions present in WY2018 when salinity was in the stressful envelope 30% of the water year, and within the damaging envelope for 3% of the water year (**Table 8D-5**). A decline in *H. wrightii* cover from wet to dry season in WY2021 is likely due to typical seasonal patterns in South Florida seagrasses, where productivity and aboveground biomass decrease over the dry season, winter months to minimal levels in February (Dawes et al. 1985, Fourqurean et al. 2001).

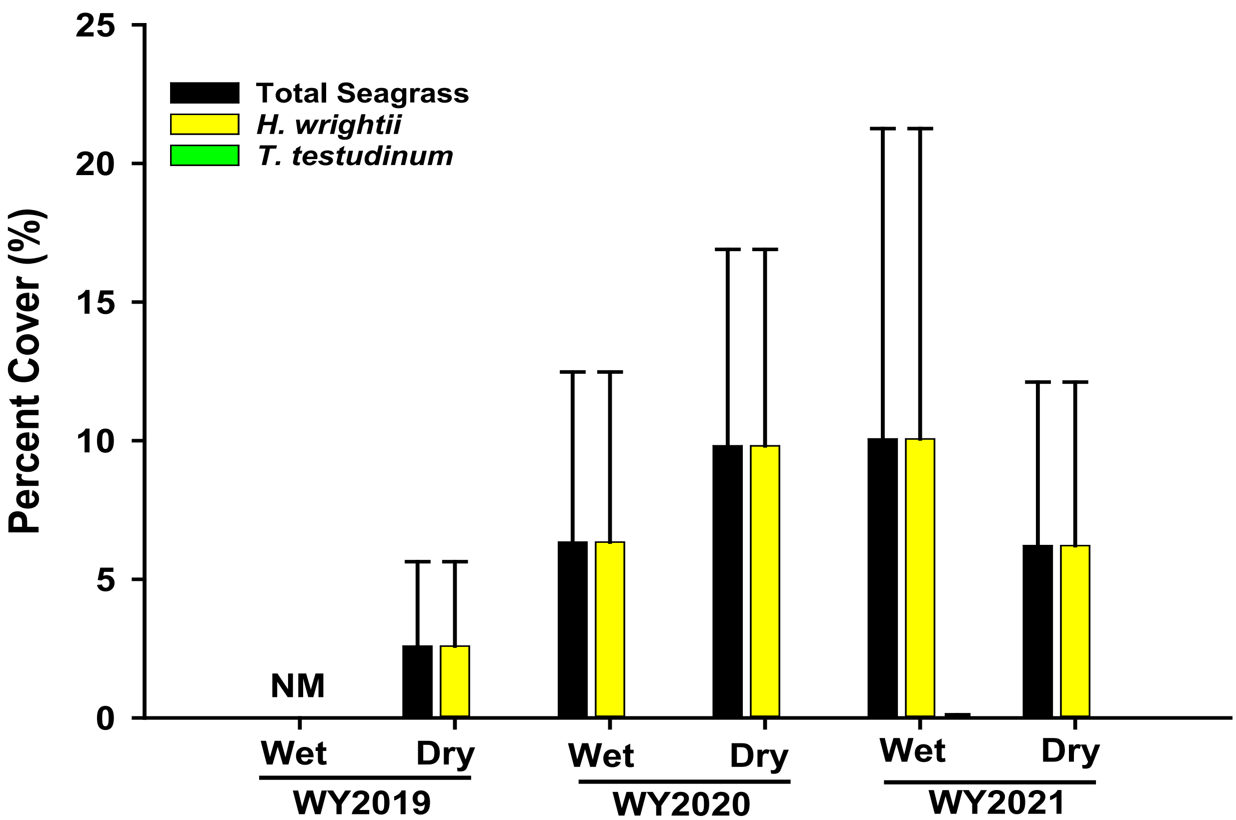

Figure 8D-24. Average percent cover ± SD of SAV (black) and individual species (yellow and green) for CRE 5 monitoring site by season for WY2019–WY2021. This site was not monitored (NM) in the WY2019 wet season.

Lower Estuary – Segment D, CRE 8

SAV in the lower estuary, Segment D, is primarily comprised of *H. wrightii* and *T. testudinum.* These species exhibit the greatest productivity at stable marine salinities, yet the early successional species *H. wrightii* is more likely to occur in environments with low or variable salinity and often recovers more quickly from disturbances compared to *T. testudinum* (Lapointe 1994, Lirman et al. 2014). Compared to other segments monitored in the CRE, Segment D has substantially greater SAV SE, abundance, and number of species. Within water years, seasonal trends were apparent in SE and abundance indexes with greater values in wet than dry seasons (**Figures 8D-18** and **8D-19**). The maximum SE of SAV (0.46) occurred in the WY2019 wet season while minimum SE of SAV (0.30) occurred in the WY2020 dry season. Abundance values within dry seasons were very consistent among water years ranging from 0.27 to 0.30 (**Figure 8D-19**). The seagrass community in Segment D was comprised primarily of *H. wrightii* and *T. testudinum* with *H. wrightii* as the most dominant species in five out of six monitored periods (**Figure 8D-25**).

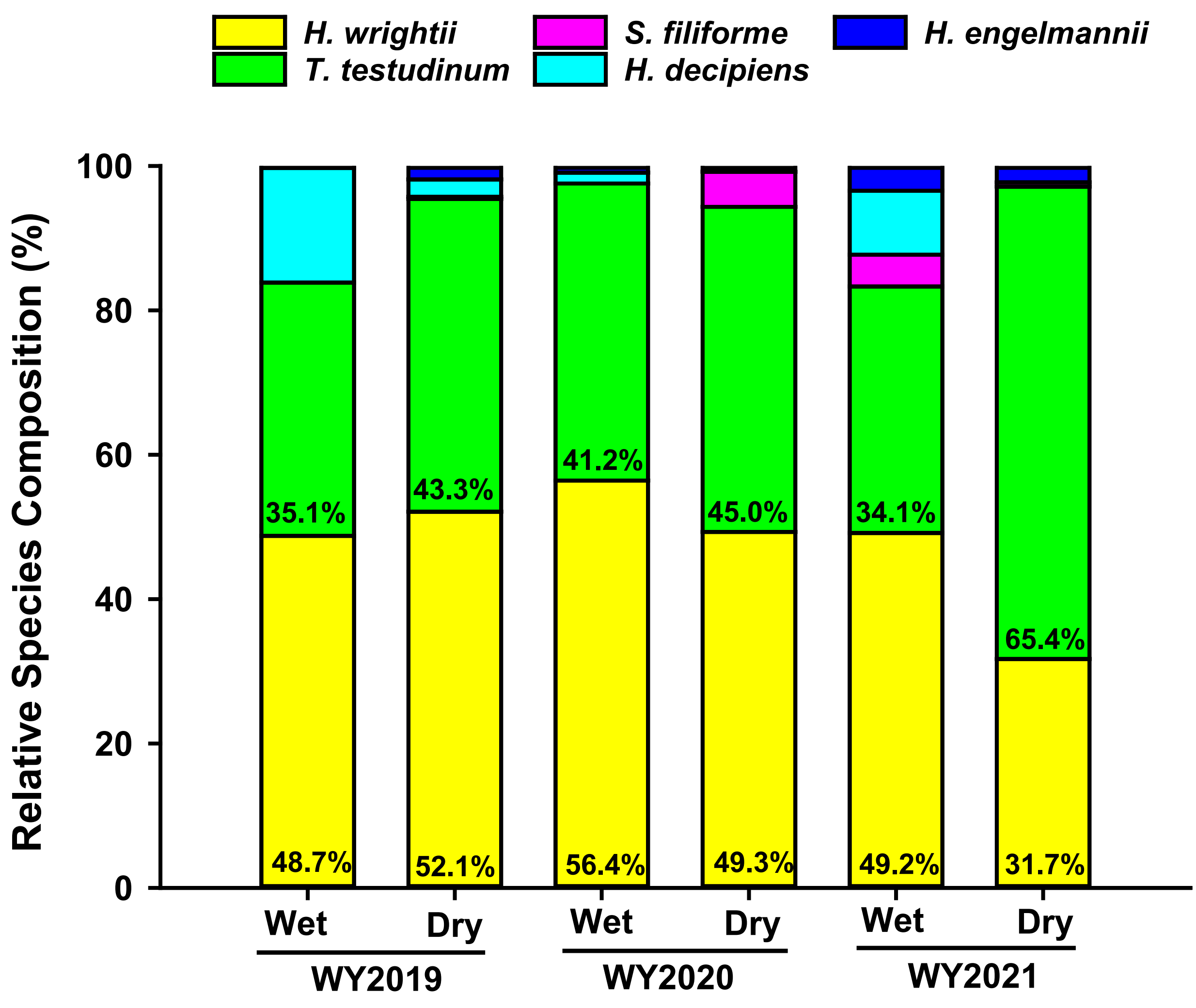

Figure 8D-25. Relative species composition in CRE Segment D by season for WY2019–WY2021 including *H. wrightii* (yellow), *T. testudinum* (green), *S. filiforme* (fuschia), *Halophila decipiens* (paddle grass; teal), and *Halophila engelmannii* (star grass; blue).

The downstream SAV monitoring site, CRE 8, has a seagrass meadow that is predominately comprised of *H. wrightii* and *T. testudinum*, with sparse quantities of *Syringodium filiforme* (manatee grass) and ephemeral patches of *Halophila engelmannii* (star grass; **Figure 8D-26**). Peak total seagrass percent cover occurred in the WY2021 wet season (32.8% ± 32.1) with *T. testudinum* as the species with the greatest contribution to total percent cover (**Figure 8D-26**). *H. wrightii* had the highest average coverage and abundance values of observed seagrasses in WY2019 until the WY2020 dry season when *T. testudinum* had the highest percent cover among seagrass species; a change which persisted through subsequent monitoring periods in WY2021. Minimum total seagrass cover was recorded in the WY2020 dry season and was primarily due to lower percent cover of *H. wrightii* (**Figure 8D-26**). Seasonality of seagrass cover was not observed for any seagrass species in WY2019 but was observed for *H. wrightii* and *T. testudinum* in WY2020 and WY2021 (**Figure 8D-26**).

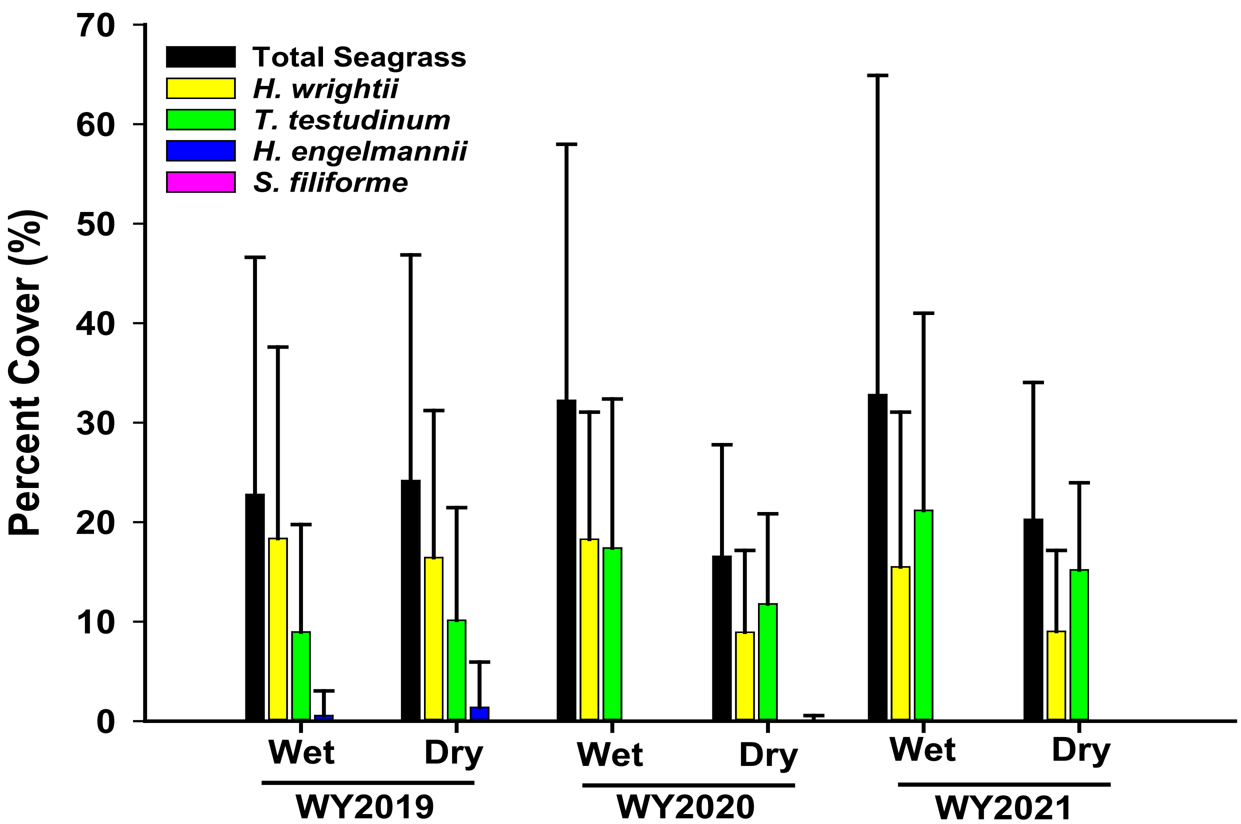

Figure 8D-26. Average percent cover ± SD of SAV (black) and individual species including *H. wrightii* (yellow), *T. testudinum* (green), *H. engelmannii* (blue), and *S. filiforme* (fuchsia) for the CRE 8 monitoring site by season for WY2019–WY2021.

H. wrightii is adapted to a broad salinity range of 15 to 45 (Doering et al. 2002, Buzzelli et al. 2014c). Salinities were measured at the nearby Shell Point salinity station to evaluate conditions for *H. wrightii*. In WY2021, the 14-day moving average salinity was in the optimum envelope (15 to 45) for *H. wrightii* 99% of days with only 1% of days in the stressed envelope (5 to 15; **Table 8D-5**). The observed decline in seagrass coverage and abundance from the wet to dry season in WY2021 may be contributed to the seasonality of seagrass with an increase in productivity and aboveground biomass occurring in the wet season.

RESEARCH AND WATER QUALITY MONITORING PROGRAM PART II: CALOOSAHATCHEE RIVER WATERSHED

The Caloosahatchee River Watershed Protection Plan (CRWPP) includes five major drainage basins: S-4, East Caloosahatchee, West Caloosahatchee, Tidal, and Coastal Basins (**Table 8D-1** and **Figure 8D-27**). The Caloosahatchee River Watershed (CRW) totals approximately 861,063 ac or 348,460 hectares (ha) and includes three primary contributing areas: Caloosahatchee Basins, Tidal Basin, and Lake Okeechobee (**Table 8D-1**).

As part of the RWQMP, SFWMD maintains a long-term water quality monitoring network within the CRW. The network stations are continuously reviewed by the coordinating agencies—SFWMD, FDEP, and FDACS—for efficiency and to ensure all data collection objectives associated with legislatively-mandated and permit-required monitoring are being met. Data collected as part of the RWQMP, along with data collected by other local entities, allow FDEP to evaluate water body conditions, measure progress toward the TMDLs, and ensure that necessary projects and programs are incorporated into the BMAP (FDEP 2020). The District coordinates monitoring efforts with FDEP, FDACS, and the United States Geological Survey (USGS) to leverage monitoring sites and reduce duplication of efforts.

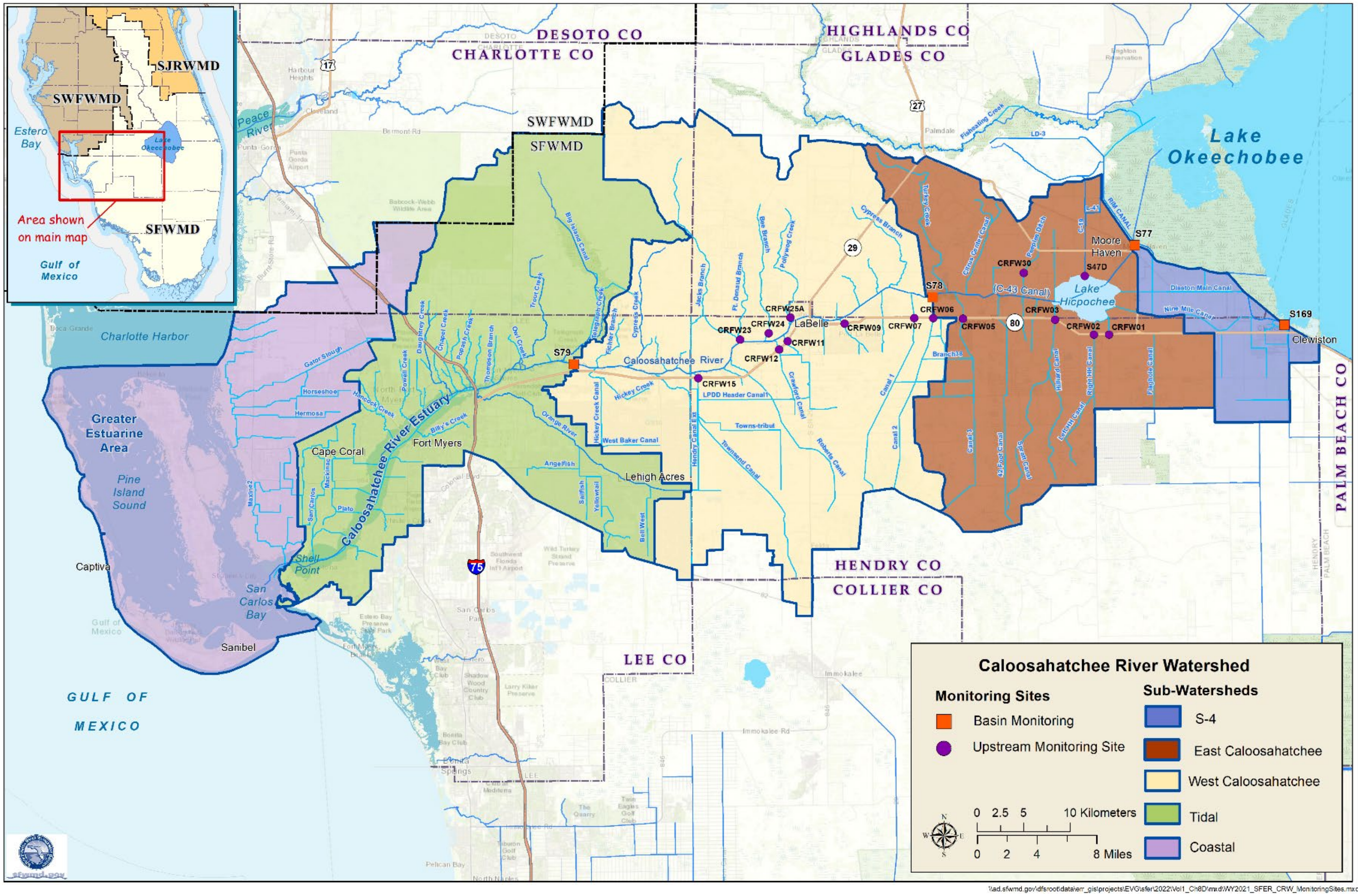

Figure 8D-27. The Caloosahatchee River Watershed with basins and SFWMD monitoring locations.

CALOOSAHATCHEE RIVER WATERSHED BASIN LOADING

Basin loading to the CRE from the contributing areas were reviewed for the long-term POR (WY1997–WY2021) and the most recent 5 water years (WY2017–WY2021). Contributions to the CRE include inflows from Lake Okeechobee, the Caloosahatchee Basins (S-4, East Caloosahatchee, and West Caloosahatchee basins), and the Tidal Basin. Relative proportion of TP and TN loading to the estuary from each contributing area are shown in **Figures 8D-28** and **8D-29**, respectively, and from each basin are shown in **Figures 8D-30** and **8D-31**, respectively.

An overview of the recent 5-year TP and TN loads and flow-weighted mean concentrations (FWMCs) from each basin to the CRE is provided in **Figures 8D-32** and **8D-33** and **Table 8D-11** below. The 5-year average contribution from the Caloosahatchee Basins to the CRE accounted for 46% of total flow, 58% of TP load, and 51% of TN load. The relative contribution from the Tidal Basin to the CRE was 19% of total flow, 14% of TP load, and 13% of TN load. The relative contribution from Lake Okeechobee to the CRE was 35% of total flow, 28% of TP load, and 36% of TN load over the five-year period (**Table 8D-11**). A time series for flow, TN load, TP load, TN FWMC, and TP FWMC are provided for the WY1997–WY2021 POR (**Figure 8D-34**).

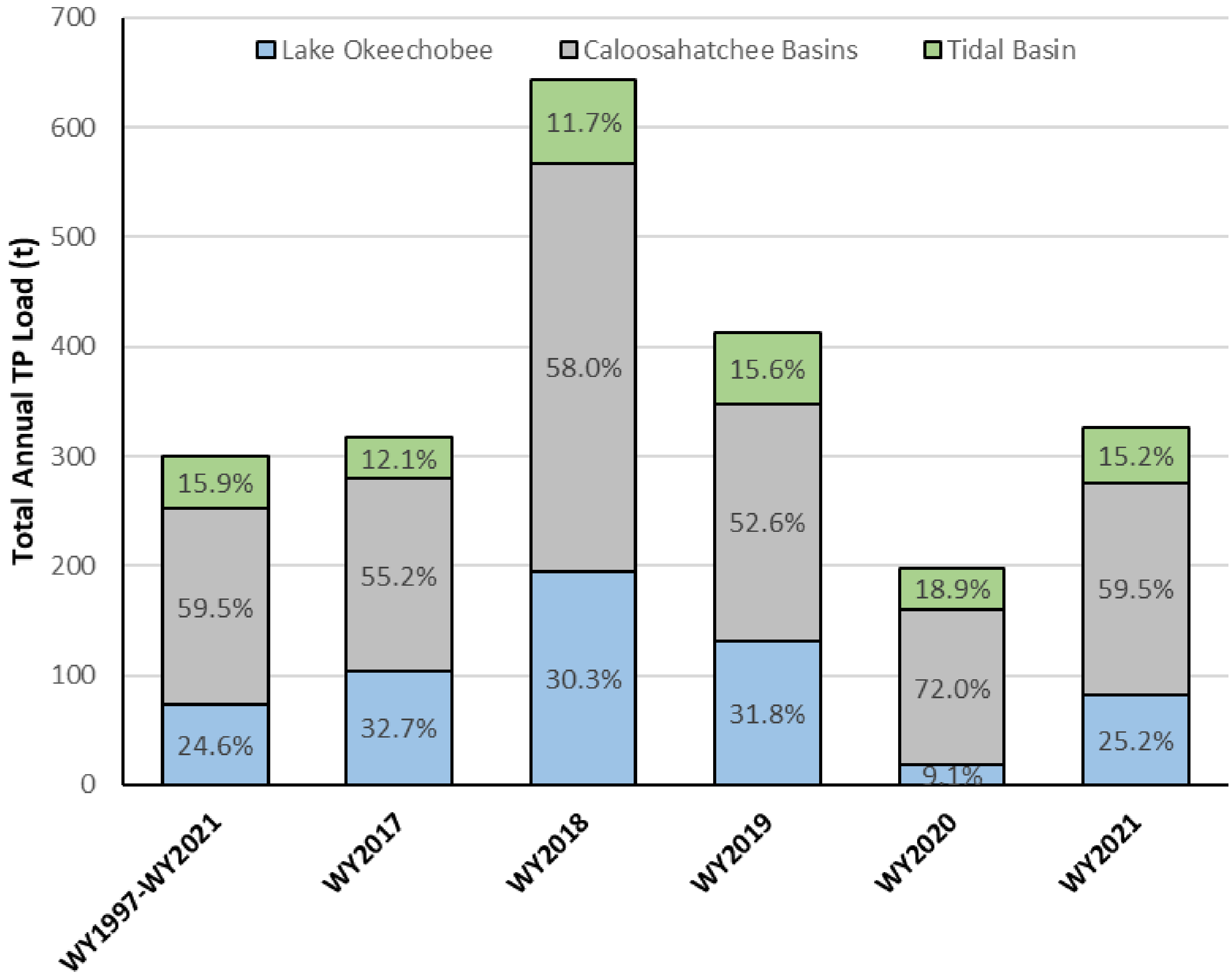

Figure 8D-28. Total annual TP load for the CRW and from each contributing area by water year for WY2017–WY2021 and the long-term annual average (WY1997–WY2021) with relative percent contribution to total.

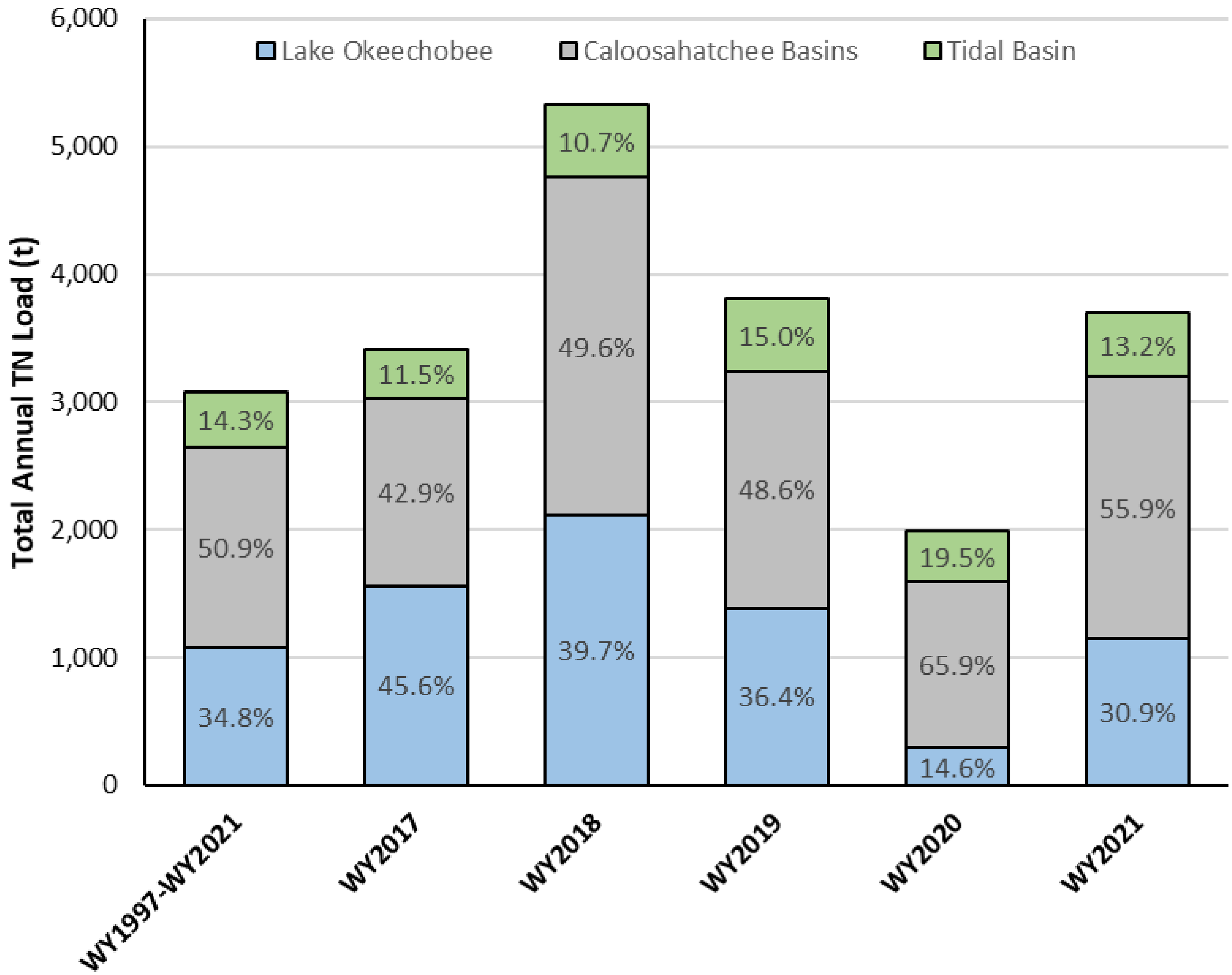

Figure 8D-29. Total annual TN load for the CRW and from each contributing area by water year for WY2017–WY2021 and the long-term annual average (WY1997–WY2021) with relative percent contribution to total.

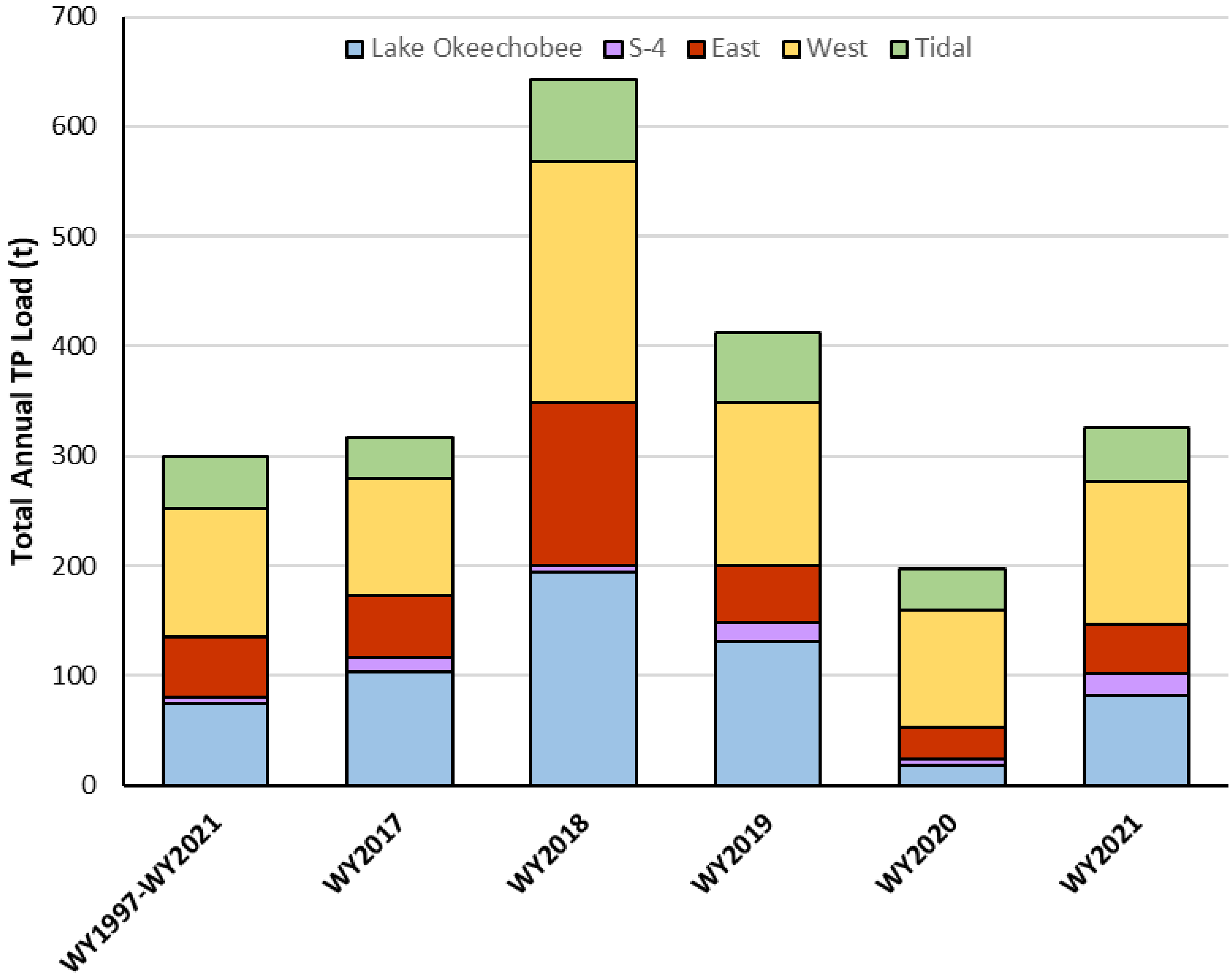

Figure 8D-30. Total annual TP load for the CRW and load from contributing basins, Tidal Basin, and Lake Okeechobee by water year for WY2017–WY2021 and the long-term annual average (WY1997–WY2021).

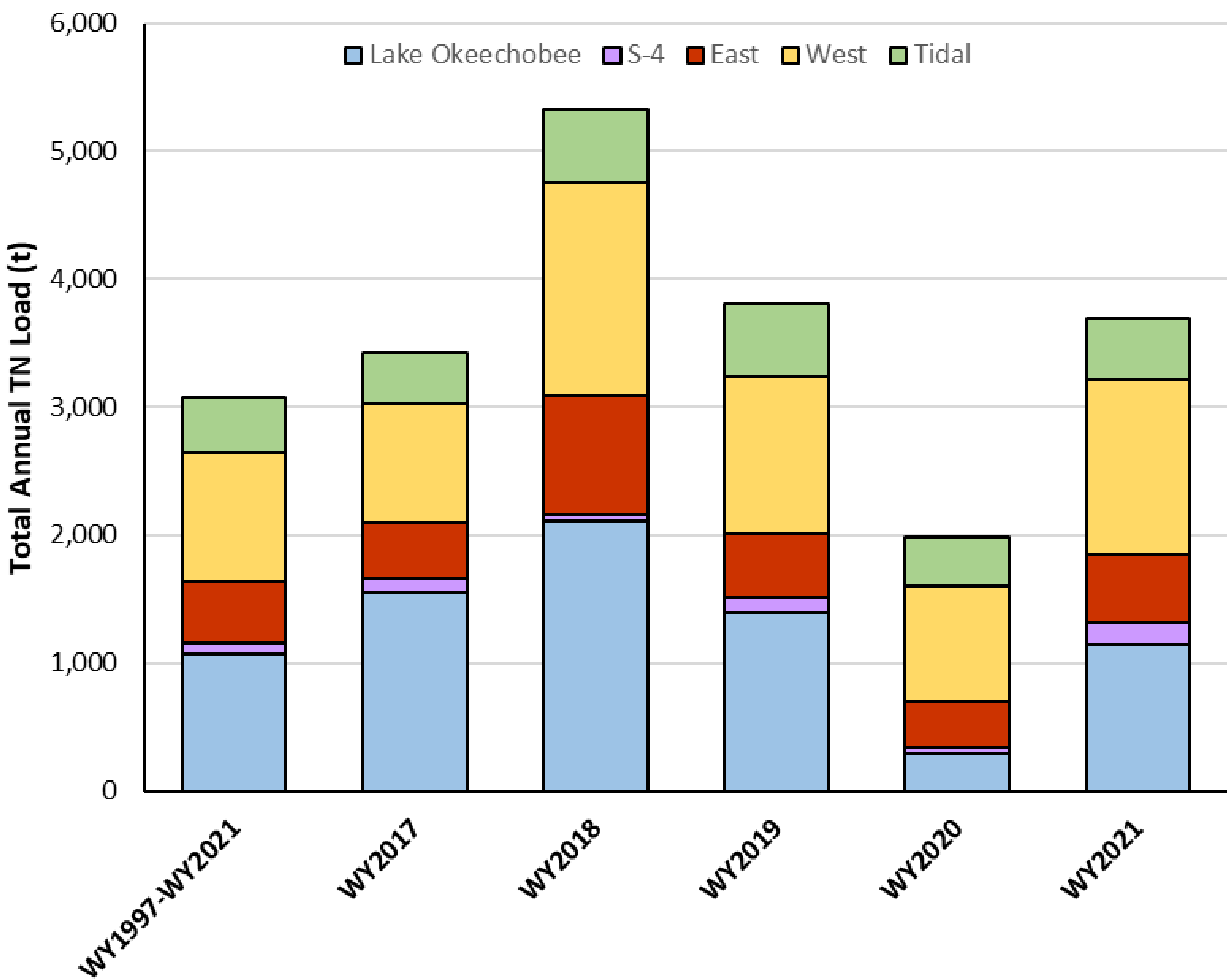

Figure 8D-31. Total annual TN load for the CRW and load from contributing basins, Tidal Basin, and Lake Okeechobee by water year for WY2017–WY2021 and the long-term annual average (WY1997–WY2021).

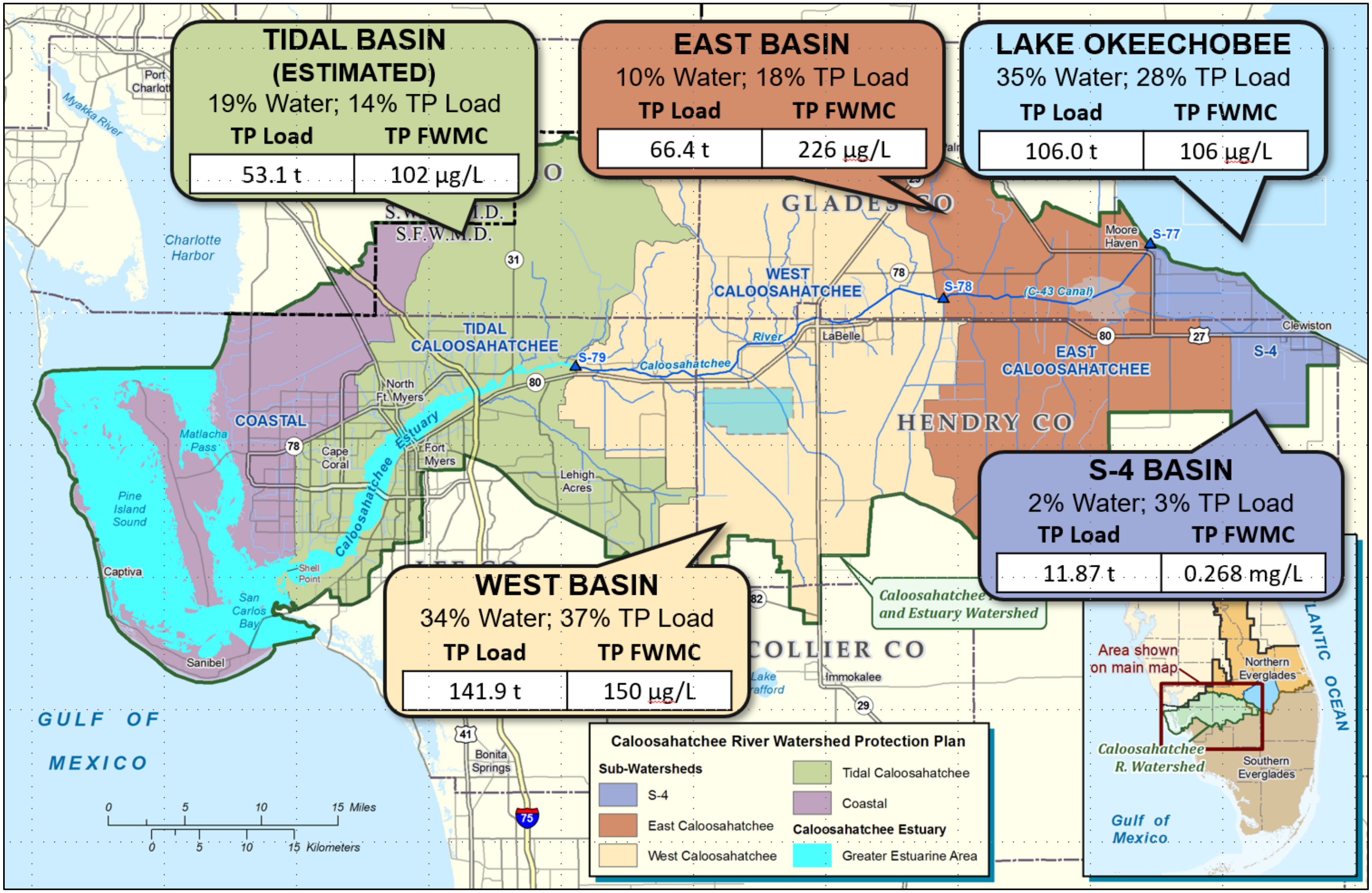

Figure 8D-32. Summary of contributions from each basin to the estuary for the most recent 5-year period (WY2017–WY2021) with annual average TP load, annual average TP FWMC, and relative percent contributions for TP load and flow volume.

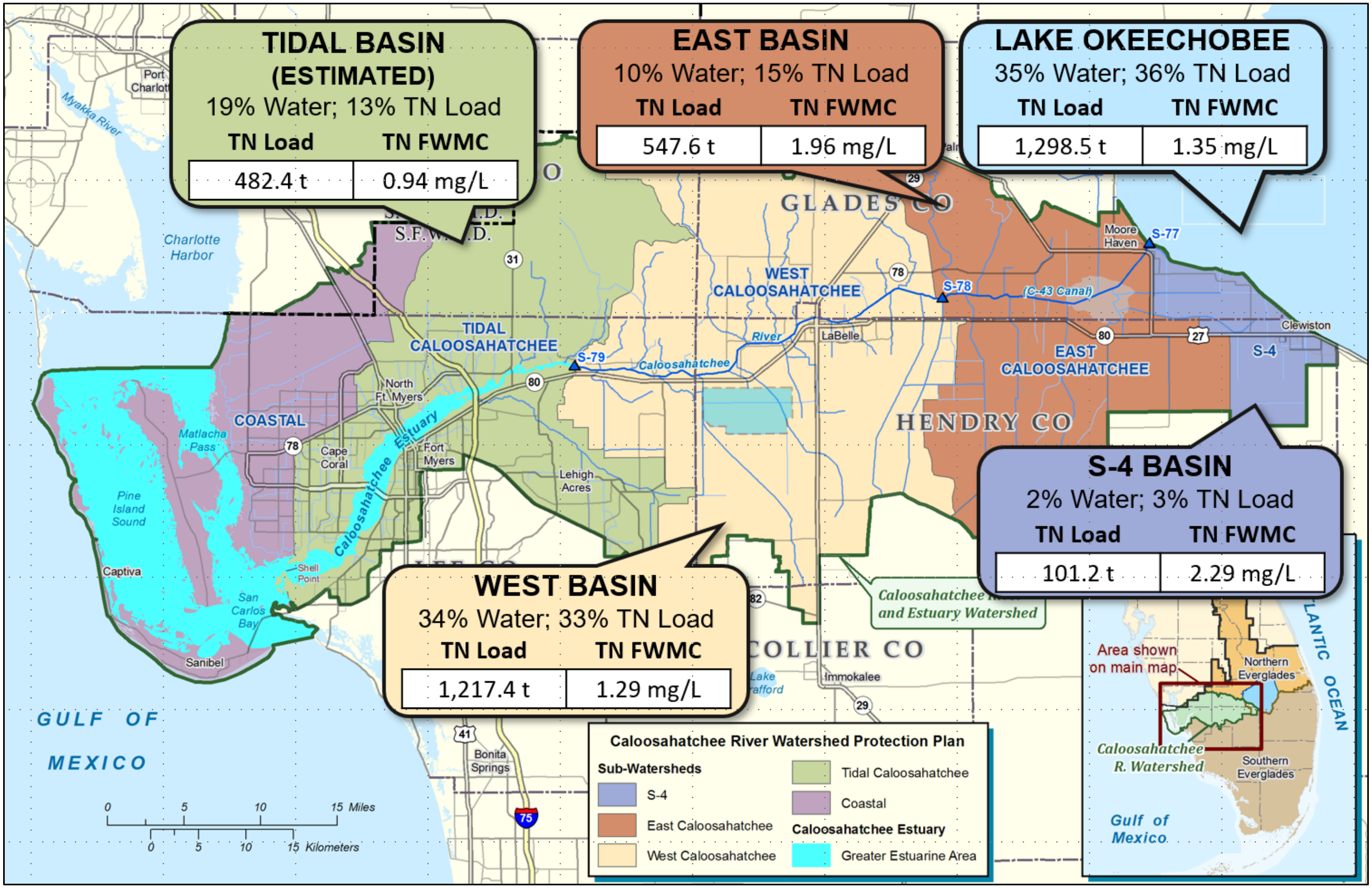

Figure 8D-33. Summary of contributions from each basin to the estuary for the most recent 5-year period (WY2017–WY2021) with annual average TN load, annual average TN FWMC, and relative percent contributions for TN load and flow volume.

Table 8D-11. Annual flow volumes and TP and TN loads and FWMCs for the contributing areas of the CRW to the CRE.

	Lake Okeechobee	Caloosahatchee Basins [a]	Tidal Basins	Total Caloosahatchee	Caloosahatchee Basins		
					West Basin	East Basin	S-4 Basin
Flow (ac-ft X 10³)							
WY2017	1,010	929	393	2,332	733	163	34
WY2018	1,201	1,392	474	3,067	1,025	348	19
WY2019	761	998	472	2,231	730	225	43
WY2020	170	729	350	1,249	525	185	20
WY2021	753	1,066	377	2,196	808	198	59
5-Yr Avg. [b]	778.92	1,023	413	2,215	764	224	35
5-Yr % [c]	35%	46%	19%	100%	34%	10%	2%
WY1997-WY2021	617	887	381	1,884	624	232	30
TP Load (t)							
WY2017	103.9	175.1	38.4	317.4	106.1	57.0	12.0
WY2018	194.7	372.8	75.6	643.1	218.4	149.2	5.2
WY2019	131.2	217.1	64.6	412.9	148.0	52.3	16.8
WY2020	18.0	142.2	37.3	197.6	107.7	28.3	6.2
WY2021	82.1	193.8	49.6	325.5	129.3	45.4	19.2
5-Yr Avg. [b]	106.0	220.2	53.1	379.3	141.9	66.4	11.9
5-Yr % [c]	28%	58%	14%	100%	37%	18%	3%
WY1997-WY2021	73.7	178.2	47.8	299.7	116.9	55.0	6.4
TP FWMC (µg/L)							
WY2017	83	153	79	110	117	284	288
WY2018	131	217	129	170	173	347	223
WY2019	140	176	111	150	164	189	313
WY2020	86	158	87	128	166	124	253
WY2021	88	147	106	120	130	185	262
5-Yr Avg. [b]	106	170	102	136	150	226	268
5-Yr FWMC [d]	110	175	104	139	151	241	274
WY1997-WY2021	97	163	102	129	152	192	172

Table 8D-11. Continued.

	Lake Okeechobee	Caloosahatchee Basins [a]	Tidal Basins	Total Caloosahatchee	Caloosahatchee Basins [a]		
					West Basin	East Basin	S-4 Basin
TN Load (t)							
WY2017	1,559.2	1,464.7	392.9	3,416.9	931.9	429.7	103.0
WY2018	2,115.2	2,641.4	572.5	5,329.0	1,673.4	921.9	46.2
WY2019	1,386.4	1,852.2	572.3	3,810.8	1,222.3	502.8	127.1
WY2020	289.0	1,308.1	387.7	1,984.9	901.7	351.2	55.3
WY2021	1,142.8	2,064.3	486.7	3,693.8	1,357.6	532.2	174.4
5-Yr Avg. [b]	1,298.5	1,866.1	482.4	3,647.1	1,217.4	547.6	101.2
5-Yr % [c]	36%	51%	13%	100%	33%	15%	3%
WY1997-WY2021	1,073.1	1,567.9	440.0	3081.0	1004.8	482.0	81.2
TN FWMC (mg/L)							
WY2017	1.25	1.28	0.81	1.19	1.03	2.14	2.47
WY2018	1.43	1.54	0.98	1.41	1.32	2.15	1.97
WY2019	1.48	1.50	0.98	1.38	1.36	1.81	2.37
WY2020	1.38	1.45	0.90	1.29	1.39	1.54	2.27
WY2021	1.23	1.57	1.05	1.36	1.36	2.18	2.38
5-Yr Avg. [b]	1.35	1.47	0.94	1.33	1.29	1.96	2.29
5-Yr FWMC [d]	1.35	1.48	0.95	1.34	1.29	1.98	2.34
WY1997-WY2021	1.41	1.43	0.94	1.33	1.30	1.68	2.20

a. The Caloosahatchee Basins are the West, East, and S-4 basins.
b. 5-Yr Avg. refers to the arithmetic mean of annual data.
c. 5-Yr% refers to the percent of Total Caloosahatchee from Lake Okeechobee, Caloosahatchee Basins (West, East, and S-4 basins), and Tidal Basins.
d. 5-Yr FWMC is the overall FWMC for the 5-year period (calculated from 5-year load and 5-year flow).

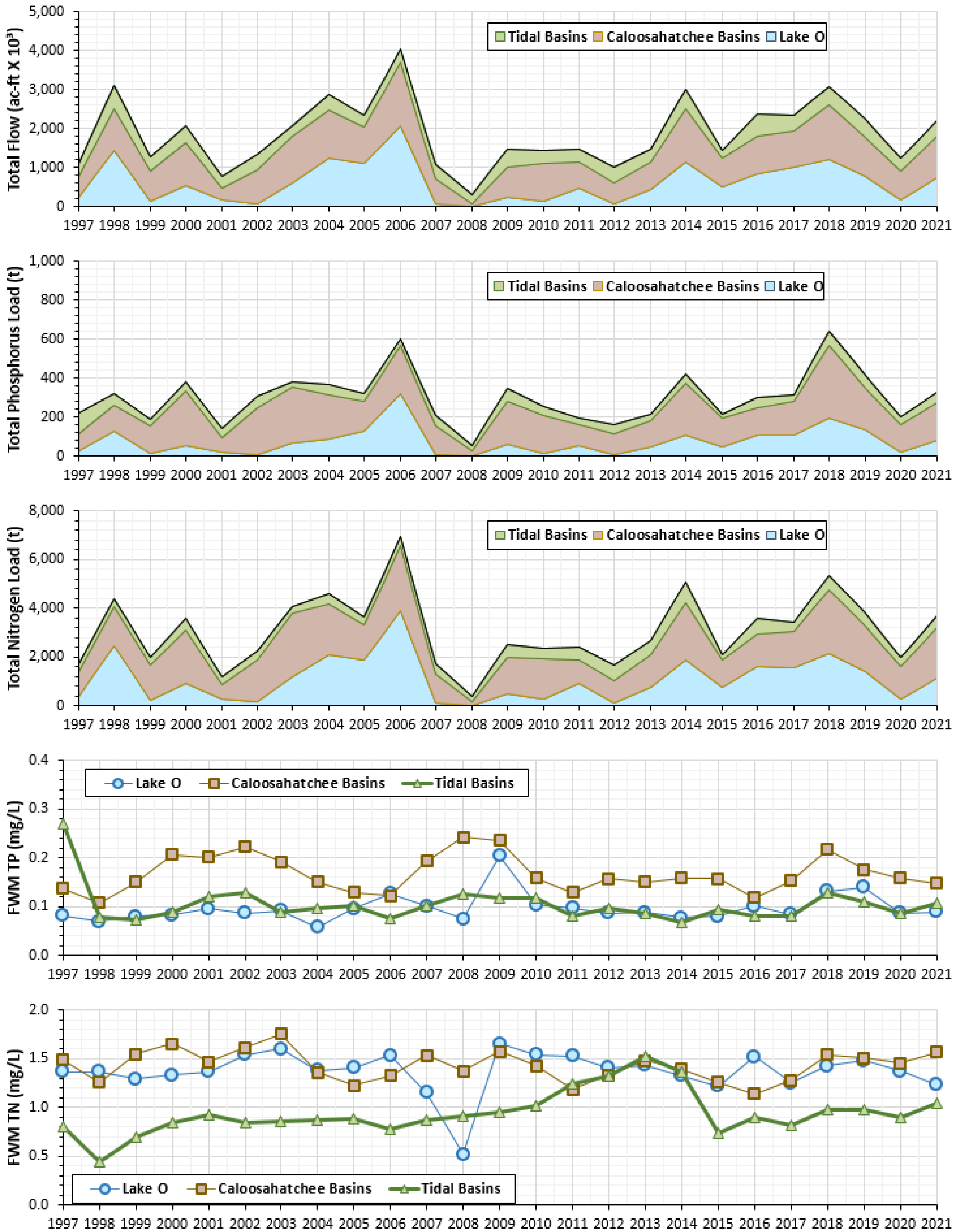

Figure 8D-34. Time series of (a) flow, (b) TP load, (c) TN load, (d) TP FWMC, and (e) TN FWMC for the Tidal Basin (green), Caloosahatchee Basins (gray), and Lake Okeechobee (blue) for WY1997–WY2021 (x-axis is in water years).

CALOOSAHATCHEE RIVER WATERSHED CONSTRUCTION PROJECT

In WY2020, SFWMD initiated annual Caloosahatchee River Watershed Construction Project (CRWCP) reviews, as part of the CRWPP reviews, in support of the BMAP. These annual reviews are critical to maintaining transparency and accountability in the BMAP process and for assisting to progressively move towards the achievement of TMDLs.

The coordinating agencies—FDEP, FDACS, and SFWMD—partner with local stakeholders to develop and implement projects and programs to improve hydrology and water quality throughout the CRW. Under the BMAP, projects include treatment and storage facilities constructed through public works and public-private partnerships and programs are comprised of regulatory and non-regulatory programs, incentive-based programs, and nonstructural projects. FDEP's 2020 update to the *Caloosahatchee River and Estuary Basin Management Action Plan* (FDEP 2020) states, "to achieve the CRE TMDL by 2032 (20-year milestone), stakeholders must identify and submit additional local projects, and the coordinating agencies must identify additional regional projects and determine the significant funding that will be necessary." The BMAP notes that enhancements to programs addressing basin-wide sources will also be required.

Many of these initial project and program benefits (e.g., stormwater detention and nutrient load reductions) are modeled estimates and measured data are used to verify and supersede these estimates when available for the iterative process of updating the BMAP until the TMDLs are achieved. This iterative or adaptive management process is established by the Florida Watershed Restoration Act, Subparagraph 403.067(7)(a)1., F.S. This approach allows for gradually reducing loadings through the implementation of projects and programs while simultaneously monitoring and conducting studies to better understand water quality dynamics (sources and response variables) in each impaired water body.

The CRWCP is SFWMD's comprehensive strategy for tracking projects and programs to improve the quality, quantity, timing, and distribution of water in the Caloosahatchee River ecosystem and assist in achieving TMDLs. The strategy utilizes an adaptive management approach consistent with FDEP's BMAP process. The annual review of the CRWCP considers the latest science-based information and measured data available to verify and update project benefits. When available, measured data will supersede estimated (modeled) data. Therefore, the collective benefits of projects and programs described in the CRWCP will be adjusted annually as needed for the most accurate method for gauging progress and achieving effective results.

A key aspect of the annual CRWCP review is the basin analyses. The objective of the analyses is to relate projects and programs within each basin to improvements in water quality as measured by the associated monitoring network and make recommendations for future activities. They present basin characteristics, such as descriptions of the regional drainage systems, flow patterns, and major water control structures; water quality and flow monitoring locations; monitoring data assessments; general observations in terms of flow volume, TP and TN concentrations, or both; and generalized land uses (agricultural, nonagricultural, and natural areas). The basin analyses also present an inventory of the current SFWMD projects and associated data including location, status (e.g., planning, design, construction, or operation) and estimated project benefits (storage and/or nutrient reductions) as well as implementation costs. The subwatershed analysis also lays the foundation for detailed assessments. The purpose of the detailed assessments is to identify areas for the highest priority for action, gather information to pinpoint the nutrient sources contributing to the water quality problems, recognize the existing programs that have the potential to impact those sources and their status, consider existing and planned projects and their expected impact to water quality, determine what remains to be done to improve water quality, and recommend strategic actions for future planning in collaboration with the coordinating agencies.

In performing this year's basin analyses, it was determined that some data gaps exist relative to verifying project performance and identifying nutrient hotspots within the watershed (e.g., unmonitored tributaries, projects where we are not monitoring project performance, etc.). In addition to developing recommendations to address the identified data gaps, basin-specific detailed assessments within focus areas are underway as described in Appendix 8D-2 of this volume.

OVERVIEW OF CURRENT PROJECT BENEFITS

The original CRWCP was completed and submitted to the Florida legislature in 2009 (SFWMD et al. 2009). It defined the cumulative benefit of existing and planned restoration efforts in promoting nutrient reductions and desirable salinity ranges within the CRE. In addition, it applied the Northern Everglades Regional Simulation Model to outline necessary actions for continued restoration, including an estimated storage provision of approximately 400,000 ac-ft necessary to meet water quality and quantity objectives in the CRW. Currently, estimated storage benefits for all existing and planned projects in the CRW total 197,555 ac-ft (**Table 8D-12**). When available, measured data will supersede estimated (modeled) data.

The CRE TMDL was adopted in 2009 and includes a 23% reduction in TN loading to the CRE (Bailey et al. 2009). The Caloosahatchee Tributaries TMDL was adopted in 2019 and establishes TN, TP, and biochemical oxygen demand (BOD) reduction targets for five freshwater tributaries, including (1) S-4 Basin, (2) C-19 Canal, (3) Lake Hicpochee, (4) Long Hammock Creek, and (5) Townsend Canal (Albright et al. 2019). FDEP's determination in the *2020 Statewide Annual Report on Total Maximum Daily Loads, Basin Management Action Plans, Minimum Flows or Minimum Water Levels, and Recovery or Prevention Strategies* (FDEP 2021) indicates that completed projects through December 31, 2020, are estimated to achieve total reductions of 78,031 pounds per year (lbs/yr; 35 metric tons per year [t/yr]) of TP and 708,110 lbs/yr (321 t/yr) of TN. This represents approximately 78% of the overall TN reduction goal of 910,676 lbs/yr (413 t/yr) required to achieve the CRE TMDL. Additionally, 83 projects are underway or planned as identified in the BMAP. Since tributary TMDLs were adopted only a few months prior to the BMAP update, the discussion of these in the BMAPs is limited. Future BMAPs will include progress towards the tributary TMDLs. **Table 8D-12** provides project performance, estimated (planned projects) and actual (operating projects), in terms of storage and nutrient removal by basin.

Table 8D-12. Summary of coordinating agency projects for each basin with the estimated and actual storage and nutrient reductions compared to the CRW storage target and CRE reduction targets.

Basin	Project Storage Estimates (ac-ft)	WY2021 Storage (ac-ft)	Project TN Reduction Estimates (t/yr)	WY2021 TN Reduction (t)	Project TP Reduction Estimates (t/yr)	WY2021 TP Reduction (t)
S-4	0	0	N/A	0	N/A	0
East Caloosahatchee	27,159	5,534	N/A	15	N/A	2
West Caloosahatchee	170,396	620	N/A [a]	0	N/A [a]	0
Tidal	0	0	N/A [a]	0	N/A [a]	0
CRW Totals	197,555	6,154	N/A [a]	15	N/A [a]	2
CRE Targets	400,000		413		N/A [b]	

a. Nutrient reduction is not associated with these project's primary objective; however, actual performance may be calculated if data are available.

b. TP target has not been developed for the watershed as a whole by FDEP. However, the CRW 2020 BMAP reports TP loading targets for 5 tributaries in the CRW including the C-19 Canal, Lake Hicpochee, Long Hammock, S-4 Basin, and Townsend Canal (FDEP 2020).

Within the *Basin Analyses* subsections later in this chapter are maps showing the locations of existing and planned SFWMD projects for the East and West Caloosahatchee basins (**Figures 8D-40** and **8D-45**, respectively). Additional information is provided in the Basin Analyses subsections. Storage estimates, general project information, and project status for existing and planned projects are presented in **Tables 8D-13** (East Caloosahatchee Basin) and **8D-17** (West Caloosahatchee Basin). Once projects are operational, measured data are used to determine project performance and supersede design estimates where possible. When measured data are not available, predicted project benefits and estimated project performance are used for planning purposes. Project status is listed as one of four possible phases: Planned – will be implemented in the future, Design – has received funding or is scheduled for further planning/design, Construction – project is under construction, or O&M – project is currently in Operation and Maintenance. Comprehensive project timelines as of the end of Fiscal Year 2021 (FY2021; October 1, 2020–September 30, 2021) for the East and West Caloosahatchee Basins are shown in **Tables 8D-14** and **8D-18**, respectively. Lastly, project costs and funding information are summarized in **Tables 8D-15** (East Caloosahatchee Basin) and **8D-19** (West Caloosahatchee Basin). Additional funding information is available for SFWMD-funded BMAP projects for FY2021–FY2025 in the *2021 South Florida Environmental Report – Volume II*, Appendix 5A-1 (Ollis and Sori 2021).

To identify potential new projects, a team of SFWMD subject matter experts with experience in the Northern Everglades reviewed materials gathered as part of the detailed assessment process. The team reviewed alternative nutrient reduction technologies, considered basin water quality, factors contributing to increased pollutant levels, and areas that may be considered ideal locations for capturing runoff from known problem areas. With guidance and recommendations from the team, SFWMD continues to pursue funding opportunities and water quality grants for potential nutrient reduction and storage projects. More information on the detailed assessments can be found in Appendix 8B-2 of this volume.

In FY2021, operational projects included the Boma Interim Storage project, Lake Hicpochee Hydrologic Enhancement (Phase I) project, and Mudge Ranch DWM project. Construction on the C-43 Reservoir continued and is expected to be completed in 2023. Conceptual design is currently underway for the Boma FEB, C-43 Reservoir Water Quality Component, and Lake Hicpochee Hydrologic Enhancement Expansion (Phase II) project.

OVERVIEW OF PROGRAMS

Table 8B-21 in Chapter 8B of this volume provides an overview of nutrient source control programs and the responsible entities related to the Lake Okeechobee Watershed Construction Project. These incentive-based and regulatory programs of the coordinating agencies are essential for controlling nutrients at the source and assisting with the reduction of nutrient loading to the Northern Everglades receiving water bodies including the Caloosahatchee River, Estuary, and Watershed. Both point and nonpoint sources of phosphorus and nitrogen in runoff are addressed through these collective programs (SFWMD et al. 2011). As problem areas are identified through detailed assessments, these programs will be reviewed for association with identified sources and potential recommended actions. Other relevant programs will also be considered such as the Onsite Sewage Program, which was transferred from the Department of Health to FDEP on July 1, 2021, per Senate Bill 712, which passed during the 2020 Florida Legislative Session and was based on a recommendation from the Blue Green Algae Task Force.

SFWMD is responsible for two source control programs: Environmental Resource Permitting (ERP) and Chapter 40E-61, F.A.C. Updates on FDACS and FDEP programs can be found in Chapter 8A of this volume. SFWMD's ERP program regulates any activity involving the alteration of surface water flows. An operating agreement specifies the division of responsibilities between FDEP and SFWMD and is used to determine which agency processes each of the ERP applications. Senate Bill 712 required FDEP and the water management districts to initiate rulemaking to update ERP rules to include BMPs and design criteria to increase the removal of nutrients from storm water. In response, SFWMD published a Notice of Rule Development regarding Rule 40E-4.091 on December 18, 2020. SFWMD will update the *Environmental*

Resource Permit Applicant's Handbook Volume II for Use Within the Geographic Limits of the South Florida Water Management District (SFWMD 2016) in conjunction with FDEP's rulemaking effort in accordance with Section 5 of Chapter 2020-150, Laws of Florida to update the stormwater design and operation regulations adopted under Section 373.4131, F.S., using the most recent scientific information available. FDEP and SFWMD will develop amendments to update the stormwater design and operation regulations, and will consider and address low impact design BMPs and design criteria that increase the removal of nutrients from stormwater discharges and measures for consistent application of the net improvement performance standard to ensure significant reductions of any pollutant loadings to a water body. FDEP's rulemaking will include amendments to Chapter 62-330, F.A.C., and the *Environmental Resource Permit Applicant's Handbook Volume I (General and Environmental)* (FDEP et al. 2018) that apply statewide. SFWMD's rulemaking pursuant to this notice is expected to include updates to the Volume II as well.

Under the 2016 NEEPP legislation, SFWMD was directed to amend Chapter 40E-61, F.A.C., and provide a monitoring program for nonpoint source dischargers required to monitor water quality under Section 403.067, F.S. In 2020, SFWMD conducted a series of public workshops related to the amendments and amendments to Chapter 40E-61 became effective on April 11, 2021. The rules were expanded to encompass the entirety of the three Northern Everglades watersheds and provide a monitoring program for those under a BMAP not implementing BMPs. The program requires nonpoint source dischargers not implementing BMPs to submit a SFWMD-approved water quality monitoring plan and regularly report associated monitoring data.

BASIN ANALYSES

A basin analysis is presented for each of the basins within the CRW: S-4, East Caloosahatchee, West Caloosahatchee, and Tidal Basin. General characteristics such as hydrology and land use are described, and projects, water quality data, and associated analyses for each basin are provided.

SFWMD watershed monitoring is currently conducted at two hydrologic levels within the CRW (**Figure 8D-27** in the *Research and Water Quality Monitoring Program Part II: Caloosahatchee River Watershed* section earlier in this chapter): basin level (basin monitoring sites) and sub-basin level (upstream monitoring sites). At basin monitoring sites, flow and nutrient (TP and TN) concentrations are monitored and used to calculate nutrient loads. The calculated nutrient load at each basin monitoring site is used to estimate the total basin load. These basin-level monitoring data are presented for each basin in **Table 8D-11**, also in in the *Research and Water Quality Monitoring Program Part II: St. Lucie River Watershed* section earlier in this chapter. Each *Basin-Level Monitoring* subsection below presents a summary of this information for the most recent 5-year period (WY2017–WY2021). Long-term nutrient loading summaries are also presented for each basin as time series for flow, TP, and TN.

The second type of monitoring by SFWMD occurs at upstream monitoring sites within the East Caloosahatchee and West Caloosahatchee basins and provides data representative of localized areas. There are 15 upstream monitoring sites that include the following water quality monitoring parameters: TP, orthophosphate (OPO_4), TN, ammonium (NH_4), nitrate + nitrite (NO_X), dissolved oxygen, specific conductance, pH, and temperature. Grab samples are collected biweekly at these upstream monitoring sites when flow is visually observed. Of the upstream monitoring sites, concurrent flow monitoring is available at CRW06, CRW15, CRW23, and S47D. The *Upstream-Level Monitoring* subsection for each basin presents summaries of the upstream monitoring data. Further analyses of upstream monitoring data are presented in Appendix 8D-1 of this volume.

Land use maps presented below include generalized land use categories for agricultural, non-agricultural, and natural areas. The agricultural land use category includes pasture, row crops, citrus groves, and other similar land uses. The non-agricultural land use category includes residential, institutional, and urban land uses. The natural areas land use category includes wetlands, water bodies, and forested areas, among others. These three generalized land use categories broadly reflect the existing framework for implementing various programs.

Parameters presented in the basin analyses discussed below include TN and TP loads, flow, unit area loads (UALs), and FWMCs. Nutrient loads are the cumulative weight of a nutrient transported past the point of measurement and are commonly expressed in metric tons (t). Flow is the total discharge volume for the water year, commonly expressed in acre-feet (ac-ft), i.e., the volume of water required to cover one acre of land to a depth of one foot. The UAL is the nutrient load per acre of a given drainage area and is expressed in pounds per acre (lbs/ac). The FWMC represents the average concentration of a constituent relative to the total flow volume and is expressed here in milligrams per liter (mg/L).

S-4 Basin Analysis

The S-4 Basin has a total drainage area of approximately 42,146 ac (17,056 ha). The basin is in northeastern Hendry County and southeastern Glades County. Land use types in the S-4 Basin are primarily agricultural (80%; 33,721 ac), followed by non-agricultural (14%; 5,861 ac) and natural land cover (6%; 2,563 acres) (**Figure 8D-35**).

Approximately 15 miles of the northern boundary of the S-4 Basin runs adjacent to Lake Okeechobee. The major drainage canals in the basin include the L-D1 perimeter, C-20, C-21, and Clewiston (Industrial) canals. There are four main structures that regulate flow within the S-4 Basin: S-4 pump station (located at the northern end of the C-20 Canal) that controls flow from the basin into Lake Okeechobee; S-310 navigational lock structure (located between Lake Okeechobee and the Clewiston Canal); S-169 (a series of three-gated culverts connecting the Clewiston and C-21 canals); and S-235 (a pair of gated culverts connecting the L-D1 and C-43 canals). This highly managed drainage basin can discharge to either the Caloosahatchee River (via S-235) or Lake Okeechobee (via S-4, S-169, and S-310) according to operational decisions and based on larger regional conditions. The CRWPP addresses only the S-4 Basin's contribution to the CRE. The Lake Okeechobee Watershed Protection Plan considers flow from the S-4 Basin into Lake Okeechobee (see Chapter 8B of this volume).

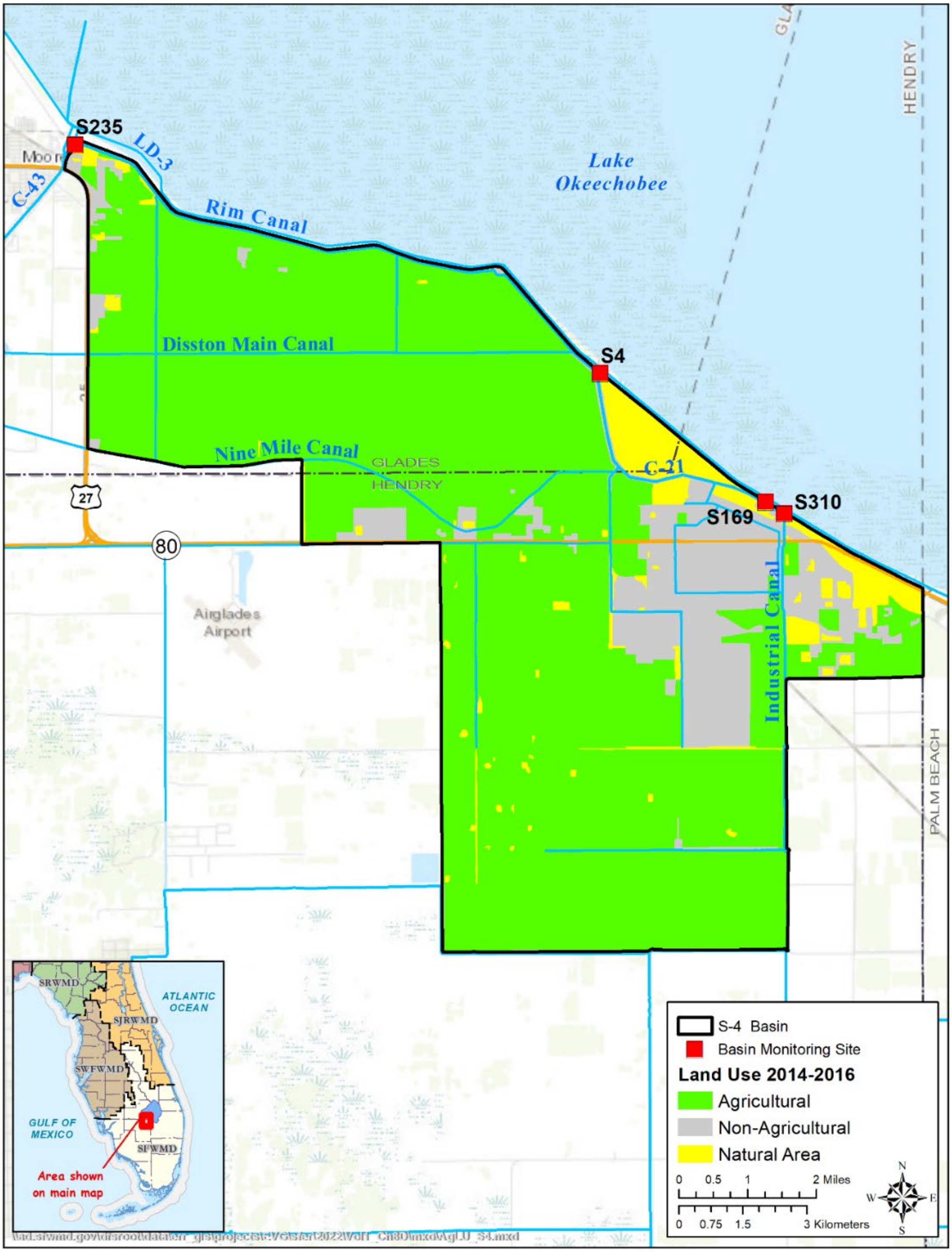

Figure 8D-35. The S-4 Basin boundary showing generalized land use and basin monitoring stations (red squares). There are no upstream monitoring stations in the S-4 Basin.

S-4 Basin-Level Monitoring

To characterize contributions to the CRE, basin-level monitoring in the S-4 Basin is conducted at major water control structure S-235. Monitoring results for TP, TN, and flow volumes are summarized below in **Table 8D-13** for the most recent 5-year period (WY2017–WY2021). In addition, long-term time series are presented for flow and precipitation, TP load and FWMC, and TN load and FWMC in **Figures 8D-36** through **8D-38**, respectively.

Table 8D-13: Annual TP loads, TN loads, and total flow for WY2017–WY2021 and 5-year averages for the S-4 Basin.

S-4 Basin							
Water Year	TP			TN			Flow (ac-ft)
	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	
WY2017	12.01	0.63	0.288	103.01	5.39	2.47	33.86
WY2018	5.22	0.27	0.223	46.15	2.41	1.97	19.01
WY2019	16.78	0.88	0.313	127.13	6.65	2.37	43.41
WY2020	6.17	0.32	0.253	55.27	2.89	2.27	19.75
WY2021	19.18	1	0.262	174.44	9.12	2.38	59.35
5-Year Avg.	**11.87**	**0.62**	**0.27**	**101.20**	**5.29**	**2.29**	**35.08**

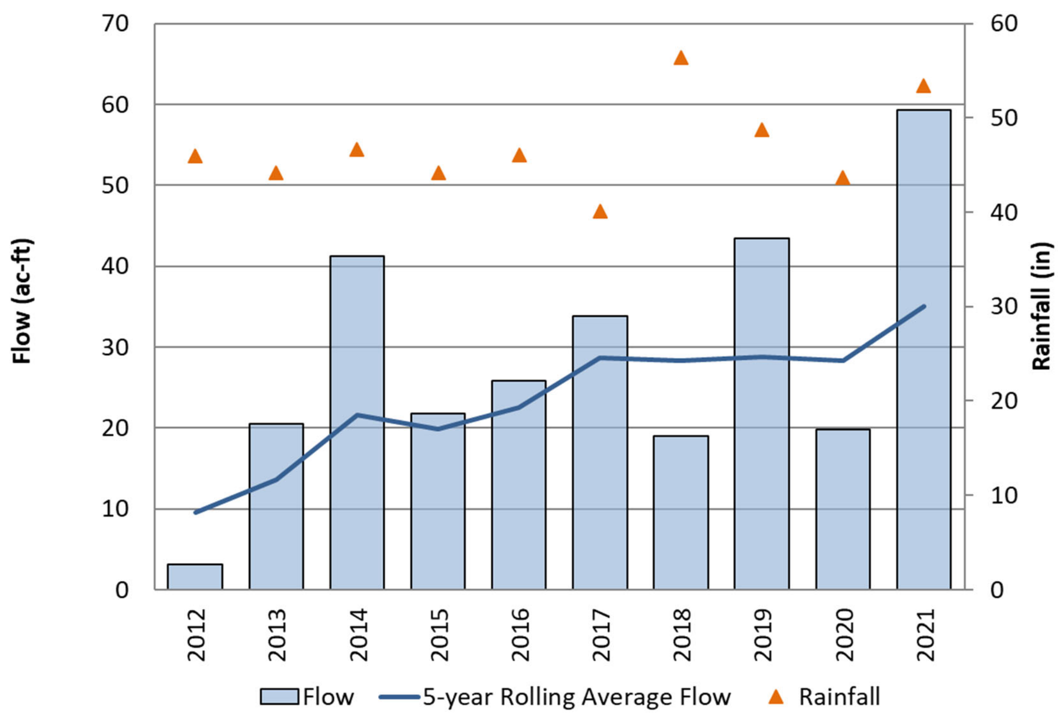

Figure 8D-36. S-4 Basin annual flow (blue bars), 5-year rolling average flow (blue line), and total annual rainfall in inches (in; orange triangle, right axis) for WY2012–WY2021.

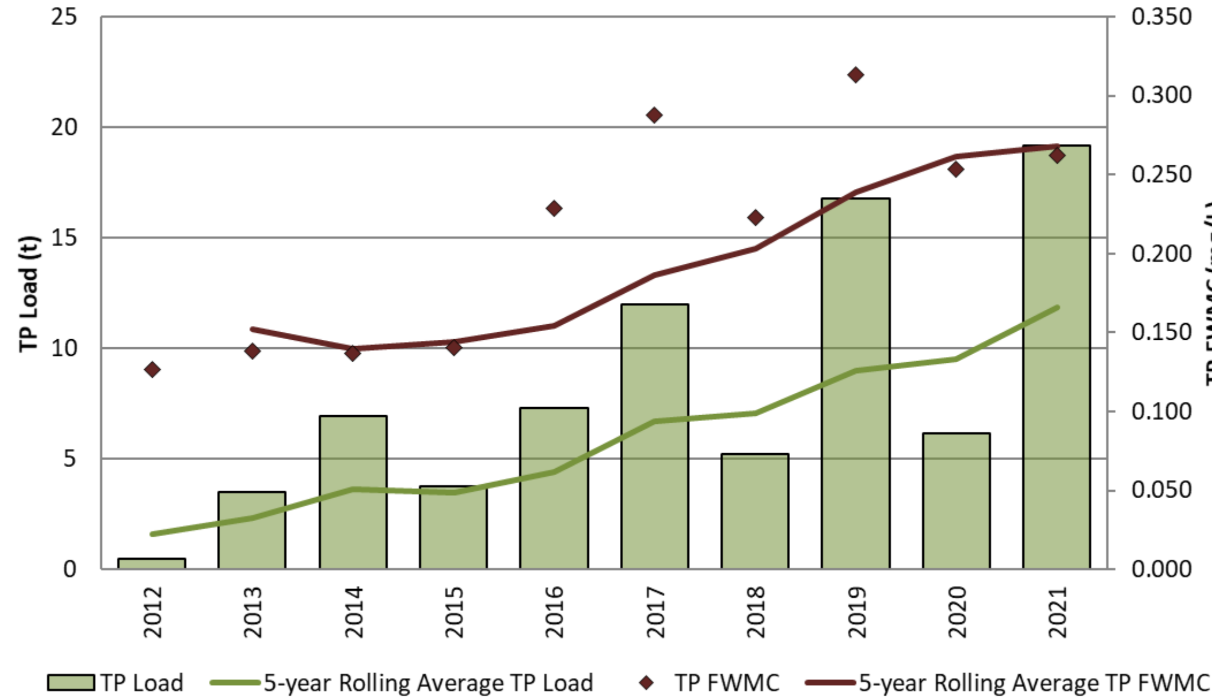

Figure 8D-37. Annual TP load (green bars) and TP FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the S-4 Basin. (Note: 5-year rolling average FWMC not provided for WY2012 due to no flow or no data in WY2008.)

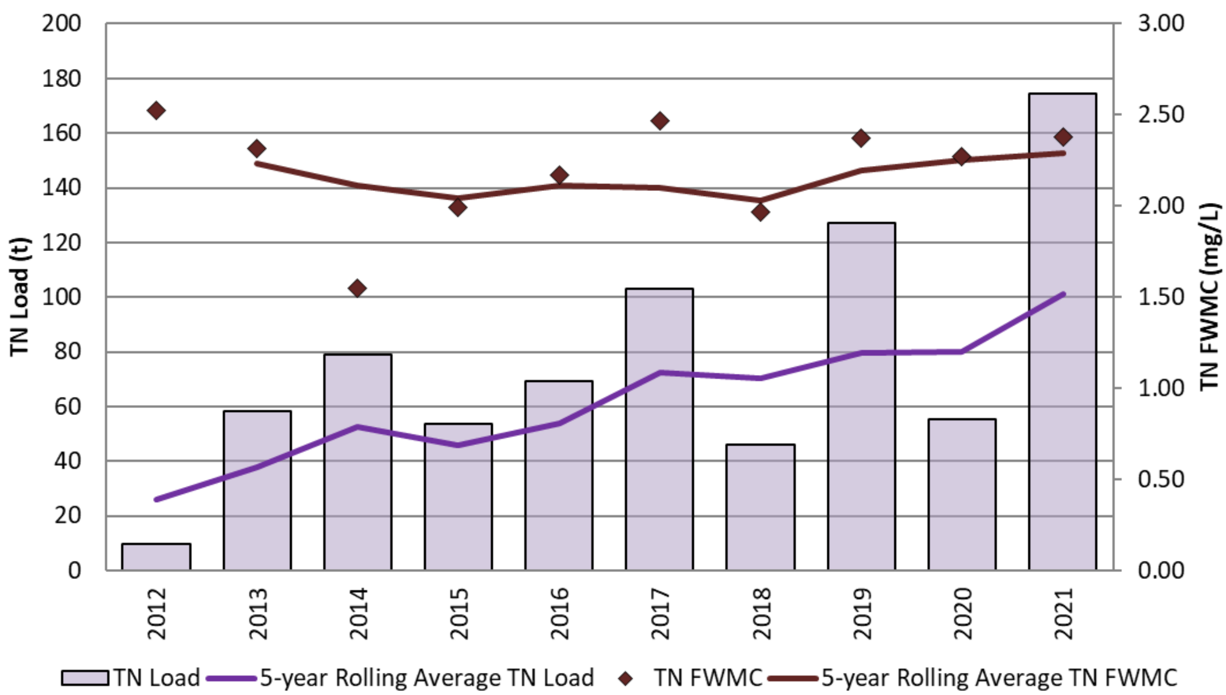

Figure 8D-38. Annual TN load (purple bars) and TN FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the S-4 Basin. (Note: 5-year rolling average FWMC not provided for WY2012 due to no flow or no data in WY2008.)

S-4 Basin Upstream-Level Monitoring

There are currently no SFWMD upstream water quality monitoring stations located within the S-4 Basin.

S-4 Basin Observations

For the WY2017–WY2021 period, the S-4 Basin contributions to the CRE were generally below average in comparison to the other three CRW basins. However, the S-4 Basin showed the highest TP and TN FWMCs of the four CRW basins (**Table 8D-11**).

Information presented in this chapter reflects only S-4 Basin contributions to the CRE. However, hydrology in the S-4 Basin is highly altered and discharges can be made to both the Caloosahatchee River (via S-235) and directly to Lake Okeechobee (via S-4, S-169, and S-310). These operational decisions are based on larger regional conditions, and often impact the observed S-4 Basin discharges when evaluating each water body in isolation.

Currently, no upstream monitoring stations or new SFWMD projects are planned within the S-4 Basin.

East Caloosahatchee Basin Analysis

The East Caloosahatchee Basin is in southern Glades County and northern Hendry County. It has a total drainage area of approximately 204,095 ac (82,594 ha). Land use types in the East Caloosahatchee Basin are primarily agricultural (66%; 135,023 ac) and natural areas (28%; 58,127 ac) (**Figure 8D-39**). The primary conveyance in the basin is the C-43 Canal (Caloosahatchee River). Two control structures are in the basin: S-77 gated spillway (Moore Haven Lock and Dam) and S-78 gated spillway (Ortona Lock and Dam). The C-43 Canal is intersected by Lake Hicpochee about five miles west of S-77. Water surface elevations in the basin are regulated by the S-78 gated spillway and regulatory releases from Lake Okeechobee are made by way of the S-77 gated spillway. Water flows north to south in the C-19 Canal before discharging into Lake Hicpochee and before entering the C-43 Canal (SFWMD et al. 2009).

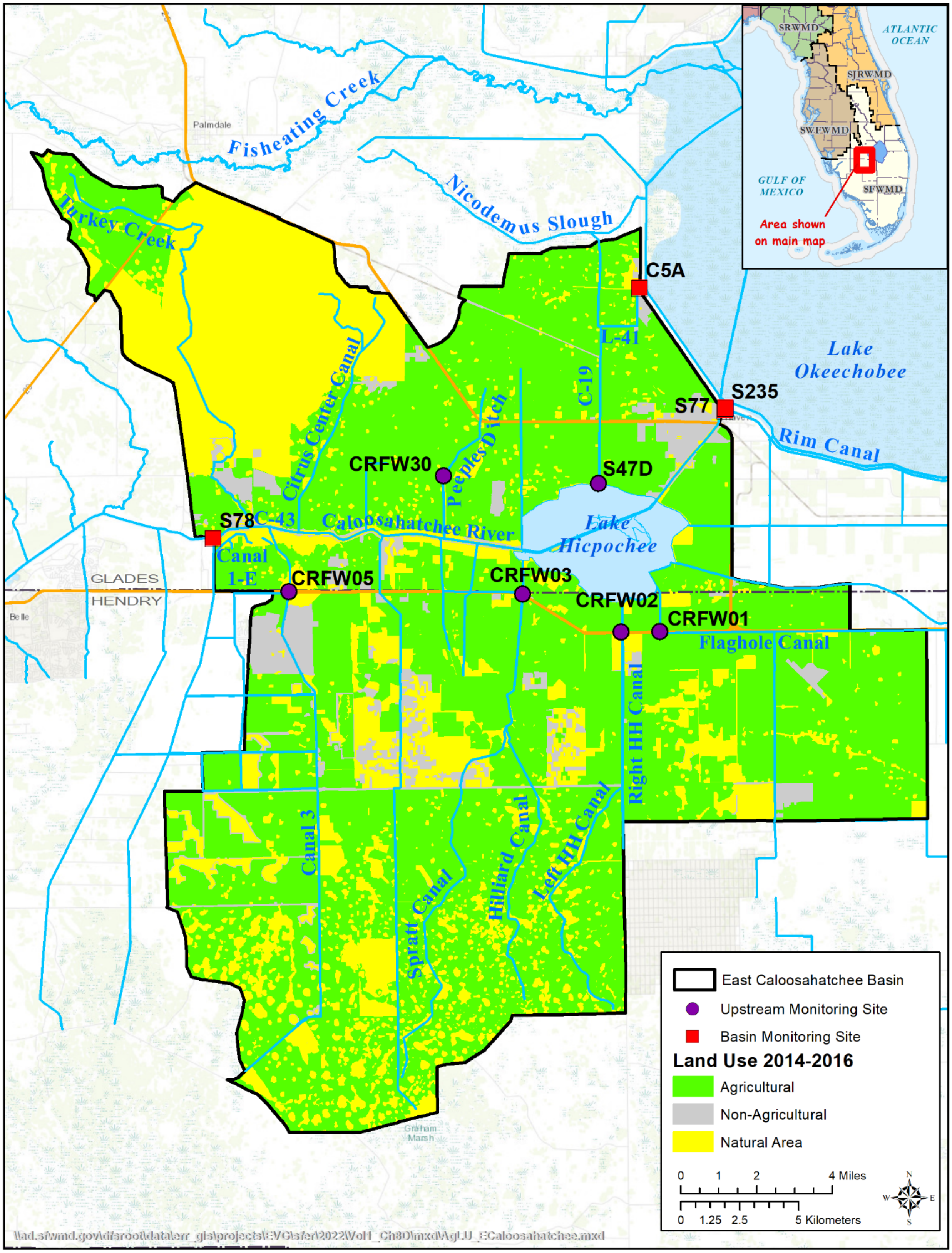

Figure 8D-39. East Caloosahatchee Basin boundary showing generalized land use and basin (red squares) and upstream (purple circles) monitoring stations.

East Caloosahatchee Projects

Current SFWMD projects within the East Caloosahatchee Basin are displayed in **Figure 8D-40** and described in **Table 8D-14**. A timeline for each project and FY2021 project status is shown in **Table 8D-15** and cost information is presented in **Table 8D-16**.

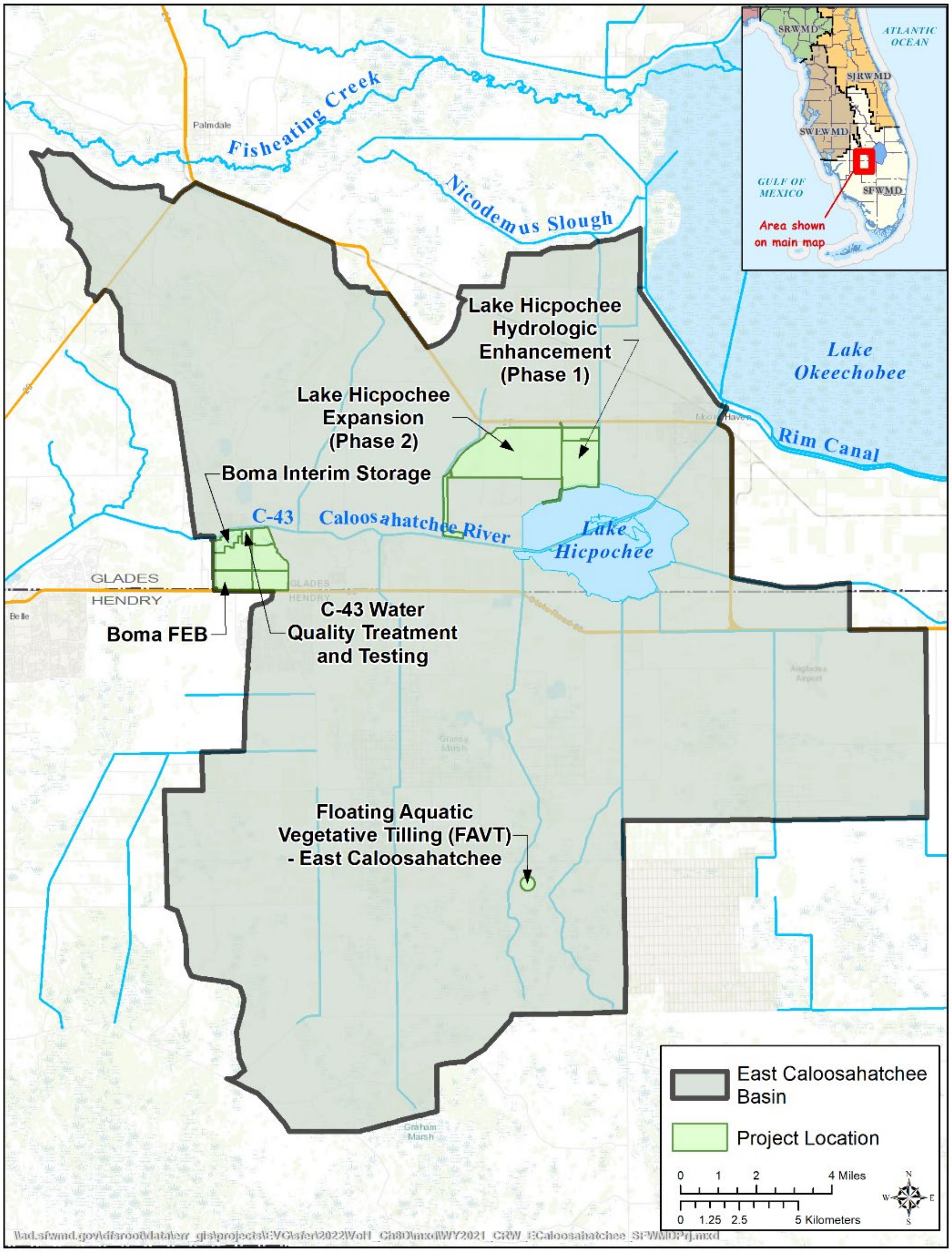

Figure 8D-40. Current SFWMD projects in the East Caloosahatchee Basin.

Table 8D-14. Current SFWMD projects in the East Caloosahatchee Basin with the associated annual estimated and WY2021 observed storage and nutrient reductions for each project.

Project Name	Project Type	Project Area (ac)	Project Status (FY2021) [a]	Description	Estimated Storage (ac-ft)	WY2021 Storage (ac-ft)	Estimated TN Removed (t/yr)	WY2021 TN Removed (t/yr)	Estimated TP Removed (t/yr)	WY2021 TP Removed (t/yr)
Boma Interim Storage Project	DWM	369	O&M	Two aboveground impoundments (AGIs; Basin 2 – 143 ac and Basin 3 – 226 ac) store excess water pumped from local drainage canals and the C-43 Canal. Temporary project until Boma FEB begins construction.	1,500	3,787	N/A [b]	3.5	N/A [b]	0.27
Boma Flow Equalization Basin	Hydrologic Restoration	1,796	Design	Project expands regional storage on publicly owned land. Project will attenuate high flows and store excess runoff to reduce harmful releases to the CRE.	7,200	N/A [c]	TBD [d]	N/A [c]	TBD [d]	N/A [c]
C-43 Water Quality Treatment and Testing Project (Phase II)	Study	80	Design	Project evaluates the effectiveness of constructed wetland treatment systems in reducing nitrogen at a test scale.	N/A [b]	N/A [b]	N/A [b]	N/A [b]	N/A [b]	N/A [b]
Lake Hicpochee Hydrologic Enhancement (Phase I)	Hydrologic Restoration	798	O&M	Project captures excess surface water from the C-19 Canal before it discharges to the Caloosahatchee River, directs flow to a shallow water storage area, and distributes discharge via a spreader canal to the northwestern portion of Lake Hicpochee.	1,297	1,747 [e]	N/A [b]	2.14 [e]	N/A [b]	0.13 [e]
Lake Hicpochee Expansion (Phase II)	Hydrologic Restoration	2,494	Design	Project will increase the operational capacity of the FEB and spreader swale currently constructed under Phase I.	17,162	N/A [c]	N/A [b]	N/A [c]	N/A [b]	N/A [c]
Lake Okeechobee Watershed Restoration Project (LOWRP) - C-43 Aquifer Storage and Recovery (ASR) Well Cluster	Storage	TBD	Planning	The LOWRP received $50 million (M) in FY2020 and $50M in FY2021. Additionally, Senate Bill 2516 was approved in June 2021 appropriating $50M each year for the next 6 years, totaling $400M from FY2020 through FY2027. The first ASR well clusters to be constructed are north of Lake Okeechobee. Construction of the clusters at the C-40, C-41 and C-43 canals will be at a later date.	TBD [d]	N/A [c]	N/A [b]	N/A [b]	N/A [b]	N/A [b]
East Caloosahatchee Floating Aquatic Vegetative Tilling (FAVT) (FDACS)	Nutrient removal	540	O&M	FAVT technology uses the direct assimilation of nutrients from the water column using floating plant roots, and all the biomass is rapidly incorporated directly into the soil through tilling. The East Caloosahatchee FAVT project is in the CRW and became operational in 2014. It is comprised of 540 ac of floating aquatic vegetation (FAV) and SAV communities and has a treatment capacity of 90 cubic feet per second (cfs) or 2.55 cubic meters per second (m^3/s).	N/A [b]	N/A [b]	TBD [d]	12.4	TBD [d]	2.1
				East Caloosahatchee Total	**27,159**	**5,534**	**--**	**14.54**	**--**	**2.23**

a. Reflects the project status at the end of FY2021.

b. N/A – not applicable; benefit is not associated with the project's primary objective; however, project performance will be calculated where data are available.

c. Measured project performance is not available for WY2021; however, future water year performance may be determined once the project begins operation.

d. TBD – to be determined; estimated benefits have not been established.

e. Data is only available beginning December 9, 2021.

Table 8D-15. Project timeline for current SFWMD projects in the East Caloosahatchee Basin.

Project Name	Project Status FY2021	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026
Boma Interim Storage Project	O&M							Construction	O&M	O&M	O&M				
Boma Flow Equalization Basin	Design							Planning	Design	Design	Design	Construction	Construction	Construction	O&M
C-43 Water Quality Treatment and Testing Project (Phase II)	Design								Design	Design	Construction	O&M	O&M	O&M	
Lake Hicpochee Hydrologic Enhancement (Phase I)	O&M							Construction	O&M	O&M	O&M	O&M	O&M	O&M	O&M
Lake Hicpochee Expansion (Phase II)	Design							Planning	Design	Design	Design	Construction	Construction	Construction	Construction
Lake Okeechobee Watershed Restoration Project Aquifer Storage and Recovery Well Cluster	Planning								Planning	Planning	Planning	Planning	Planning	Planning	Planning
Floating Aquatic Vegetative Tilling (FDACS)	O&M		O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M

= **Planning** = **Design** = **Construction** = **O&M**

Table 8D-16. Project cost estimates for current SFWMD projects in the East Caloosahatchee Basin. [a]

Project Name	Funding Source	Land Acquisition	Cost to Date [b]	FY2022 [c]	FY2023 [c]	FY2024 [c]	FY2025 [c]	FY2026 [c]
Boma Interim Storage Project	State Appropriations/ District Ad Valorem	-	$2.0M	$79K	$133K	$133K	$133K	$133K
Boma Flow Equalization Basin	State Appropriations/ District Ad Valorem	$37.3M	$2.7M	$2.3M	$15M	$21.5M	$20M	$11M
C-43 Water Quality Treatment & Testing Project (Phase II)	State Appropriations/ District Ad Valorem/Federal	-	$2.1M	$12.9M	$1M	$1M	$1M	$1M
Lake Hicpochee Hydrologic Enhancement (Phase I)	State Appropriations/ District Ad Valorem	$4.9M	$17.0M	$111K	$111K	$111K	$111K	$111K
Lake Hicpochee Expansion (Phase II)	State Appropriations/ District Ad Valorem	$17.1M	$12.2M	$7.5M	$17.4M	$30M	$32M	$20M

a. A fiscal year begins on October 1 and continues until September 30 of the fiscal year indicated, e.g., FY2022 is October 1, 2021–September 30,2022. K – thousand and M – million.

b. Cost to Date includes FY21 and all previous years, where available. Costs include design, construction, operations, maintenance, and other contractual costs, where available. Land acquisition, monitoring, and other programmatic costs are not included.

c. Future cost estimates include all planned capital/contractual expenses plus annual O&M cost estimates (FY21 O&M costs).

East Caloosahatchee Basin-Level Monitoring

To characterize contributions to the CRE, basin-level monitoring in the East Caloosahatchee Basin is conducted at major water control structures S-77, S-78, and S-235. Monitoring results for TP, TN, and flow volumes are summarized below for the most recent 5-year period (WY2017–WY2021) in **Table 8D-17**. In addition, long-term time series are presented for flow and precipitation, TP load and FWMC, and TN load and FWMC in **Figures 8D-41** through **8D-43**, respectively.

Table 8D-17: Annual TP loads, TN loads, and total flow for WY2017–WY2021 and 5-year averages for the East Caloosahatchee Basin.

East Caloosahatchee Basin							
Water Year	TP			TN			Flow (ac-ft)
	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	
WY2017	57.03	0.62	0.284	429.74	4.64	2.14	162.58
WY2018	149.21	1.61	0.347	921.85	9.96	2.15	348.14
WY2019	52.31	0.57	0.189	502.77	5.43	1.81	224.73
WY2020	28.29	0.31	0.124	351.16	3.79	1.54	184.80
WY2021	45.38	0.49	0.185	532.23	5.75	2.18	198.36
5-Year Avg.	**66.44**	**0.72**	**0.23**	**547.55**	**5.91**	**1.96**	**223.72**

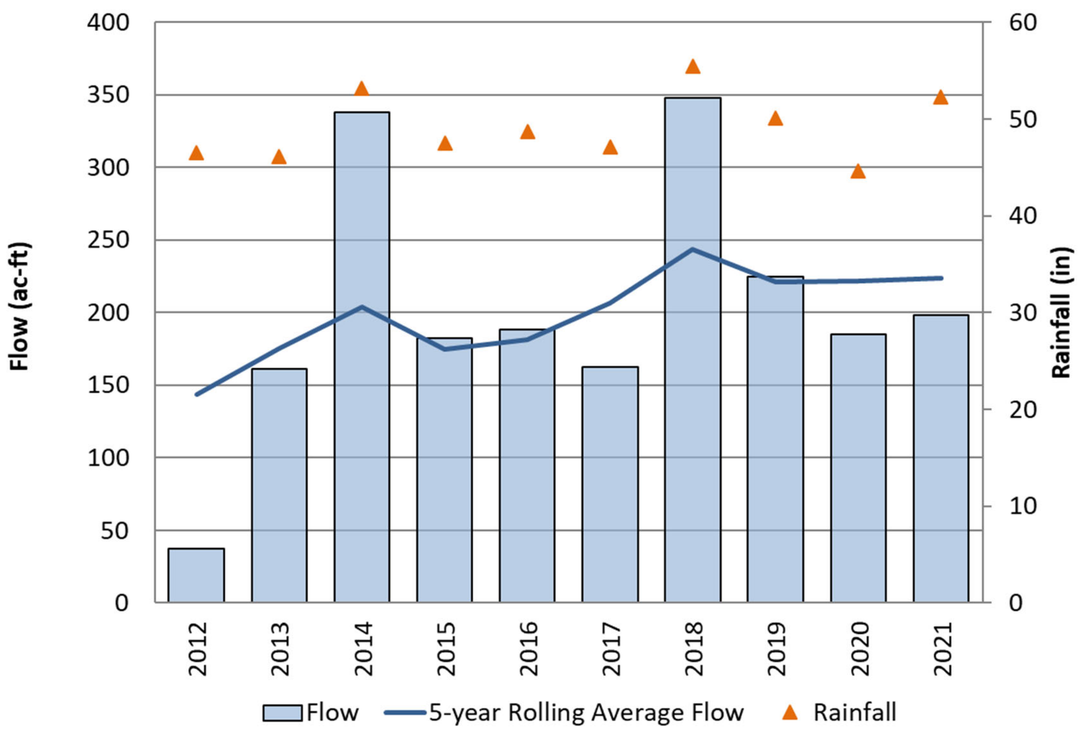

Figure 8D-41. East Caloosahatchee Basin annual flow (blue bars), 5-year rolling average flow (blue line), and total annual rainfall in inches (in; orange triangle, right axis) for WY2012–WY2021.

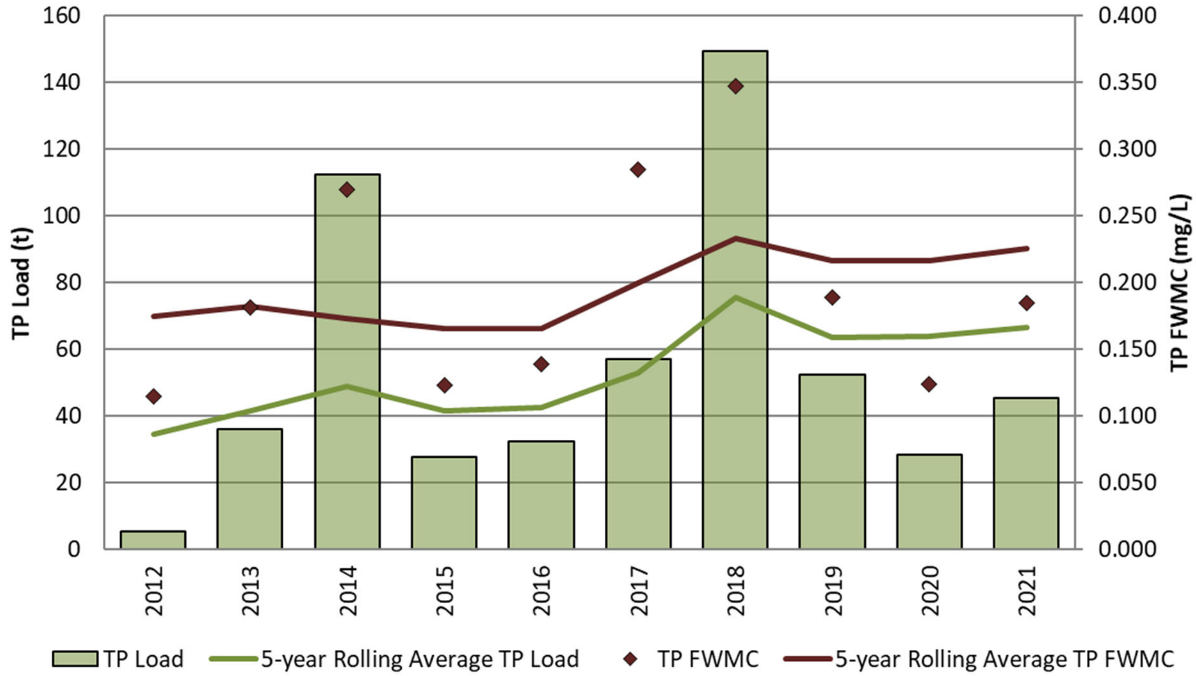

Figure 8D-42. Annual TP load (green bars) and TP FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the East Caloosahatchee Basin.

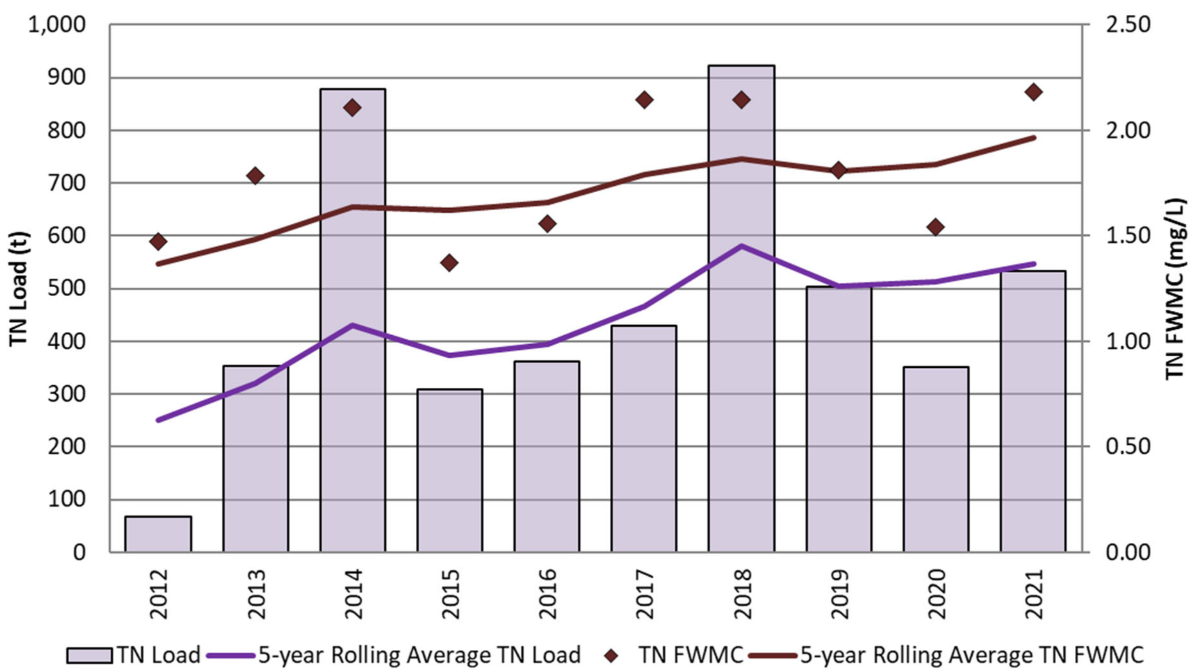

Figure 8D-43. Annual TN load (purple bars) and TN FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the East Caloosahatchee Basin.

East Caloosahatchee Basin Upstream-Level Monitoring

The East Caloosahatchee Basin contains six upstream monitoring sites; all of which were reinstated in WY2020 (January 2020) as part of the expanded monitoring program. Five of these six sites were monitored previously under synoptic water quality monitoring efforts; therefore, data for WY2015 and WY2016 are also available for review. The data collected during these periods indicated somewhat elevated TN concentrations for all six sites. Available upstream monitoring data are presented in more detail in Appendix 8D-1 of this volume.

East Caloosahatchee Basin Observations

For the WY2017–WY2021 period, the East Caloosahatchee Basin contributions to the CRE were generally below average in comparison to the other three CRW basins, except for above average TP and TN FWMC (**Table 8D-11**).

Rainfall in the East Caloosahatchee Basin generally falls below the CRW average. However, high rainfall years (e.g., WY2018) generally correspond to above average flow volumes. Overall, the 5-year rolling average flow shows increases that are proportional relative to trends in precipitation for the period evaluated. Likewise, variability for both TP and TN loading generally correspond to changes in annual flow volumes.

Several projects are now operational in the East Caloosahatchee Basin, including the Lake Hicpochee Hydrologic Enhancement Phase I project and the Boma Interim Storage project. These projects are expected to achieve improvements to flow and nutrient contributions from the East Caloosahatchee Basin to the CRE. Projects currently in design (e.g., Lake Hicpochee Expansion Phase II and Boma FEB) will continue progress toward the CRW objectives.

West Caloosahatchee Basin Analysis

A majority of the West Caloosahatchee Basin is in southern Glades and northern Hendry counties, with smaller portions in eastern Charlotte, northeastern Lee, and north-central Collier counties. It has a total drainage area of 350,116 ac (141,687 ha). Land use types in the West Caloosahatchee Basin are primarily agricultural (47%; 163,470 ac) and natural areas (39%; 136,723 ac) (**Figure 8D-44**).

The primary conveyance in the West Caloosahatchee Basin is the C-43 Canal. Two control structures are in the basin: S-78 gated spillway and S-79 gated spillway (also known as the W.P. Franklin Lock and Dam). S-78 aids in control of water levels on adjacent lands upstream. The S-79 is the most downstream structure and marks the beginning of the CRE. S-79 helps maintain specific water levels upstream, regulates freshwater discharges into the estuary, and serves as an impediment to saltwater intrusion upstream (SFWMD et al. 2009).

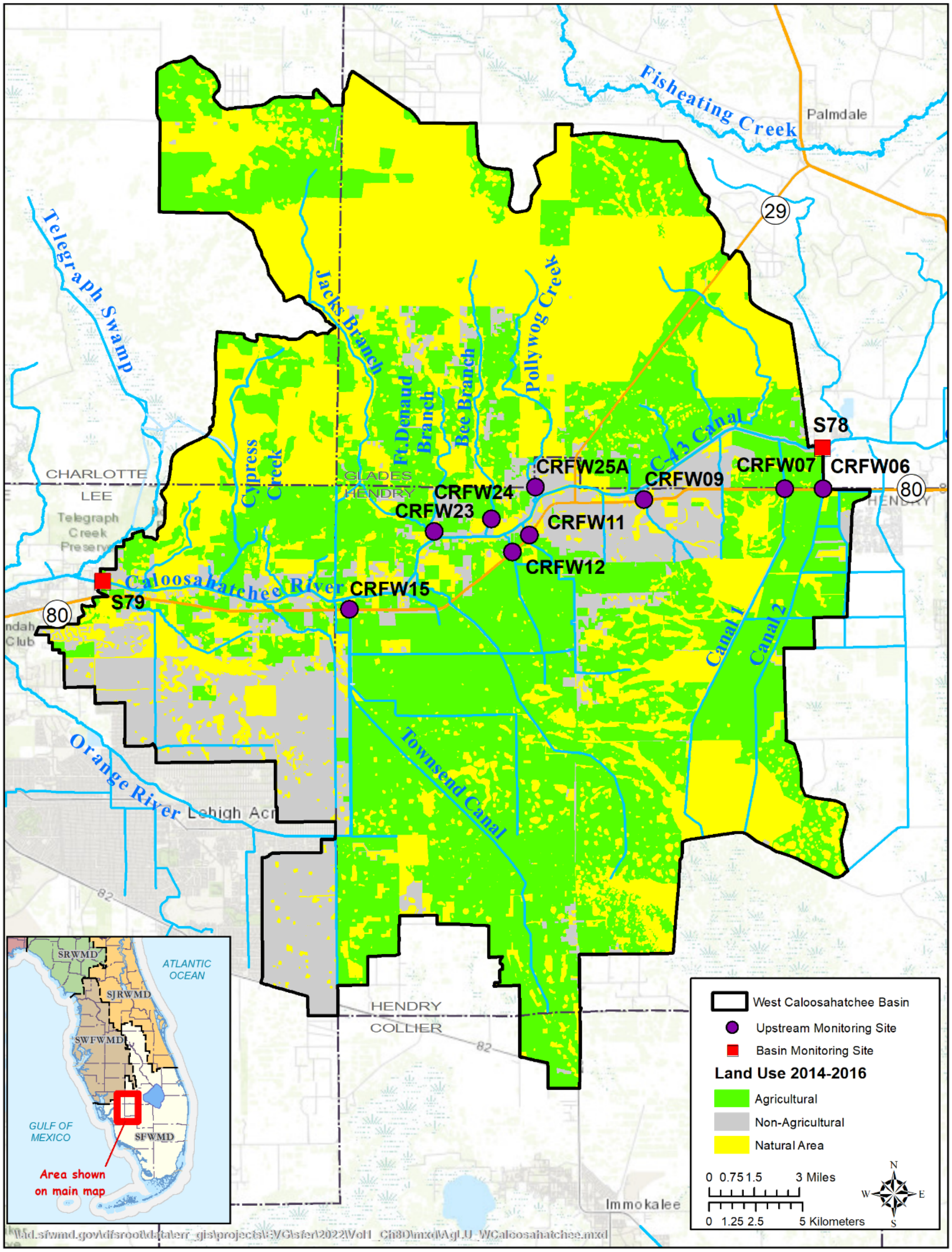

Figure 8D-44. West Caloosahatchee Basin boundary showing generalized land use and basin (red squares) and SFWMD upstream (purple circles) monitoring stations.

West Caloosahatchee Projects

Current SFWMD projects within the West Caloosahatchee Basin are displayed in **Figure 8D-45** and described in **Table 8D-18**. A timeline for each project and FY2021 project status is shown in **Table 8D-19** and cost information is presented in **Table 8D-20**.

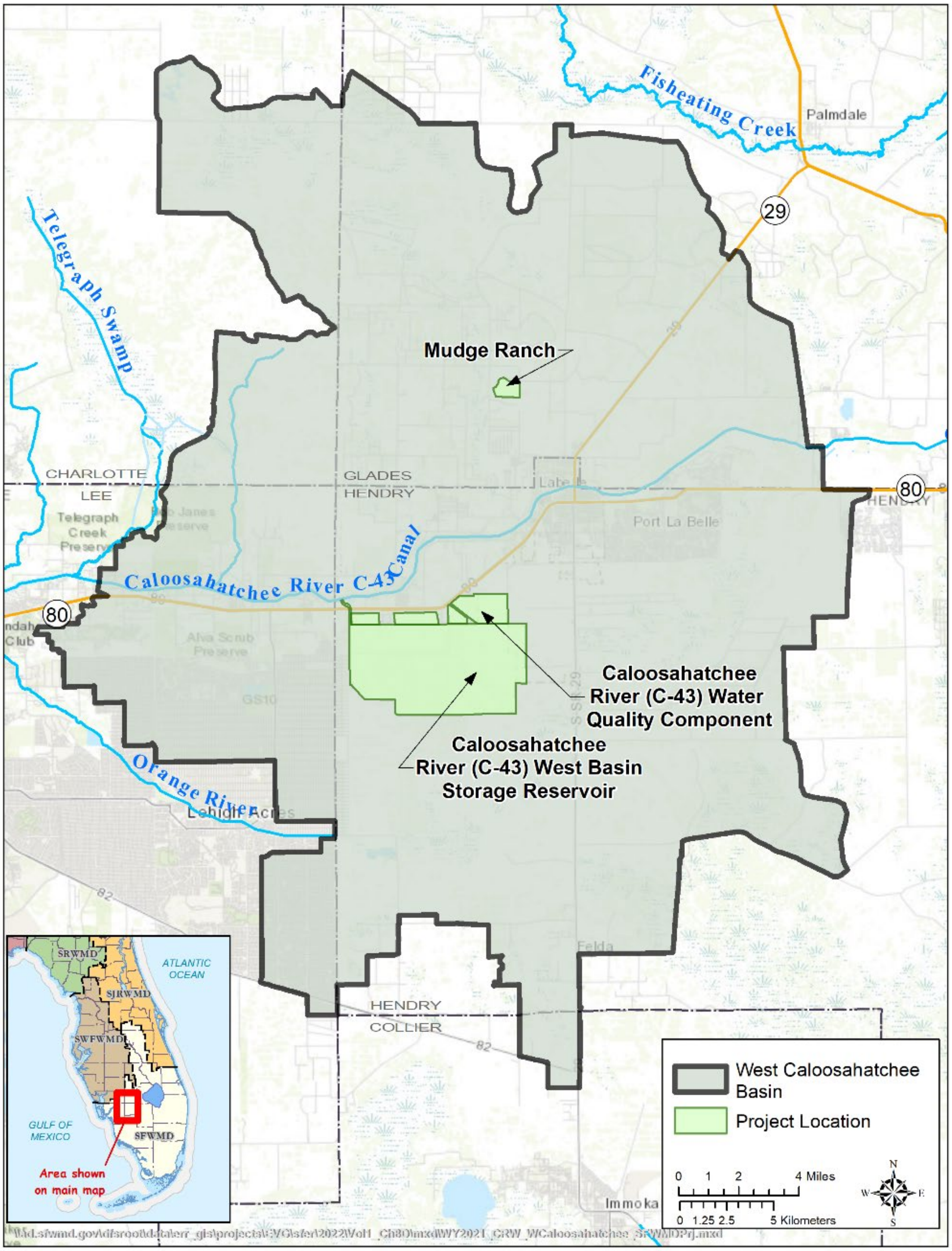

Figure 8D-45. Current SFWMD projects in the West Caloosahatchee Basin.

Table 8D-18. Current SFWMD projects in the West Caloosahatchee Basin with the associated annual estimated and WY2021 observed storage and nutrient reductions for each project.

Project Name	Project Type	Project Area (ac)	Project Status (FY2021) [a]	Description	Estimated Storage (ac-ft)	WY2021 Storage (ac-ft)	Estimated TN Removed (t/yr)	WY2021 TN Removed (t/yr)	Estimated TP Removed (t/yr)	WY2021 TP Removed (t/yr)
Mudge Ranch (NE-PES) [b]	DWM	304	O&M	Dispersed Water Management public-private partnership. This passive storage project on 304 ac retains excess stormwater.	396	620	N/A [c]	N/A [c]	N/A [c]	N/A [c]
C-43 Reservoir	Hydrologic Restoration	10,700	Construction	Storage of 170,000 acre-feet of local stormwater runoff and Lake Okeechobee regulatory releases. The project will reduce the volume of lake discharges in the wet season and provide freshwater flow to the estuary in the dry season to promote desirable salinities. Construction completion expected in 2023.	170,000	N/A [d]	N/A [c]	N/A [c]	N/A [c]	N/A [c]
C-43 Reservoir: Water Quality Component	Constructed Wetland Treatment	TBD	Design	Construct an inline alum injectionsystem at the C-43 Reservoir project to reduce the discharge of nutrients.	TBD [e]	N/A [d]	TBD [e]	N/A [d]	TBD [e]	N/A [d]
				West Caloosahatchee Total	**170,396**	**620**	**--**	**--**	**--**	**--**

a. Reflects the project status at the end of FY2021.

b. NE-PES – Northern Everglades Payment for Environmental Services.

c. N/A – not applicable; benefit is not associated with the project's primary objective; however, project performance will be calculated where data are available.

d. Measured project performance is not available for WY2021; however, future water year performance may be determined once project begins operation.

e. TBD – to be determined; estimated benefits have not been established.

Table 8D-19. Project timeline for current SFWMD projects in the West Caloosahatchee Basin.

Project Name	Project Status FY2021	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026
Mudge Ranch (NE-PES)	O&M	Construction	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M			
C-43 West Basin Storage Reservoir	Construction					Design	Design	Construction	Construction	Construction	Construction	Construction	O&M	O&M	O&M
C-43 West Basin Storage Reservoir - Water Quality Component	Design							Planning	Planning	Design	Design	Design	Construction	Construction	O&M

= Planning = Design = Construction = O&M

Table 8D-20. Project cost estimates for current SFWMD projects in the West Caloosahatchee Basin. [a]

Project Name	Funding Source	Land Acquisition	Cost to Date [b]	FY2022 [c]	FY2023 [c]	FY2024 [c]	FY2025 [c]	FY2026 [c]
Mudge Ranch	State Appropriations/ District Ad Valorem	-	$350K	$48K	$48K	$48K	-	-
C-43 West Basin Storage Reservoir	State Appropriations/ District Ad Valorem/Federal	$73.9M	$575.8M	$139.8M	$140M	$1.9M	$1.7M	$1.7M
C-43 West Basin Storage Reservoir – Water Quality Component	State Appropriations	-	$2.3M	-	$5.3M	-	-	-

a. A fiscal year begins on October 1 and continues until September 30 of the fiscal year indicated, e.g., FY2022 is October 1, 2021–September 30,2022. K – thousand and M – million.

b. Cost to Date includes FY21 and all previous years, where available. Costs include design, construction, operations, maintenance, and other contractual costs, where available. Land acquisition, monitoring, and other programmatic costs are not included.

c. Future cost estimates include all planned capital/contractual expenses plus annual O&M cost estimates (FY21 O&M costs).

West Caloosahatchee Basin-Level Monitoring

To characterize contributions to the CRE, basin-level monitoring in the West Caloosahatchee Basin is conducted at major water control structures S-78 and S-79. Monitoring results for TP, TN, and flow volumes are summarized below for the most recent 5-year period (WY2017–WY2021) in **Table 8D-21**. In addition, long-term time series are presented for flow and precipitation, TP load and FWMC, and TN load and FWMC in **Figures 8D-46** through **8D-48**, respectively.

Table 8D-21: Annual TP loads, TN loads, and total flow for WY2017 –WY2021 and 5-year averages for the West Caloosahatchee Basin.

West Caloosahatchee Basin							
Water Year	TP			TN			Flow (ac-ft)
	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	
WY2017	106.08	0.67	0.117	931.93	5.87	1.03	732.96
WY2018	218.35	1.37	0.173	1673.35	10.54	1.32	1024.76
WY2019	148.00	0.93	0.164	1222.32	7.7	1.36	730.02
WY2020	107.74	0.68	0.166	901.67	5.68	1.39	524.75
WY2021	129.29	0.81	0.130	1357.63	8.55	1.36	808.45
5-Year Avg.	**141.89**	**0.89**	**0.15**	**1217.38**	**7.67**	**1.29**	**764.19**

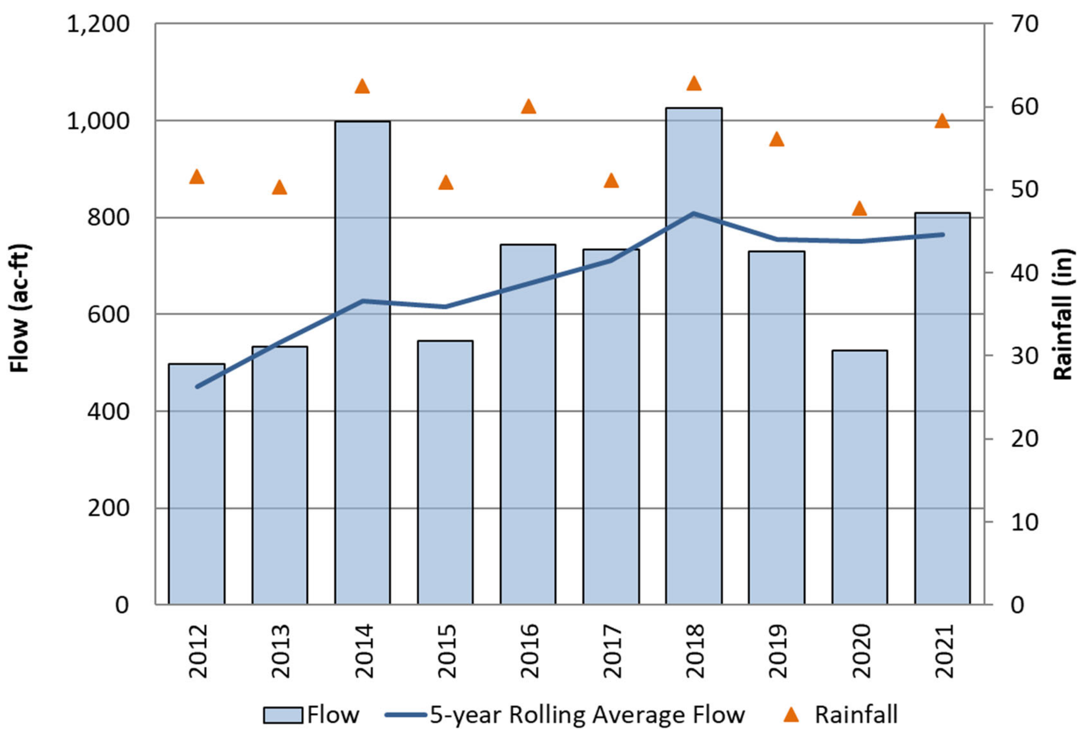

Figure 8D-46. West Caloosahatchee Basin annual flow (blue bars), 5-year rolling average flow (blue line), and total annual rainfall in inches (in; orange triangle, right axis) for WY2012–WY2021.

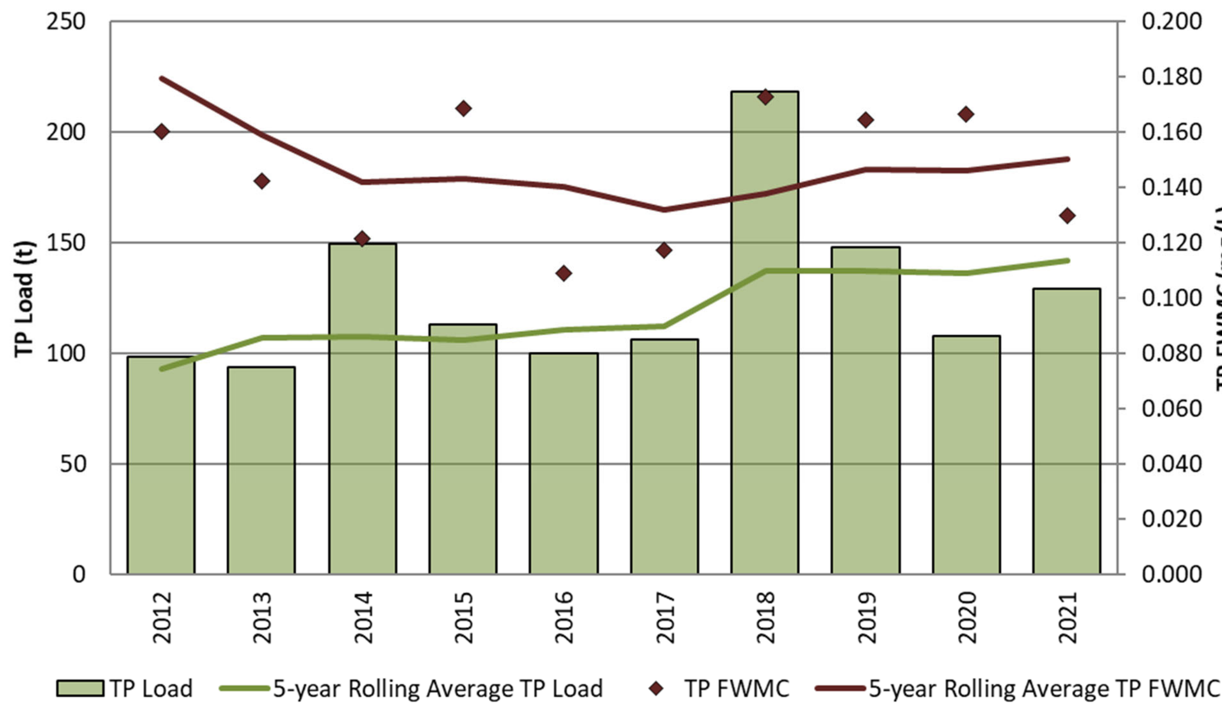

Figure 8D-47. Annual TP load (green bars) and TP FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the West Caloosahatchee Basin.

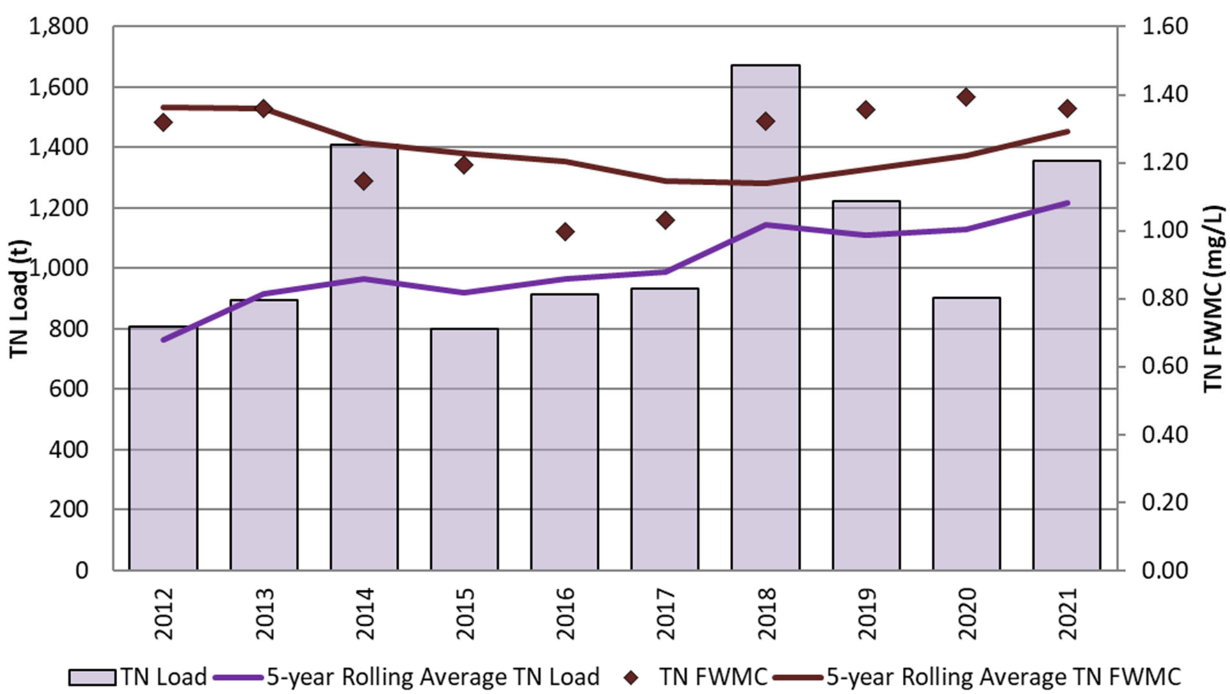

Figure 8D-48. Annual TN load (purple bars) and TN FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the West Caloosahatchee Basin.

West Caloosahatchee Upstream-Level Monitoring

The West Caloosahatchee Basin contains nine upstream monitoring sites; all of which were reinstated in WY2020 (January 2020) as part of the expanded monitoring program. Eight of these nine sites were monitored previously under synoptic water quality monitoring efforts; therefore, data for WY2015 and WY2016 are also available for review. Available upstream monitoring data are presented in more detail in Appendix 8D-1 of this volume.

West Caloosahatchee Basin Observations

For the WY2017–WY2021 period, the West Caloosahatchee Basin contributions to the CRE were generally above average in comparison to the other three CRW basins, except for below average TP and TN FWMC. The West Caloosahatchee Basin showed the highest TP load, TN load, and flow volume of the four CRW basins (**Tables 8D-11**).

Variability for both TP and TN loading generally correspond to changes in annual flow volumes with years of low nutrient loading observed during low flow conditions (e.g., WY2012) and years of high nutrient loading observed in high flow conditions (e.g., WY2014 and WY2018; **Figures 8D-46** through **8D-48**).

Construction on the C-43 Reservoir continued through FY2021, and construction completion is expected in FY2023. A feasibility study was completed in December 2020 as part of the C-43 Reservoir Water Quality Component and is now currently in design. These important projects are expected to provide significant improvements to water delivery within the CRW.

Tidal Basin Analysis

The Tidal Basin is in northern Lee County and southwestern Charlotte County. Numerous tidal creeks drain into the Tidal Basin between S-79 and Shell Point. The total drainage area of the basin is approximately 264,706 ac (107,123 ha). Land use types in the Tidal Basin are primarily natural areas (47%; 125,020 ac) and non-agricultural (38%; 101,579 ac) (**Figure 8D-49**). The only control structure located in the Tidal Basin is the S-79 gated spillway, which acts to regulate freshwater discharges to the estuary from the upstream watershed and serves as an impediment to saltwater intrusion further upstream (SFWMD et al. 2009).

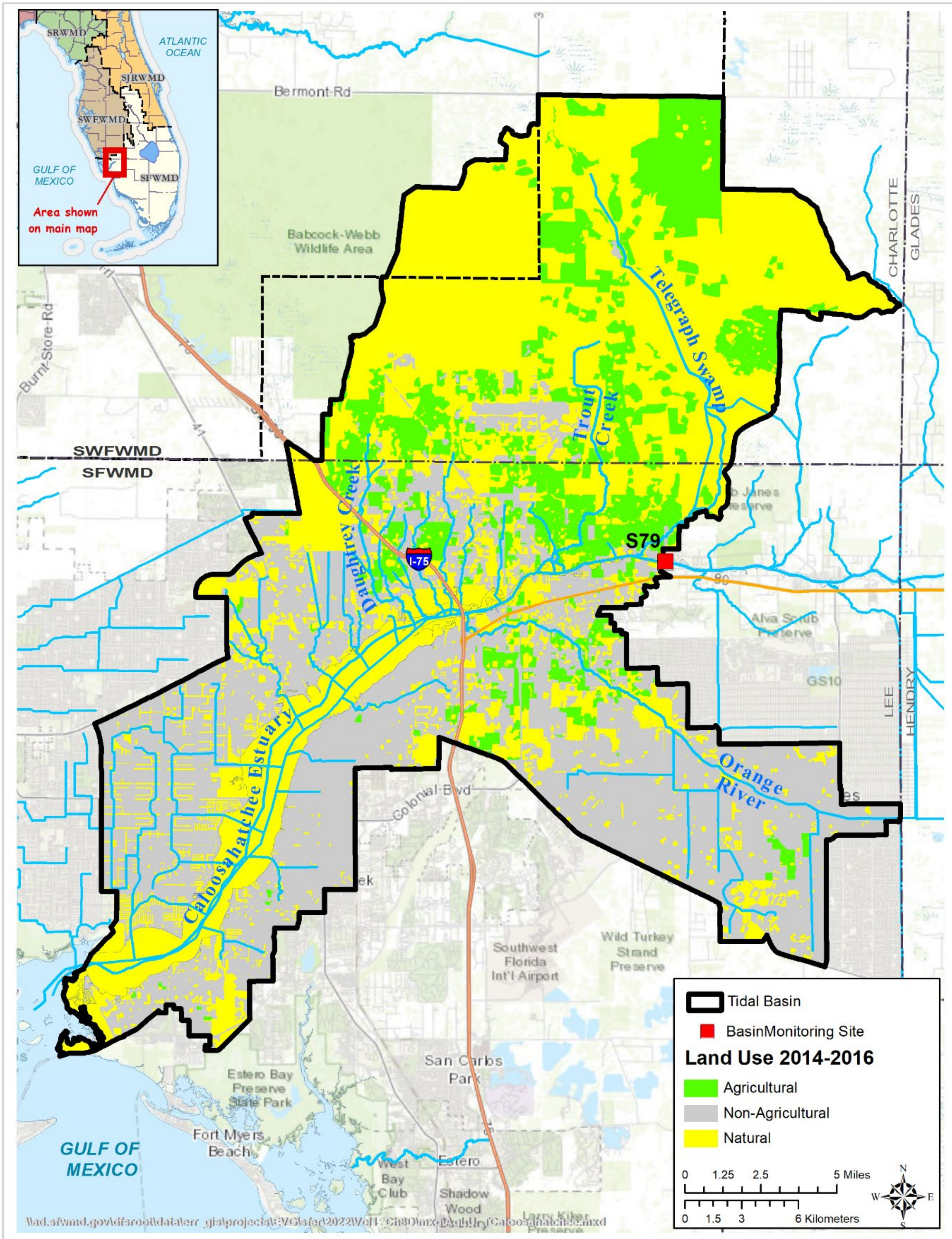

Figure 8D-49. Tidal Basin showing generalized land use and basin monitoring stations (red squares). There are no upstream monitoring stations in the Tidal Basin.

Tidal Basin-Level Monitoring

Since no major water control structures exist within the Tidal Basin, the Lin Res model is used to estimate contributions to the CRE (Wan and Konyha 2015). Modeled results for TP, TN, and flow volumes are summarized below for the most recent 5-year period (WY2017–WY2021) in **Table 8D-22**. In addition, long-term time series are presented for flow and precipitation, TP load and FWMC, and TN load and FWMC in **Figures 8D-50** through **8D-52**, respectively.

Table 8D-22. Annual TP loads, TN loads, and total flow for WY2017–WY2021 and 5-year averages for the Tidal Basin.

Tidal Caloosahatchee Basin							
Water Year	TP			TN			Flow (ac-ft)
	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	Load (t)	UAL (lbs/ac)	FWMC (mg/L)	
WY2017	38.38	0.32	0.079	392.94	3.27	0.81	392.76
WY2018	75.55	0.63	0.129	572.50	4.77	0.98	474.37
WY2019	64.60	0.54	0.111	572.27	4.77	0.98	472.45
WY2020	37.33	0.31	0.087	387.74	3.23	0.90	349.84
WY2021	49.58	0.41	0.106	486.7	4.05	1.05	377.42
5-Year Avg.	**54.33**	**0.45**	**0.10**	**510.56**	**4.25**	**0.91**	**451.98**

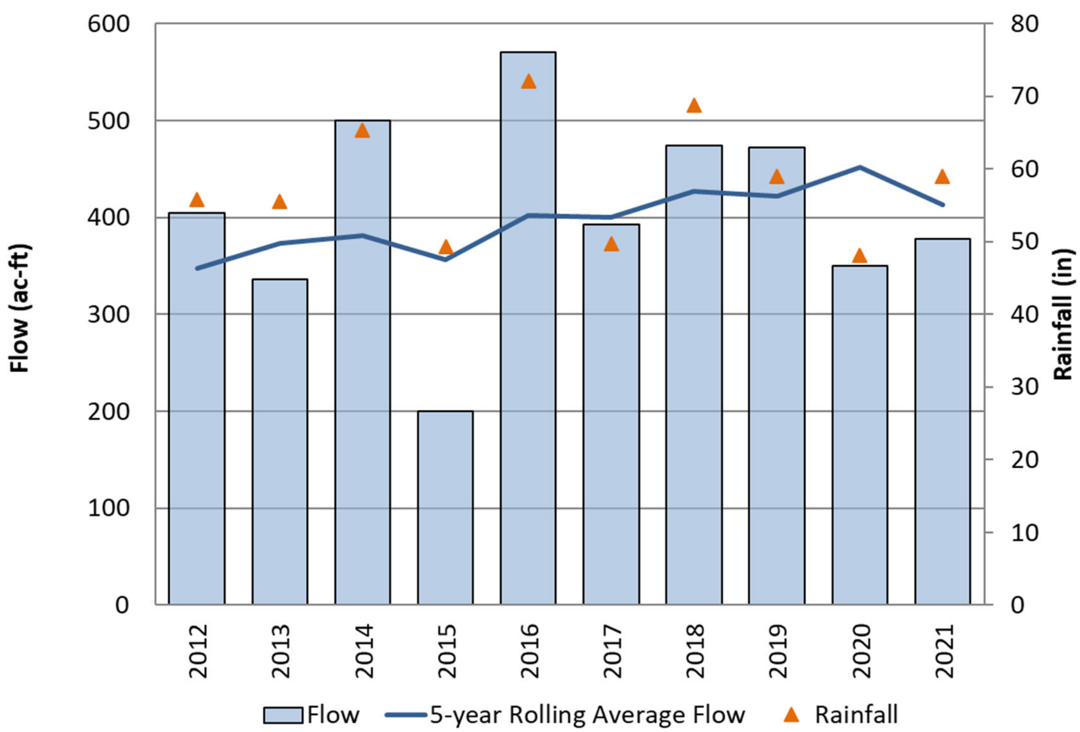

Figure 8D-50. Tidal Basin annual flow (blue bars), 5-year rolling average flow (blue line), and total annual rainfall in inches (in; orange triangles, right axis) for WY2012–WY2021.

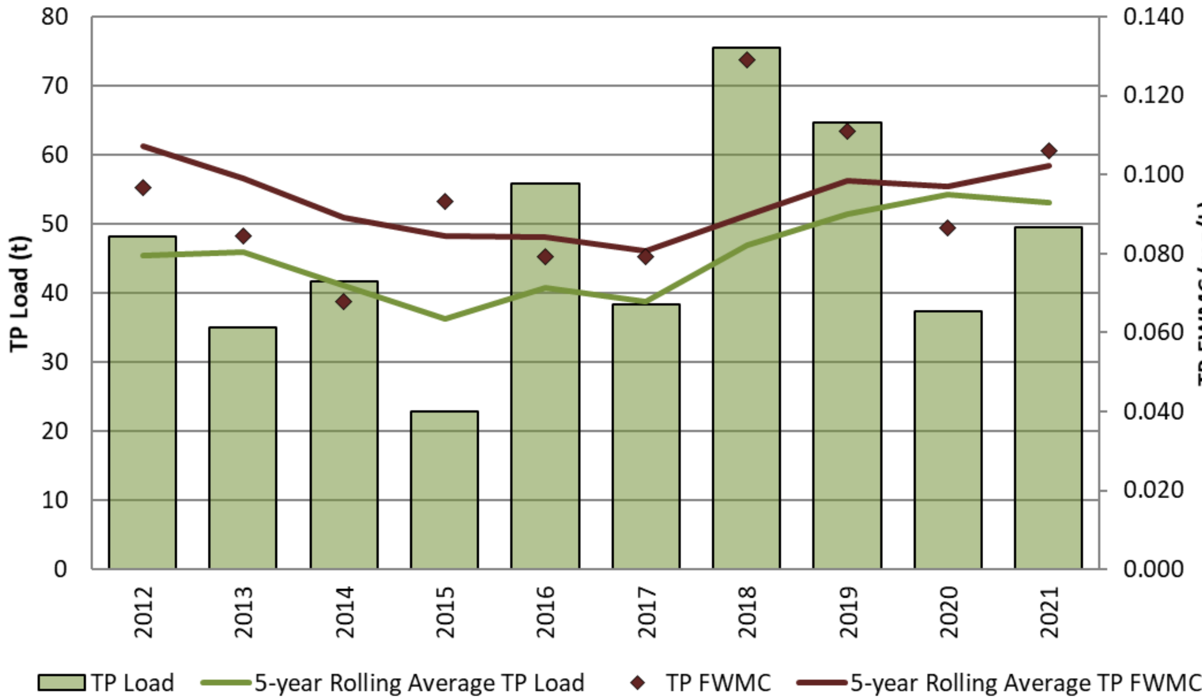

Figure 8D-51. Annual TP load (green bars) and FWMC data (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the Tidal Basin.

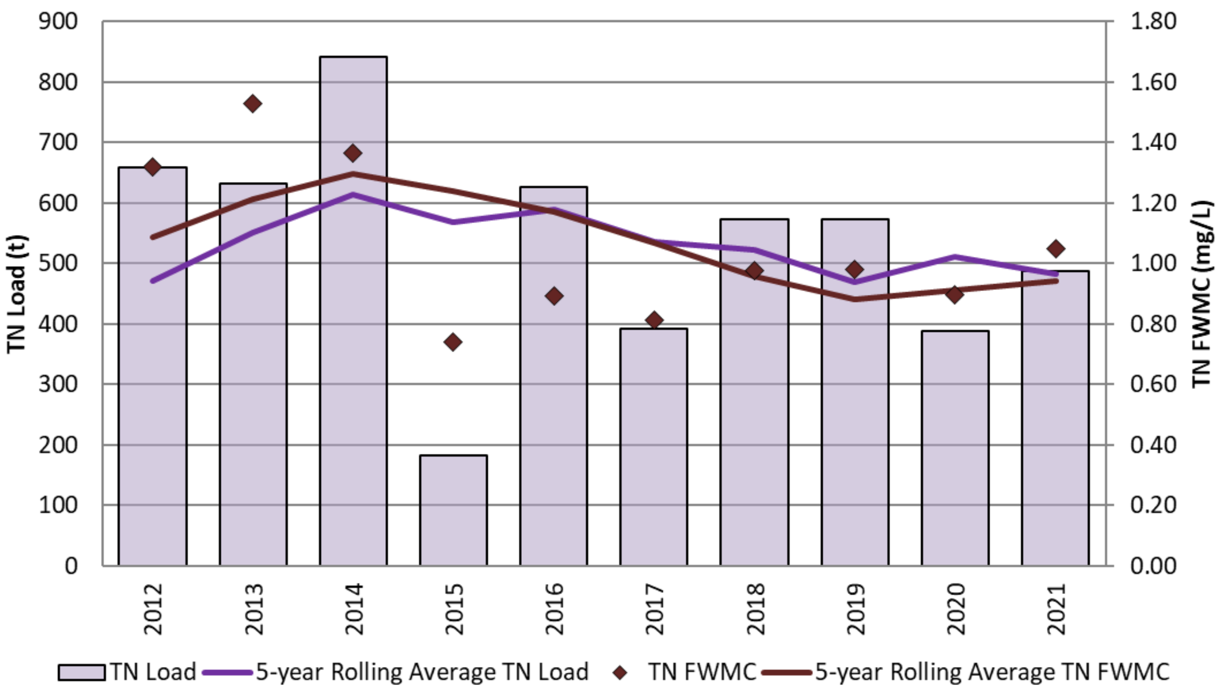

Figure 8D-52. Annual TN load (purple bars) and FWMC (brown diamonds, right axis) for WY2012–WY2021 with 5-year rolling averages for the Tidal Basin.

Tidal Basin Upstream-Level Monitoring

There are currently no SFWMD upstream water quality monitoring stations located within the Tidal Basin. Ten water quality stations located in the CRE, San Carlos Bay, and Pine Island Sound are discussed in the *Research and Water Quality Monitoring Program Part I: Caloosahatchee River Estuary* section earlier in this chapter.

Tidal Basin Observations

For the WY2017–WY2021 period, the Tidal Basin contributions to the CRE were generally below average in comparison to the other three CRW basins. The Tidal Basin showed the lowest TN and TP FWMCs and the second highest flow of the four CRW basins (**Tables 8D-11**).

The Tidal Basin exists downstream of all major water control structures, and discharges are made to directly to the CRE via numerous tributaries and discharge points. Information presented in this chapter for the Tidal Basin reflects loading estimates simulated using the Lin Res model (Wan and Konyha 2015).

Currently, no upstream monitoring stations or new SFWMD projects are planned within the Tidal Basin. Local municipalities maintain a network of monitoring stations and have documented numerous restoration projects and activities in the *Caloosahatchee River and Estuary Basin Management Action Plan* (FDEP 2020).

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