Chapter 10: St. Lucie and Caloosahatchee River Watershed Protection Plan Annual and Three-Year Updates

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SUMMARY

This chapter of the *2015 South Florida Environmental Report* (SFER) – *Volume I* focuses on two Northern Everglades estuaries, the St. Lucie and Caloosahatchee river estuaries, and their respective River Watershed Protection Plan (RWPP) updates. In accordance with the Northern Everglades and Estuaries Protection Program (NEEPP; Section 373.4595, Florida Statutes), the original RWPPs were completed and submitted to the Florida legislature in March 2009 (SFWMD et al., 2009a; 2009b) by the three coordinating agencies [South Florida Water Management District (SFWMD or District), Florida Department of Environmental Protection (FDEP), and the Florida Department of Agriculture and Consumers Services (FDACS)], with significant stakeholder input. The NEEPP requires annual progress reports and three-year evaluations of the RWPPs. This chapter fulfills both the annual and three-year reporting requirements of NEEPP for the RWPPs. The first three-year updates were submitted in March 2012 (SFWMD et al., 2012a; 2012b), and this chapter is the second three-year update for both of the RWPPs.

This report primarily focuses on watershed activities (e.g., construction projects), the latest scientific results from the research and water quality monitoring program, and the coordinating agencies' strategies moving forward. Overall, several strategies are discussed with a system-wide perspective in terms of restoring ecosystems that are currently within the influence of the Central and South Florida Flood Control Project. Key to these strategies are the FDEP Basin Management Action Plans (BMAPs), which are the blueprint to meet FDEP's Total Maximum Daily Loads (TMDLs) and are the overarching water quality restoration plans for the Northern

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Everglades. Therefore, water quality projects and monitoring information provided in this document may be used by the FDEP to augment future BMAP annual updates and additional BMAP phases. In addition, the RWPPs provide important information and scientific evaluation of freshwater inflow and its influence on both estuaries' salinity regimes and ecology. A status report on the coordinating agencies' regional projects and initiatives that will benefit the freshwater inflow and salinity regimes of both estuaries is also provided. The *Strategies Moving Forward* section of this chapter also includes recommendations and legislative response to the Florida Senate Indian River Lagoon Lake Okeechobee (IRLLOB) Select Committee in 2014.

ST. LUCIE ESTUARY LOCATION, BOUNDARY AND LAND USE

Located in southeastern Florida in Martin and St. Lucie counties, the St. Lucie Estuary (SLE) is a major tributary to the Southern Indian River Lagoon (SIRL) (Sime, 2005; Ji et al., 2007; Buzzelli et al., 2012). To accommodate population growth and coastal development, the St. Lucie River Watershed has been highly altered from natural sloughs and wetlands into a system of sub-basins, which make up eight sub-watersheds. The boundaries of the watershed and its sub-watersheds have been updated in this report, with the overall acreage increasing from 529,194 acres to 537,805 acres. Based on the 2009 Florida Land Cover Classification System (FLUCCS) Level 1 land use, the top three land uses in the watershed are agriculture (53.9 percent), urban and built up (19.1 percent), and wetlands (10.9 percent).

Pollutant Source Control Program

Some important pollutant source control milestones include continued enrollment of agricultural lands in the FDACS Agricultural BMP program and the SFWMD's continued development of supporting documentation for a regulatory source control program in the Northern Everglades consistent with the FDEP BMAP strategies (see Chapter 4 of this volume). Efforts included optimization of the monitoring network by collection of stream gauging flow measurements for St. Lucie tributary stations that concluded in WY2014.

Watershed Efforts

The St. Lucie River and Estuary Basin BMAP was adopted in June 2013 (FDEP et al., 2013), following completion of a stakeholder-driven process that was focused on identifying projects that have been constructed since 2000 or are planned to be built within the first five years after BMAP adoption (June 2013–June 2018). Overall, the first five-year iteration is expected to reach 30 percent of the required adopted TMDL reductions for total phosphorus (TP) and total nitrogen (TN) by 2018 based on projects submitted by responsible stakeholders (17 entities). The FDEP recently held the first annual BMAP update (August 2014), and stakeholders made good progress over the first year in implementing their projects and initiatives. Projects completed during the first reporting period achieved over 50,000 pounds of TN reduction and nearly 280 pounds of TP reduction. A copy of the BMAP and its first year update are available on the FDEP's website at http://www.dep.state.fl.us/water/watersheds/bmap.htm.

The coordinating agencies' regional and sub-regional projects are critical to achieving the water quality and storage goals of the St. Lucie River Watershed Protection Plan (SLRWPP). Several important milestones for the Comprehensive Everglades Restoration Plan (CERP) Indian River Lagoon South – C-44 Reservoir/STA Project were realized since the 2012 SLRWPP Update. Importantly, the SFWMD and U.S. Army Corps of Engineers (USACE) amended the Project Partnership Agreement to allow the SFWMD to construct the STA at a faster schedule than previously planned. The State of Florida has appropriated more than $60 million over the last two years to implement the STA construction that is planned to start in October 2014 and be completed by March 2017. In August 2014, the District's

Governing Board continued that process by awarding a contract for construction of a spillway that will serve as the single point of water movement out of the entire C-44 project (http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/nr_2014-0814_c44_discharge.pdf). Also, in August 2014 the U.S. Army Corps of Engineers (USACE) completed its Contract 1 construction phase.

The District's Dispersed Water Management (DWM) Program is a multifaceted approach to working cooperatively with public and private land owners to identify, plan, and implement mechanisms to retain or store water. In the St. Lucie watershed, three Water Farming Payment for Environmental Services (WF-PES) pilot projects were started in 2013–2014 with the assistance of Clean Water Act Section 319(h) funds that the FDEP administers. The State of Florida also appropriated additional funding to continue NE-PES projects throughout the Northern Everglades. The storage, retention, and detention created by projects within the DWM Program since 2005 will be approximately 93,202 acre-feet (ac-ft).

Watershed Research and Water Quality Monitoring Program

Rainfall during Water Year 2014 (WY2014) (May 1, 2013–April 30, 2014) at times was near historical levels in South Florida, including the wettest start to the wet season since 1968 (see http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/nr_2013_0802_july_rainfall.pdf). The District also reported the wettest April–July period on record in South Florida since 1932. Many results from the Research and Water Quality Monitoring Program are a reflection of these high levels of rainfall. In WY2014, for example, the total annual rainfall in the St. Lucie Watershed exceeded the long-term (WY1997–WY2014) average (48.9 inches) due to greater precipitation in both the dry and wet seasons. This in turn led to total freshwater inflows to the estuary, which exceeded the long-term average (by approximately 400,000 ac-ft), with 70 percent from the St. Lucie Watershed and 30 percent from Lake Okeechobee. Salinity typically displays an inverse relationship to freshwater inflow in estuaries, while nutrient loading typically displays a direct relationship, which was evident in WY2014. Salinity was particularly low during the wet season when rainfall and inflows were relatively high. TP and TN loading in WY2014 was noticeably higher than for the long-term average and the last two water years (WY2012 and WY2013), with 81 percent of the TP load and 69 percent of the TN load coming from the St. Lucie Watershed.

During WY2014, annual and seasonal concentrations of TN within the SLE were lower than the long-term average, while annual and seasonal concentrations of TP were equal to or lower than long-term averages, respectively. The FDEP's TMDL for the TN target concentration of 0.72 milligrams per liter (mg/L) and the TMDL TP target of 0.081 mg/L were exceeded at the two estuarine sites where the targets are applicable. These annual exceedances were typically caused by increased TN and TP values observed in the wet season. There were significant intra- and inter-annual variations in water column chlorophyll *a* (Chl-*a*) concentrations (a pigment reflective of phytoplankton biomass) among the three monitoring locations from WY1997–WY2014. Chl-*a* concentrations at an upper estuarine site were comparable to or greater that the long-term average, but were lower than the long-term average at the Roosevelt Bridge and near the estuary mouth concentrations during WY2012–WY2014.

The occurrences of different species of submerged aquatic vegetation (SAV) fluctuated with salinity at Willoughby Creek within the lower SLE from WY2007–WY2014. Live oyster density was low (31 oysters/m^2) in December 2013, following extreme freshwater inflow and depressed salinity in July–October 2013. Larval supply appears sufficient to support a natural recovery. Both the prevalence and intensity of Dermo, a marine parasite, were suppressed with increased freshwater inflow in September–November 2013.

CALOOSAHATCHEE RIVER ESTUARY LOCATION, BOUNDARY AND LAND USE

The Caloosahatchee River Watershed is located on the lower west coast of Florida in Lee, Charlotte, Collier, Glades, and Hendry counties (Barnes, 2005). The Caloosahatchee River and Estuary have been altered by human activities starting in the 1880s when the river was straightened and deepened losing 76 river bends and 13.2 kilometers (km) of length (Antonini et al., 2002). The Caloosahatchee River Watershed Protection Plan (CRWPP) study area includes the areas that drain to the mouth of the Caloosahatchee River and the associated offshore estuarine area, and comprises five sub-watersheds, totaling 1,090,381 acres, with the same boundaries as reported in the 2012 CRWPP Update (SFMWD et. al, 2012b). Similar to the St. Lucie Watershed, based on the 2009 FLUCCS Level 1 land use, the top three ranked land uses are agriculture (34.6 percent), urban and built up (18.5 percent), and wetlands (15.9 percent).

Pollutant Source Control Program

Some important pollutant source control milestones include continued enrollment of agricultural lands in the FDACS Agricultural BMP program and SFWMD's continued development of supporting documentation for a regulatory source control program in the Northern Everglades consistent with FDEP BMAP strategies (see Chapter 4 of this volume). Through improvements and additions to existing water quality monitoring networks, additional monitoring is now being performed in the East and West Caloosahatchee sub-watersheds for two additional water years.

Watershed Efforts

The Caloosahatchee Estuary Basin BMAP was adopted in November 2012 (FDEP et al., 2013), following completion of a stakeholder driven processes that was focused on identifying projects that had been constructed since 2000 or are planned to be built within the first five years after BMAP adoption (November 2012–November 2017). Overall, the first five-year iteration is expected to reach approximately 40 percent of the required reductions for TN by 2017 based on projects submitted by stakeholders (17 entities). The FDEP recently held the one-year BMAP update (February 2014), and stakeholders have made good progress over the first year of the BMAP in implementing their projects and initiatives. A copy of the BMAP and its first year update are available on the FDEP's website at http://www.dep.state.fl.us/water/watersheds/bmap.htm.

The coordinating agencies' regional and sub-regional projects are also critical to achieving the water quality and storage goals of the CRWPP. Several important milestones for the CERP Caloosahatchee River (C-43) West Basin Storage Reservoir Project include federal authorization of the project with the 2014 Water Resources Reform and Development Act. In 2014, the State of Florida appropriated $18 million to design and construct a C-43 Early Start Project, which would have provided interim water storage on-site until the full reservoir could be completed. The state is now planning to move forward to complete Phase I of the full C-43 Reservoir Project by 2019. Other regional project highlights include the implementation of Phase I of the C-43 Water Quality Treatment and Testing Facility Project's including bioassays and mesocosms to test and optimize wetland treatment that began in fall 2014. In addition, the SFWMD anticipates that final engineering design will be completed for the Lake Hicpochee Hydrologic Enhancement Project in 2015 and, recently in June 2014, 640 acres of strategic land was acquired for use as part of an important shallow water storage feature. Finally, in the Caloosahatchee Watershed, several DWM storage projects on public lands have occurred over the last two years as well as some on private lands. As previously mentioned, the NE-PES Program has also received additional state funding to increase number of projects.

Watershed Research and Water Quality Monitoring Program

As noted above, rainfall during WY2014 in South Florida was at times near historical levels including the wettest start to the wet season since 1968, and the wettest April–July POR in South Florida since 1932 was reported. Many results from the research and water quality monitoring program are a reflection of these high levels of rain. In WY2014, for example, the total annual rainfall in the Caloosahatchee Watershed exceeded the long-term (WY1997–WY2014) average (51.5 inches) due to greater precipitation in both the dry and wet seasons. This in turn led to total freshwater inflows to the Caloosahatchee River Estuary (CRE), which greatly exceeded the long-term average (by approximately 1.3 million ac-ft) and the previous two water years (WY2012 and WY2013). 62 percent of inflow in WY1014 was from the Caloosahatchee Watershed and 38 percent from the Lake Okeechobee. Salinity typically displays an inverse relationship to freshwater inflow in estuaries while nutrient loading typically displays a direct relationship, which was evident in WY2014. Salinity was particularly low during wet season when rainfall and inflows were high. The long-term averages (WY1997–WY2014) for total annual TN and TP loading were 2,952.4 and 282.1 mt, respectively, with 33.9 percent of the TN and 22.8 percent of the TP derived from Lake Okeechobee, 51.5 percent (TN) and 60.4 percent (TP) derived from the Caloosahatchee sub-watersheds, and 14.6 percent (TN) and 16.7 percent (TP) from the Tidal Basin. The percent contributions from Lake Okeechobee, the sub-watersheds, and the Tidal Basin were similar to the long-term average in WY2014.

TN concentrations in the CRE varied spatially, with the highest levels in the upper estuary sites, medium values in the middle estuary, and lowest at the lowest estuarine site closest to the mouth of the estuary. This can be attributed in part to physical (transport out of the estuary) and biological (internal recycling and phytoplankton removal) mechanisms. For TP, the upper and mid estuaries generally had the same concentrations, while the lower estuary had slightly lower values than the rest of the system. Overall, TP tends to exhibit different patterns than TN in the CRE because biogeochemical cycling and metabolism in this area are believed to be relatively insensitive to intra-annual variations in external phosphorus loading. Chl-*a* concentrations in the CRE did not correspond well to freshwater inflow. However, concentrations in the upper estuary were highest during the dry season when flows are lowest. The highest Chl-*a* concentrations were observed at the most upstream site near S-79 during the drought of WY2012. Average Chl-*a* values were lower than the long-term averages throughout the CRE in the wet seasons of WY2013 and WY2014.

While there were some observable patterns for the SAV community coincidental with freshwater inflow from WY2009–WY2014, other factors appeared to be influencing SAV species occurrence. In general larger numbers species were found at the more freshwater and marine stations, and few species were found at the stations in between. There were intra- and inter-annual variations for the indicators of oyster habitat at Bird Island in the lower CRE. There were no obvious relationships between oyster density and the average salinity of the lower CRE at the Bird Island site. Further upstream at the Iona Cove site, oysters were virtually eliminated during the wet season of WY2014. Although a large percentage of the oysters were infected with Dermo, the level or intensity of the infection was generally low.

INTRODUCTION

The St. Lucie and Caloosahatchee River Watersheds and Estuaries are located on the southern peninsula of Florida. Together with the Lake Okeechobee Watershed, they represent major overall region known as the Northern Everglades (see **Figure 10-1**). The St. Lucie watershed lies to the east of Lake Okeechobee and the Caloosahatchee Watershed to the west. Overall, the Northern Everglades is a highly modified system as it is part of the larger overall Central and South Florida Project (see *Background* section below). Importantly, the western part of the St. Lucie Watershed (C-44/S-153) and the eastern portion of the Caloosahatchee Watershed (C-43 East) have the ability to drain two ways, either into Lake Okeechobee or into their respective estuaries.

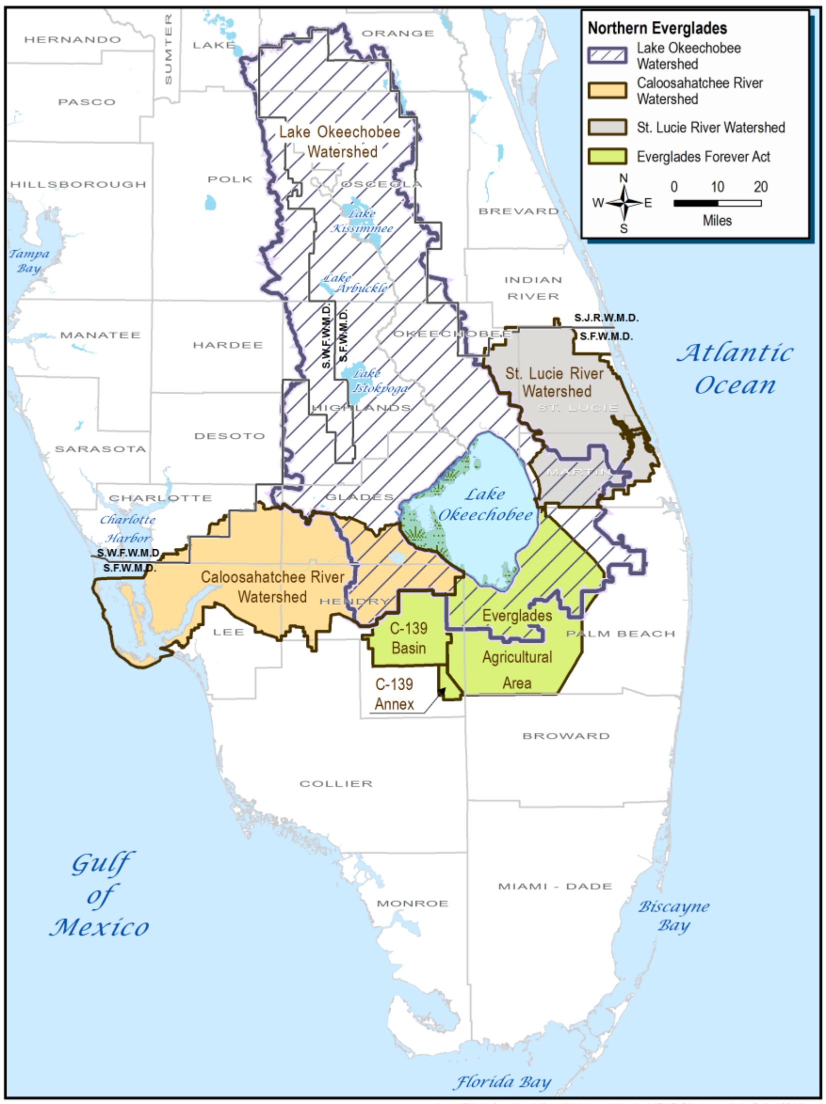

Figure 10-1. The Northern Everglades watersheds – Lake Okeechobee, St. Lucie River, and Caloosahatchee River.

In 2007, the Northern Everglades and Estuaries Protection Program (NEEPP) was authorized under Section 373.4595, Florida Statutes (F.S.), in response to legislative findings that the Lake Okeechobee, Caloosahatchee River, and St. Lucie River watersheds are critical water resources that have been and continue to be adversely affected from changes to hydrology and water quality. The NEEPP legislation specifically called for the development of the three northern watershed protection plans: Lake Okeechobee, St. Lucie River, and Caloosahatchee River.

The St. Lucie River Watershed Protection Plan (SLRWPP; SFWMD et al., 2009a) and the Caloosahatchee River Watershed Protection Plan (CRWPP; SFWMD et al., 2009b) were developed in order to minimize the undesirable freshwater inputs and improve the quality of water delivered to each estuary through implementation of the three major elements specified by the NEEPP: the Construction Project, the Pollutant Control Program, and Research and Water Quality Monitoring Program (RWQMP). The South Florida Water Management District (SFWMD or District), the Florida Department of Environmental Protection (FDEP), and the Florida Department of Agriculture and Consumer Services (FDACS), collectively known as the coordinating agencies, developed the SLRWPP and CRWPP with extensive stakeholder input. The coordinating agencies are jointly responsible for implementing NEEPP and the Protection Plans. Each coordinating agency has specific areas of responsibility consistent with each agency's statutory authority and responsibility which includes implementation of urban and agricultural BMP programs, identification and implementation of water quality and quantity projects, reporting, evaluating on ecological conditions, evaluating water quality data, implementing applicable rules and maintaining a monitoring network.

In accordance with the NEEPP, the RWPPs additional evaluations must be performed every three years. In 2012, both the first SLRWPP and CRWPP Updates were included as part of the annual South Florida Environmental Report (SFER) – Volume I (SFWMD et al., 2012a; 2012b). This chapter fulfills the annual progress report and three year evaluations for NEEPP. This report starts with a description of the overall system, the estuaries, and the river watersheds to set the stage for the rest of the chapter. Updates to the Pollutant Source Control Program and the Construction Project highlight the coordinating agencies' efforts to improve the quality, quantity, timing, and delivery of water to the estuaries. Then a summary of the conditions of the hydrology, water quality, and aquatic habitat based on results of the Research and Water Quality Monitoring Programs, as required by Section 373.4595(6), F.S is provided. This is followed by the condition of two ecological indicators—oysters and submerged aquatic vegetation (SAV)—in both estuaries. The final section outlines the coordinating agencies' future strategies for continued watershed and in-estuary restoration activities.

BACKGROUND

EVERGLADES PAST AND PRESENT

Historical Everglades – Pre-Drainage

The Kissimmee-Okeechobee-Everglades (K-O-E) system extends from the headwaters of the Kissimmee River in the north to Florida Bay in the south (**Figure 10-2**). This system, which includes the Kissimmee Valley, Lake Okeechobee, and the Southern Everglades, was once a free-flowing system. At its north end, the Kissimmee Watershed formed the headwaters of the K-O-E system. The Kissimmee Watershed meandered for 103 miles through Central Florida and encompassed a diverse group of wetland and aquatic ecosystems, including more than two dozen lakes, their tributary streams, and the Kissimmee River. The Kissimmee's floodplain, reaching up to 3 miles wide, was inundated for long periods by heavy seasonal rains and was a place where wetland plants, wading birds, and fish thrived.

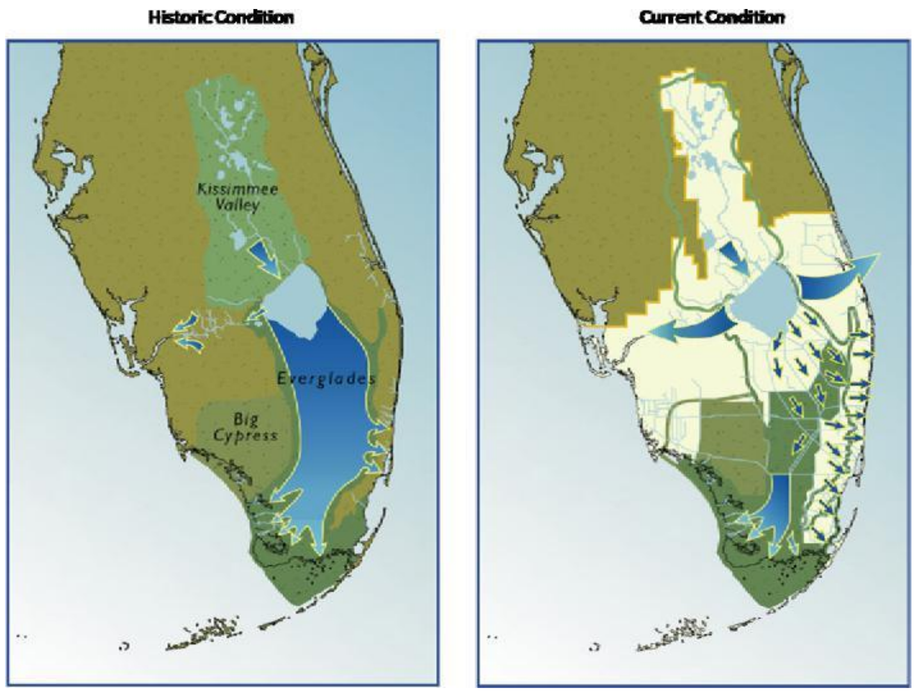

Figure 10-2. Historical and current hydrologic flow patterns.

Lake Okeechobee's name means "big water" in the Seminole language. It had a large littoral (wetland) zone that extended from the Kissimmee River to the Florida Everglades, and a pelagic (open-water) zone much larger and deeper than that observed today. During periods of high rainfall, the littoral zone expanded to the west. The natural systems of the Kissimmee Valley, which stored water following rain events, moderated water flows into Lake Okeechobee that sometimes continued for long periods following the rainfall. Lake Okeechobee likely supported dense beds of submerged plants with nesting and feeding habitat for fish and wildlife. The lake was a direct source of water to the Southern Everglades by two means. First, water was released from the lake through a series of small tributaries at the lake's southern end. Second, when water levels in the lake exceeded the height of a natural peat berm that existed along the lake's southern rim, water would enter into the Southern Everglades. Additionally, a small volume of lake water escaped through the Caloosahatchee River and into the Caloosahatchee Estuary.

The Southern Everglades portion of the K-O-E system was a relatively flat landscape prior to drainage, with a drop in elevation from 20 feet above sea level near the south shore of Lake Okeechobee to sea level over a distance of 100 miles (Tetra Tech, Inc. 2000). Water from the lake flowed slowly through this flat landscape, buffered by a dense expanse of marsh overwhelmingly dominated with sawgrass (*Cladium jamaicense*)—this landscape was referred to as the sawgrass plains. The typical hydroperiod of an Everglades sawgrass marsh is 9 to 10 months when water levels are above the ground surface with an annual range of less than 6 months to continuously flooded (Lodge, 2005). This hydroperiod was likely consistent with the Everglades sawgrass plains.

Water then flowed through the Everglades ridge and slough landscape, a series of sloughs and sawgrass ridges with tree islands whose orientation followed the direction of water flows. Sloughs in this landscape were continuously flooded while the tree islands were almost always above the water surface. Some water exited the ridge and slough landscape into Biscayne Bay on

Florida's southeastern coast, but the majority of water flowed through Shark River Slough and Taylor Slough, over marl wetlands and eventually into Florida Bay.

Evaporation and rainfall in the Southern Everglades during the summer months, was also a contributing factor in hydrology. As surface water evaporated into the atmosphere via evapotranspiration (ET), it was frequently deposited to other areas of the Everglades in the form of rainfall.

Current Everglades – Post-Drainage

Significant drainage modifications to the Everglades system have been made to accommodate agricultural and urban growth. The post-drainage conditions have substantially impacted the quantity, quality, timing and distribution of water deliveries throughout the K-O-E system. Today, the extent and hydrology of the Everglades differs drastically from the pre-drainage Everglades (**Figure 10-2**. The Everglades once covered almost 11,000 square miles of South Florida. Because of efforts to drain the marshland for agriculture, development and flood control, the Everglades is now half the size it was a century ago. In the past century, significant development has occurred within the region, allowing tremendous population and economic growth. This growth also contributed to unintended consequences including loss of 50 percent of wetlands and floodplains (Chimney and Goforth, 2001), disrupted timing of water flows, deterioration of water quality, reductions in wading birds, declining lake and estuary health, and loss of native habitat to exotic species.

The earliest modifications to the South Florida landscape were constructed in the 1880s by Hamilton Disston with the dredging of the Caloosahatchee River and the creation of drainage canals in the Kissimmee Upper Chain of Lakes. The dredging was conducted in order to drain the land to facilitate agricultural production and urban development. The C-44 Canal and the associated locks and structures were constructed between 1916 and 1928. This canal provided a navigable connection between the east and west coasts of Florida. It connects Lake Okeechobee to the south fork of the St. Lucie River and makes the St. Lucie Estuary one of the major outlets for water draining from the Upper Kissimmee and Lake Okeechobee basins.

The first efforts to contain Lake Okeechobee involved construction of a low levee and three drainage canals running south from Lake Okeechobee, the Miami, North New River, and Hillsborough canals between 1913 and 1917. In 1930, during the aftermath of the infamous Storm of 1928 which pushed water out of the shallow lake and drowned thousands of people, the federal government authorized the USACE to build the Herbert Hoover Dike. Over the next seven years, the USACE built a series of levees, culverts, and locks to contain the lake, including 67 miles of dikes along the southern shore. In 1938, the USACE began to regulate lake levels, and lake inflows and outflows were altered to include structures and channelization to more effectively move water in and out of the lake. Modifications to the outlets on the east and the west sides of the lake made the St. Lucie and Caloosahatchee rivers the primary outlets from the lake.

However, due to a series of back-to-back hurricanes in 1946 and 1947 and resulting significant flooding in South Florida, the need for additional features to manage excess water became evident. In response to these conditions, the State of Florida requested assistance from the federal government. As a result of that request, the Central and Southern Florida Flood Control Project (C&SF Project) was authorized by the U.S. Congress in 1948. Subsequently, the USACE produced a comprehensive water management plan that became the blueprint for the C&SF Project. It is a multi-purpose project, but flood control was the driving force in its design. The desire was to get the water off the land quickly and shunted to tide to allow for urban and agricultural development. It took approximately 20 years to implement the project features, canals, levees, pump stations, and other structures that were built in the 1950s and 1960s. The channelization of the Kissimmee River was completed in 1971.

The key drainage features of the C&SF Project begin in the north with the creation of hydrologic connections and management of lake levels in the Kissimmee Chain of Lakes to provide drainage for the urban/suburban areas around and north of Lake Kissimmee. The Kissimmee Basin (KB) portion of the C&SF Project was constructed between 1960 and 1971. Between 1962 and 1971, the meandering Kissimmee River was channelized and transformed into a 56 mile (90 kilometer) long by 30 foot (9 meter) deep canal, varying in width from 90 to 300 feet (27 to 91 meters) and regulated by a series of six water control structures (S-65, S-65A, S-65B, S-65C, S-65D, and S-65E) (USACE, 1992). The Kissimmee Chain of Lakes project features were constructed between 1964 and 1970 and included dredging of canals between lakes and installation of nine water control structures (S-57, S-58, S-59, S-60, S-61, S-62, S-63, S-63A, and S-65) to regulate lake water levels and outflow (USACE, 1992). Several of Disston's original canals between the lakes were enlarged and new canals were dredged to connect Alligator Lake with Lake Gentry and to connect Lake Gentry with Lake Cypress. Currently, water control structures throughout the KB are operated in accordance with criteria codified in the USACE Water Control Manual for Kissimmee River – Lake Istokpoga Basin (USACE, 1994). The operating criteria for the KB define seasonal and monthly water level limits required to meet the flood protection, water supply, recreational, and environmental objectives of the C&SF Project.

To accommodate the increase in volume and the speed with which water now moved south from the Kissimmee, modifications to the outlet structures from Lake Okeechobee diverted upwards of 85 percent of the discharge flows to the Caloosahatchee and St. Lucie estuaries. The outlets to the south of the lake were constrained by the drainage requirements of the Everglades Agricultural Area (EAA). In addition, the system was designed to bring excess stormwater from the northern half of the EAA back to the lake through pump stations S-2, S-3, and S-4 on the southern rim of the lake. Management of Lake Okeechobee is regulated by a schedule developed by the USACE and approved through the National Environmental Policy Act (NEPA) procedures.

The 2014 System Status Report (RECOVER, 2014) details much of the alterations and effect on lake stage:

> Since the natural shoreline, inflow, drainage and outflow of Lake Okeechobee was altered by the construction of the Herbert Hoover Dike and associated water control structures, water levels within the lake likely fluctuate with increased frequency and amplitude. The increase in lake stage fluctuations and amplitude occurs for several reasons: (1) the connection between the natural northern and western watershed flood plains has been severed, (2) the lake receives large volumes of channelized flow from the northern and western watershed regions, (3) there were probably no channelized flows to the south prior to the dike, water exited to the south as sheet flow, and (4) since dike completion, the lake has been managed primarily for water supply and flood control but also for navigation, regional groundwater recharge, recreational activities and ecological enhancement purposes. When rainfall is above normal in the watershed north and west of the lake, inflows can greatly exceed the ability to release water from the lake. This periodic flow imbalance has resulted in periods when lake stages exceed the stage envelope considered to be ecologically beneficial (12.5 feet–15.5 feet National Geodetic Vertical Datum of 1929 [NGVD]) (Havens 2002). Conversely, during periods of drought conditions, the combination of normal evapotranspiration and withdrawals from the lake for urban groundwater recharge and crop irrigation can lower lake stages to ecologically damaging levels (< 12 feet NGVD) as well.

Approximately 700,000 acres south of Lake Okeechobee has been designated as the EAA. The construction of the C&SF Project included the planning, design, and construction of levees and drainage improvements to provide both flood control and water supply to this area. A protective levee runs from northwest Palm Beach County south of Miami-Dade County.

The Water Conservation Areas (WCAs) are located between the EAA and the east coast levee. They consist of five surface water management areas covering approximately 1,372 square miles. These areas of the Everglades were set aside for several purposes—to provide water storage, act as seepage barriers to protect urban development along the east coast, recharge regional groundwater and prevent saltwater intrusion, offer recreational opportunities, and serve as habitat for fish and wildlife. The WCAs are also operated according to regulation schedules developed by the USACE. These schedules are designed to provide both water supply and flood control for the lower east coast of Florida. The combination of the EAA and WCAs has resulted in both a decrease in areal extent of the remaining Everglades and reduced water storage due to the need for flood protection and compartmentalization of the ecosystem.

As a result of these hydrologic modifications, the natural storage & buffering capacity of the system has been severely reduced. Under post-drainage conditions runoff from the KB reaches Lake Okeechobee much sooner and in larger volumes. As a result, water levels in Lake Okeechobee can rise substantially in short periods of time. The lake can also experience extreme low water fluctuations during times of drought. Water levels occur outside desirable ranges either too high or too low with rapid, and sometimes extreme, water level fluctuations. Both can have ecological consequences; however, with the implementation of the 2008 LORS there has been a decrease in high water fluctuations, which appear to be the most damaging to the system. Sometimes, as was the case in WY2014, there is a need to release large discharges from the lake to the estuaries. Also as a result of drainage canals and development in the river watersheds, the volumes and timing from local runoff were also changed in a similar way.

The once abundant fringing wetlands and shallow flats, water column and benthos, SAV, and oyster reefs indicative of South Florida estuaries provide essential habitat for many valuable faunal populations (Tolley et al., 2006; Rozas and Minello, 2006; Rozas et al., 2012). The distribution and status of these valuable ecosystem components are modulated by complex combinations of climate and weather, freshwater inflow, and estuarine circulation (Childers et al., 2006; Phlips et al., 2011; Buzzelli, 2011).

ST. LUCIE AND CALOOSAHATCHEE ESTUARIES

Located in southeastern Florida in Martin and St. Lucie counties, the SLE comprises a major tributary to the Southern Indian River Lagoon (SIRL) (Sime, 2005; Ji et al., 2007; Buzzelli et al., 2012; **Figure 10-1**). Historically, the SLE was a freshwater system exposed to the coastal ocean only through ephemeral passes in the barrier islands. The St. Lucie Inlet was permanently opened in 1892 to provide a connection between the SLE and coastal ocean. The C-44 Canal linking Lake Okeechobee to the South Fork of the SLE was completed in 1924. The SLE is now a partially mixed micro-tidal estuary having a semi-diurnal tide with amplitude of 0.38 meters (m). The SLE is geographically divided into four distinct segments: North Fork, South Fork, middle estuary, and lower estuary near the St. Lucie Inlet. Total surface area of the estuary is 29 square kilometers (km^2; 2,900 hectares, or ha) with an average depth of 2.4 m (Buzzelli et al., 2013b). The flushing time of the SLE ranges from 2 to 20 days (Ji et al., 2007).

To accommodate population growth and coastal development, the St. Lucie River Watershed has been highly altered from natural sloughs and wetlands into a system of sub-basins, which make up the eight sub-watersheds of the St. Lucie River Watershed. The SLE receives drainage from a comparatively large area, as the ratio between watershed area and SLE surface area is approximately 150:1 (i.e., Tampa Bay has a ratio of 5.5:1). Changes in flow and resultant variations in salinity and water quality are associated with habitat loss, decreased biodiversity, and increased prevalence of marine diseases within the estuary (Sime, 2005; SFWMD et al., 2012a). Connections to and drainage from the watershed and Lake Okeechobee have led to extreme freshwater inflow, phytoplankton blooms, accumulation of flocculent muck-like sediments, severe loss of seagrass habitat, and a dramatic decline in the extent of oyster beds within the SLE (Wilson et al., 2005).

The Caloosahatchee River Watershed is located on the lower west coast of Florida in Lee, Charlotte, Collier, Glades, and Hendry counties (Barnes, 2005; **Figure 10-1**). The Caloosahatchee River and Estuary have been altered by human activities starting in the 1880s when the river was straightened and deepened resulting in the loss of 76 river bends and 13.2 kilometers (km) of length (Antonini et al., 2002). By 1918 there were three combination lock and spillway structures at Moore Haven, Citrus Center, and Fort Thompson. These structures gave way to more recent structures at Lake Okeechobee (S-77) and Ortona (S-78) in the 1930s. The Caloosahatchee River spans 70 km from an outflow structure at Lake Okeechobee (S-77) westward to the Franklin Lock and Dam (S-79). A network of secondary and tertiary canals throughout the Caloosahatchee River Watershed (C-43 Basin) supports agriculture and urban development. The mesohaline and polyhaline estuary downstream of S-79 also has been significantly altered (Chamberlain and Doering, 1998). Early descriptions of the CRE characterize it as barely navigable due to extensive shoals and oyster bars near Shell Point (Sackett, 1888). A navigation channel was dredged and a causeway built across the mouth of San Carlos Bay in the 1960s. Historic oyster bars upstream of Shell Point were mined and removed to be used in the construction of roads.

The present C-43 Basin is a series of linked regional sub-watersheds and includes the S-4 Basin adjacent to Lake Okeechobee, East Caloosahatchee Basin, West Caloosahatchee Basin, Tidal Caloosahatchee Basin downstream of S-79, and Cape Coral Coastal Basin to the north of the CRE (SFWMD et al., 2012b). The Franklin Lock represents the head of the CRE that extends 42 km downstream to Shell Point where it empties into San Carlos Bay. The surface area of the CRE is 56 km^2 (5,600 ha) with an average depth of 2.7 m (Buzzelli et al., 2013b). The flushing time ranges from 2 to 30 days (Buzzelli et al., 2013d).

In the case of the SLE and CRE, both coastal watershed runoff and outflows from Lake Okeechobee have profound influence on estuarine physics, water quality, and biotic resources (Buzzelli et al., 2012; 2013a; 2013c; 2013d;2014). When summarizing the environmental conditions in these estuaries, it is important to consider that the dynamics of climatic drivers (e.g., rainfall and temperature) vary over timescales ranging from that of atmospheric frontal passages (synoptic scale in days) to longer-term climatic oscillations (El Niño scale of 3–5 years) and decadal patterns. Therefore, the wet-dry subtropical seasonality typical of South Florida estuaries should be contrasted annually to both longer-term (greater than 10 years) and shorter-term (1–3 years) patterns.

ST. LUCIE AND CALOOSAHATCHEE RIVER WATERSHEDS

Figure 10-4 shows the nine sub-watersheds comprising the St. Lucie River Watershed. Of those sub-watersheds, seven drain directly into the St. Lucie River or Estuary (C-24, C-23, C-44/S-153, North Fork, South Fork, and Basin 4-5-6 sub-watersheds, and a portion of the South Coastal Sub-watershed; see SFWMD et al., 2009a for further descriptions).

The Basin 1 and C-25 sub-watersheds mostly drain to the Indian River Lagoon (IRL) and therefore not the focus of the RWPP analysis. Occasional inter-basin transfer between the C-25 and C-24 sub-watersheds occurs at SFWMD structure G-81, mostly from the C-25 to the C-24, which is captured in the C-24 flows and loads.

To the southeast of G-81 (see **Figure 10-3**), the Gordy Road structure is the division between the Ten Mile Creek Basin and the tidal North Fork of the SLE. Further south, SFWMD structure S-49 separates the freshwater C-24 sub-watershed from tidal waters and S-48 is the dividing line for the freshwater C-23 sub-watershed. Finally, the USACE structure S-80 represents the confluence of the freshwater C-44/S-153 sub-watershed and estuarine waters. In addition, waters discharged from Lake Okeechobee also may pass through S-80. Cumulatively, the Tidal Basin of the St. Lucie Watershed (see **Figure 10-3**) located to the east of all these structures (including Basin 4,5,6) represent approximately 30 percent of the SLE's watershed.

Some updates to the watershed and sub-watershed boundaries were made since the 2012 RWPP Update based on new information (**Figure 10-3**). Overall, the acreage boundary of the entire watershed increased from 529,194 acres to 537,805 acres. The most significant change occurred in the St. Lucie North Fork sub-watershed acreage, which increased from 119,105 to 131,864 acres since the 2012 SLRWPP Update, primarily as the C-25 East sub-watershed was moved to St. Lucie North Fork. Subsequently, this change decreased the C-25 sub-watershed acreage from 115,177 to 99,730 acres. In addition, 4,397 acres of the C-24 sub-watershed in its east-central location northeast of G-79 was moved to the St. Lucie North Fork. The third most significant change in sub-watershed acreage was the C-44/S-153 Basin, which increased from 129,856 acres to 132,717 acres with the addition of Basin 8 in its most southwest corner adjacent to Lake Okeechobee.

Figure 10-4 shows the five sub-watersheds comprising the Caloosahatchee River Watershed, as reported in the 2012 CRWPP Update (SFWMD et al., 2012b). The CRWPP study area includes the areas that drain to the mouth of the Caloosahatchee River and the associated offshore estuarine area. The Caloosahatchee Watershed is a linear system, unlike the St. Lucie Watershed. Starting with its eastern point at the USACE structure S-77 adjacent to Lake Okeechobee, water generally flows west to east to the USACE structure S-78, which represents a major division in the freshwater portion. Moving west, flow is also modified by the S-79 that represents the confluence with the estuarine waters. The Tidal Basin of the Caloosahatchee Watershed represents approximately 30 percent of the watershed. Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence overall hydrology of the river dependence on rainfall and regional hydrological conditions.

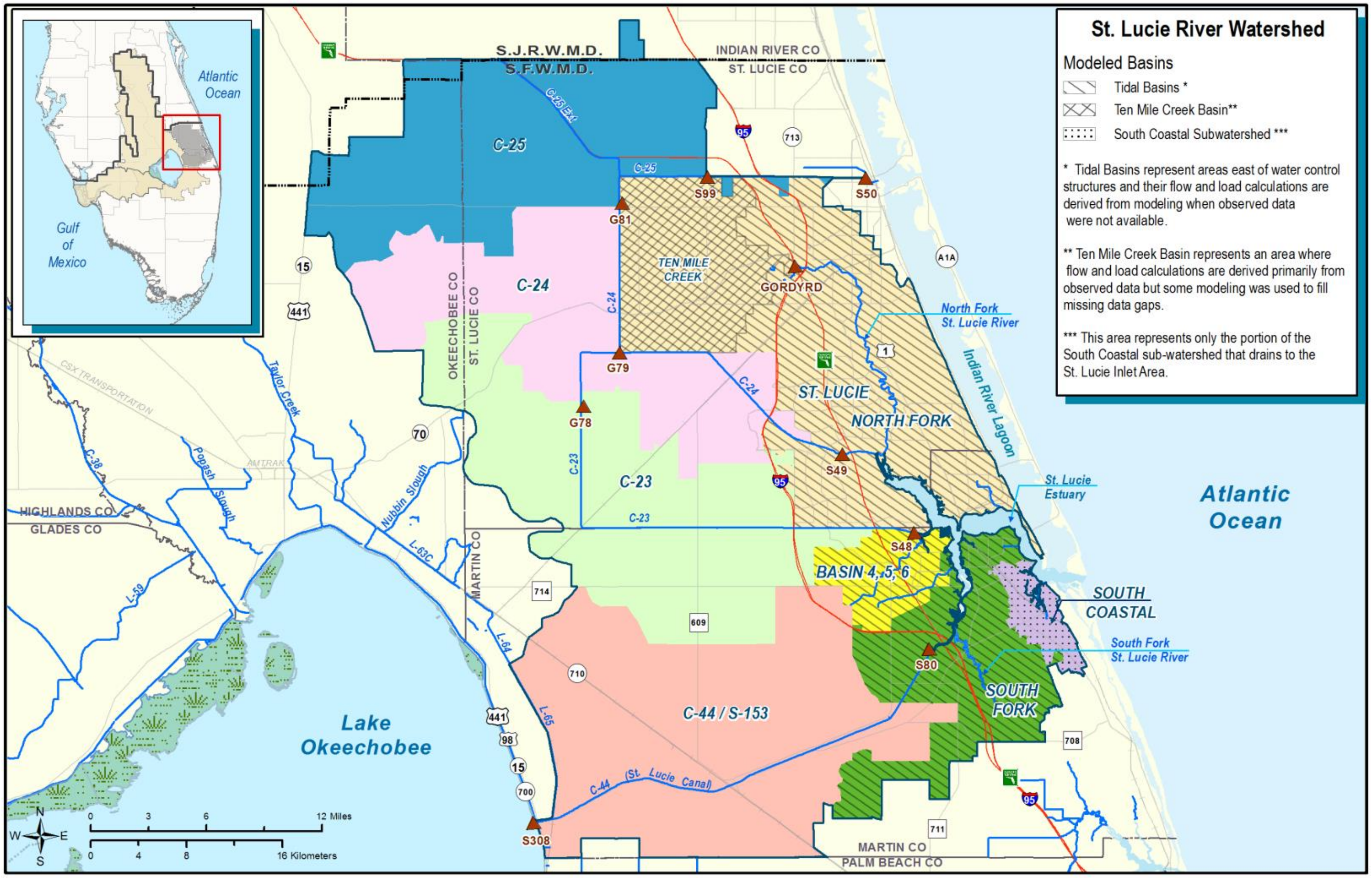

Figure 10-3. The St. Lucie Watershed with its sub-watersheds and major water control structures. In addition, modeled basins areas used in the *Research and Water Quality Monitoring* section of this chapter are depicted.

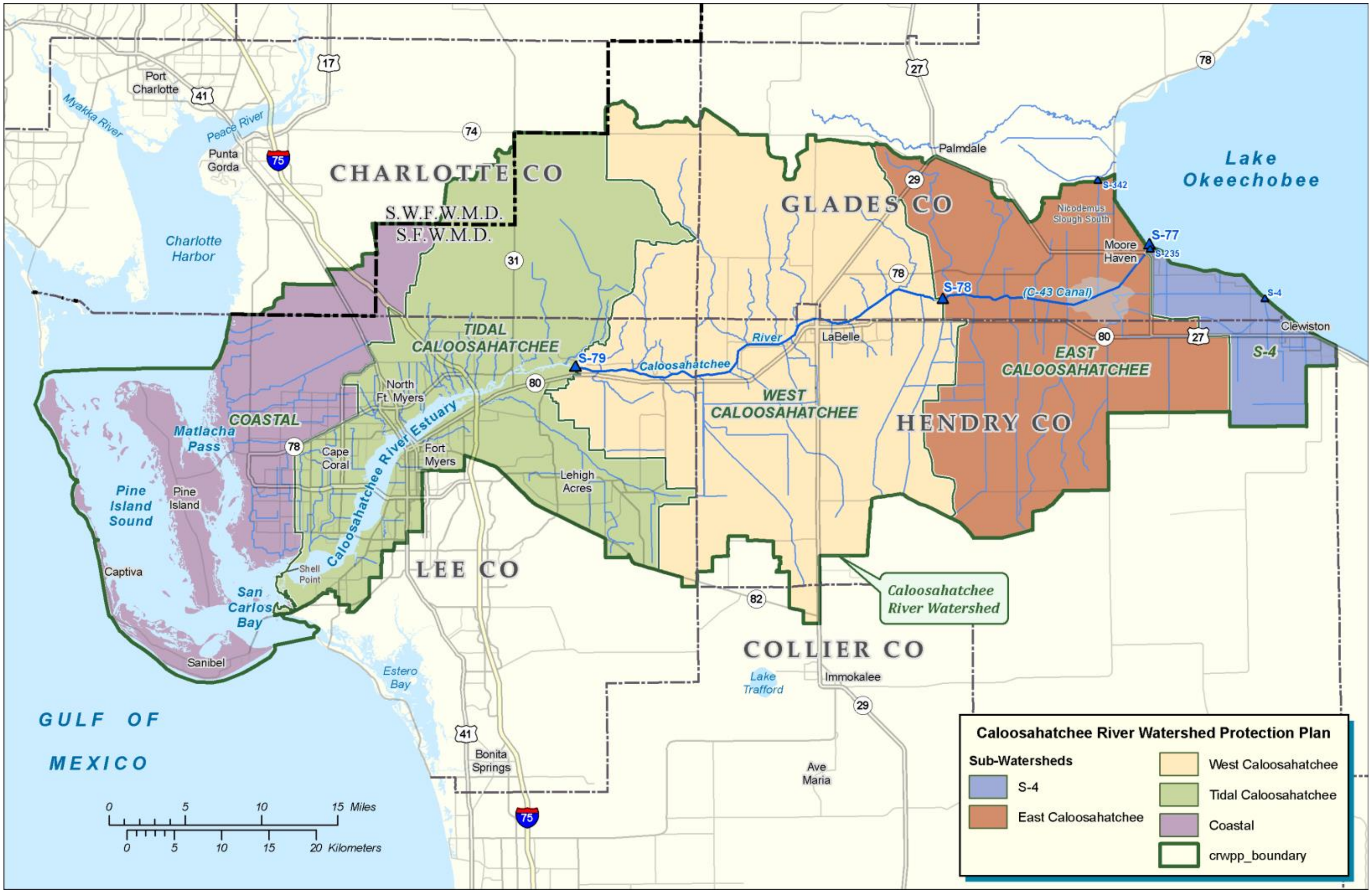

Figure 10-4. The Caloosahatchee Watershed with its sub-watersheds and major water control structures.

Land use highly affects the volume of water runoff and quality of that runoff which ultimately reaches the estuaries. Florida Land Cover Classification System (FLUCCS) Level 1 categories in the two River Watersheds are listed in **Table 10-1** and shown in **Figures 10-5** and **10-6** based on the District's most current land use data set (2009). For the St. Lucie Watershed, agriculture land use was the highest, with 53.9 percent of the overall 537,805 acres. Urban and built up areas (19.1 percent) as well as wetlands (10.9 percent) were the second and third highest, respectively, for St. Lucie Watershed.

Similar to the St. Lucie Watershed, agriculture also represents the highest land use category in the Caloosahatchee Watershed, with 35 percent of the overall 1,090,381 acres. Urban and built up areas (19 percent) and wetlands (16 percent) were also the second and third highest, respectively, for Caloosahatchee Watershed. Upland forests and Water were a larger overall proportion of land use for the Caloosahatchee as compared to the St. Lucie watershed**.**

Table 10-1. 2009 Florida Land Cover Classification System (FLUCCS) Level 1 Land Use (2009) for the St. Lucie and Caloosahatchee Watersheds.

FLUCCS1	St. Lucie			Caloosahatchee	
	Acres	%		Acres	%
Agriculture	289,635	53.9%		377,010	34.6%
Barren Land	3,392	0.6%		5,205	0.5%
Transportation, Communication and Utilities	11,794	2.2%		8,054	0.7%
Upland Forests	36,373	6.8%		136,510	12.5%
Rangeland	17,133	3.2%		60,878	5.6%
Urban and Built Up	102,717	19.1%		201,826	18.5%
Water	17,913	3.3%		128,041	11.7%
Wetlands	58,848	10.9%		172,857	15.9%
Grand Total	537,805	100.0%		1,090,381	100.0%

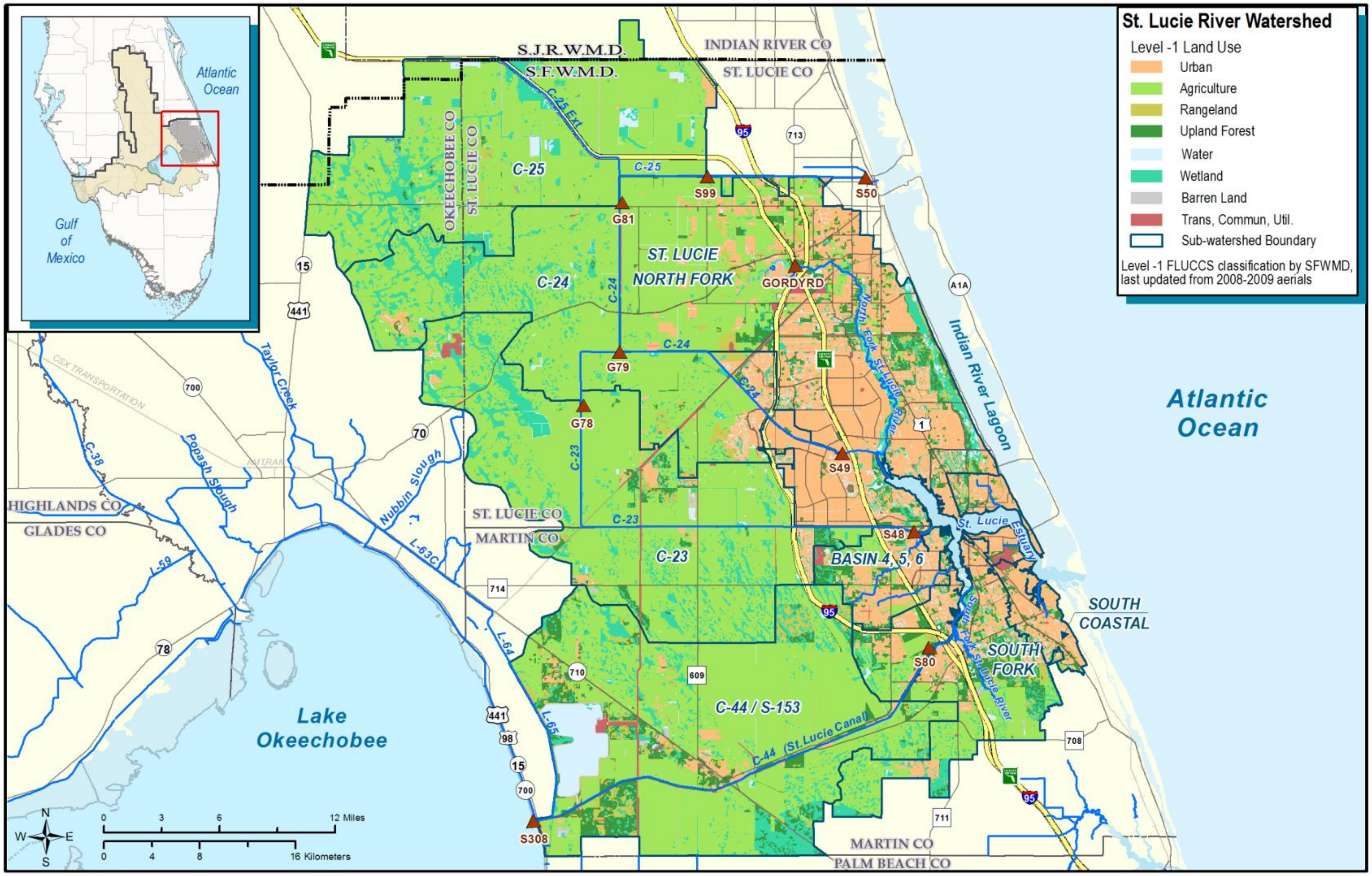

Figure 10-5. Florida Land Cover Classification System (FLUCCS) Level Land Use (2009) for the St. Lucie Watershed with the sub-watersheds and major water control structures also shown.

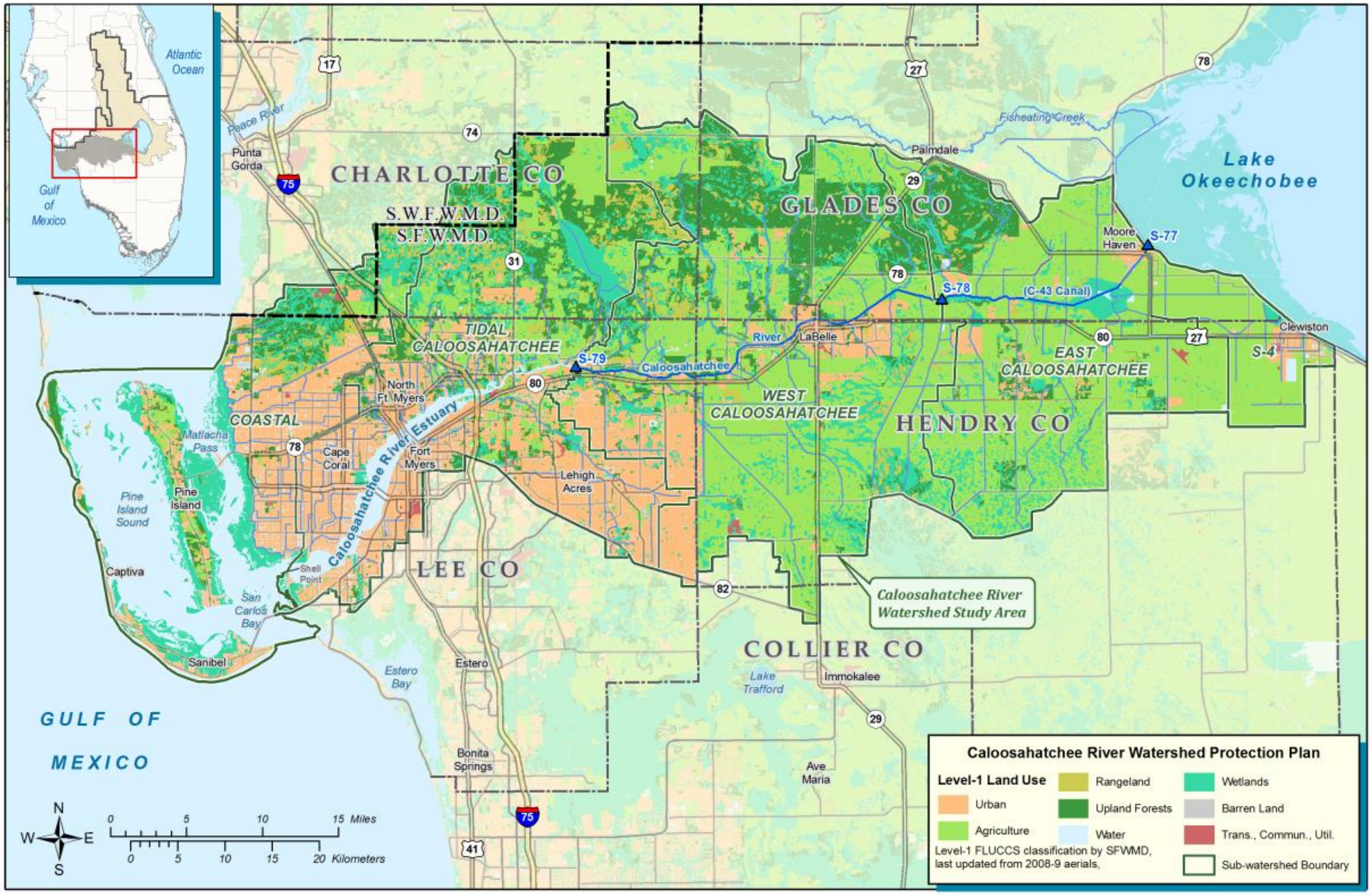

Figure 10-6. FLUCCS Level Land Use (2009) for the Caloosahatchee Watershed with the sub-watersheds and major water control structures also shown.

POLLUTANT SOURCE CONTROL PROGRAM

The Pollutant Source Control Program is a multi-faceted approach for improving the management of pollution sources within the Northern Everglades watersheds. It includes source control programs, including BMPs, on-site treatment technologies, stormwater and wastewater infrastructure upgrades and master planning, and regulatory programs focused on water quality and quantity. The SFWMD, FDEP, and FDACS are defined as the coordinating agencies for implementing the Pollutant Source Control Program in the Northern Everglades watersheds, as defined by the NEEPP. **Table 10-2** lists the specific agencies programs under the overarching Pollutant Source Control Program.

Table 10-2. Nutrient control programs within the Northern Everglades.

Lead Agency	Program[1]	Non-Point	Point
South Florida Water Management District (SFWMD)	Works of the District BMP Program[2] – Chapter 40E-61,Florida Administrative Code (F.A.C.)	√	
	Environmental Resource Permitting Program – Chapter 373, Florida Statutes (F.S.), Part IV	√	
	Dairy Remediation Projects[3]		√
	Dairy Best Available Technologies Project[3]		√
Florida Department of Agriculture and Consumer Services (FDACS)	Agricultural BMP Program – Chapter 5M-3, F.A.C.	√	
	Animal Manure Application – Chapter 5M-3, F.A.C.	√	
	Urban Turf Fertilizer Rule – Chapter 5E-1, F.A.C.	√	
Florida Department of Environmental Protection (FDEP)	Dairy Rule/Confined Animal Feeding Operation (CAFO) – Chapter 62-670, F.A.C.		√
	Environmental Resource Permitting Program – Chapter 373, F.S. Part IV	√	
	Stormwater Infrastructure Updates and Master Planning – Chapter 187, F.S.	√	
	Municipal Separate Storm Sewer System Permit Program – Chapter 62-624, F.A.C.		√
	Comprehensive Planning – Land Development Regulations – Chapter 163, F.S. Part II	√	
	Biosolids Rule – Chapter 62-640, F.A.C.	√	
Florida Department of Health (FDOH)	Application of Septage – Section 373.4595, F.S.	√	
University of Florida Institute of Food and Agricultural Sciences[4] (UF/IFAS)	Florida-Friendly Landscaping™ Program – Section 373.185, F.S.	√	

[1] Applicable to all three watersheds except where noted in the other footnotes below.
[2] The rule currently applies to the Lake Okeechobee Watershed. However, as directed by the Northern Everglades and Estuaries Protection Program (NEEPP), the rule will be amended to include the river watersheds.
[3] Applicable to only the Lake Okeechobee Watershed.
[4] Partially funded by the Florida Department of Environmental Protection (FDEP).

The status of program elements based on the 2009 protection plan objectives for the river watersheds is summarized below. Descriptions of the FDACS and FDEP programs are available in the 2014 SFER – Volume I, Chapter 8; 2012 SFER – Volume I, Chapter 4; and Caloosahatchee and St. Lucie BMAPs. More details on the District's Regulatory Source Control Programs are presented in Chapter 4 of this volume.

Implementing non-point source BMPs on agricultural and non-agricultural lands to ensure that the amount of nutrients discharged offsite are minimized to the greatest possible extent

- The District and the FDEP are granted the authority to implement Environmental Resource Permitting (ERP) programs. The ERP program requires that applicants for new activities or modifications of existing activities provide reasonable assurances that they will not cause adverse water quality such that state water quality standards will be violated, cause adverse flooding or water quantity impacts, or harm wetland or other surface water systems. Currently, 45 percent of agricultural and non-agricultural acreage in the Caloosahatchee River Watershed and 70 percent of agricultural and non-agricultural acreage in the St Lucie River Watershed have been issued an ERP permit by the District. However, not all activities are required to obtain ERPs. For example, certain agricultural activities may be exempt pursuant to Section 373.406, F.S. Other exemptions are set forth in Sections 373.4145(3) and 403.813(1), F.S., and Rule 62-330.051, F.A.C. Most lands used for improved pasture, which are approximately 30 percent of the St. Lucie Watershed and 20 percent of the Caloosahatchee Watershed, do not have ERPs.
- The Statewide ERP Rule (SWERP) became effective on October 1, 2013. The legislative mandate for this rulemaking provided that the individual water management districts maintain their existing water quality rules and their ability to promulgate future water quality rules. These rules are set forth in the District's ERP Applicant's Handbook, Volume II. In August 2014, ERP Applicant's Handbook, Volume II, was amended to codify the pre-existing guidance memorandum on water quality evaluations for discharges to outstanding Florida waters and water bodies that do not meet the state water quality standards.
- The FDACS works with agricultural producers to develop, adopt, and implement commodity-specific water quality and water conservation BMPs. Producers enroll in the relevant BMP program by submitting a Notice of Intent (NOI) to FDACS, along with an accompanying checklist of the practices applicable to the operation. To date, BMP manuals for citrus, vegetable and row crop, nursery, sod, cow/calf, equine, and specialty fruit and nut operations have been adopted. The statewide nursery manual revision was adopted in June 2014, and it now includes practices related to in-ground and cut foliage production methods in addition to container operations. Revisions to the vegetable/row crop manual have been initiated, with adoption anticipated in mid- to late- 2015. A dairy manual is also under development with adoption slated for 2015. The Florida Forest Service has a separate BMP manual for silviculture operations.

  BMP enrollment is tracked through the FDACS Office of Agricultural Water Policy's BMP Tracking System. As of September 30, 2014, the FDACS Office of Agricultural Water Policy has received 335 NOIs representing 211,744.36 acres in the St. Lucie River Watershed, and 252 NOIs representing 418,679.68 acres in the Caloosahatchee River Watershed. The St. Lucie River Watershed enrollment equates to 77.7 percent of the total adjusted agricultural acreage, and the Caloosahatchee River Watershed enrollment equates to 95.6 percent of the total agricultural acreage. To determine enrollment percentage, FDACS included both the agriculture (level 1 land use code 2000) and rangeland (level 1 land use code 3000) classifications to calculate the total agricultural acreage in each watershed. The total agricultural acreage for the St. Lucie River Watershed, which was adjusted to account for out of production citrus acreage, is 272,518.12 acres, and the total agricultural acreage for the Caloosahatchee River Watershed is 437,772.93 acres[1].

- The statewide Urban Fertilizer Rule [Rule 5E-1.003(2), F.A.C.] became effective in December 2007. Fertilizer application must comply with the statewide rule, unless the area is subject to a stricter local ordinance.
- The FDEP has been delegated the authority to issue MS4 permits to prevent harmful pollutants from being discharged into water bodies. MS4 permits include a stormwater management plan. The FDEP issued the third cycle of the Lee County NPDES MS4 permit on September 4, 2011. Hendry and Glades counties were issued Phase II MS4 permits in 2010. All reissued Phase I permits include a new section on TMDL implementation and require enhanced tracking of load reductions achieved through implementing the permit's stormwater management program including nutrient load reductions from street sweeping activities.
- Since 2009, the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Florida Yards and Neighborhood Program has been expanded from the original homeowner focus to include a broader audience. As of January 1, 2014, this certification program is required for any person applying commercial fertilizer to an urban landscape.
- The 2009 Florida legislature created or amended Sections 373.185(3)(a),(b), and (c), F.S., which promote the use of Florida-friendly landscaping to conserve and protect the state's water resources. To date, local governments with known Florida-friendly landscaping ordinances, or those known to be in the process of passing ordinances, in the Caloosahatchee River Watershed include Charlotte County, Cape Coral, Fort Myers, Lee County, Fort Myers Beach, and the City of Sanibel.
- According to the NEEPP, refinement of existing regulations and development of BMPs complementing existing regulatory programs is a basis for achieving and maintaining compliance with water quality standards. Chapters 40E-61 and 40E-63, F.A.C., contain long-standing regulations that establish criteria to ensure that discharges meet legislative objectives for water quality protection. The District regulatory plan included amending Chapter 40E-61, F.A.C., to expand the spatial extent of the existing regulatory source control program and to address the nutrients of concern for the river watersheds, which may include nitrogen as well as phosphorus. The associated activities are scheduled to begin in 2015.

[1] The FDEP uses agricultural BMP enrollment for a different purpose in the BMAP process and applies a different methodology in the St. Lucie and Caloosahatchee Estuary Basin BMAPs. Therefore, the numbers reported in the BMAPs and BMAP annual updates are different than the enrollment numbers in this report.

Ensuring that domestic wastewater residuals within the river and estuary watersheds do not contribute to nutrient loadings in the watershed

The biosolids rule, Chapter 62-640, F.A.C, was revised on August 29, 2010. Revisions include new requirements for site permitting, nutrient management plans, registration of distributed and marketed Class AA biosolids as fertilizer, and prohibition of land application of other types of biosolids (Class B) in the Northern Everglades watersheds unless the applicant completes a demonstration of nutrient balance that FDEP approves. As of January 1, 2013, all sites are required to be permitted in accordance with the revised rule. Further information on the biosolids rule is available on the FDEP website at http://www.dep.state.fl.us/water/wastewater/dom/reshome.htm.

Coordinating with the Florida Department of Health (FDOH) to ensure that septage disposal within the watershed is under an approved agricultural use plan limiting applications based on nutrient loading limits established in the proposed revisions to SFWMD's 40E-61 Regulatory Nutrient Source Control Program as stated in the NEEPP

Sections 373.4595(4)(a)2.f and 373.4595(4)(b)2.f, F.S., require that all entities disposing of septage within the river watersheds develop and submit to the FDOH, an agricultural use plan that limits applications based upon nutrient loading. Entities that apply septage in the river watersheds must do so in accordance with such a plan. Phosphorus levels originating from application sites must be consistent with the District's Regulatory Source Control Program (Chapter 40E-61, F.A.C.).

In addition, on June 4, 2010, the Florida legislature approved a bill directing the FDOH to create and administer a statewide five-year cycle septic tank evaluation program. The FDOH will not restart rule development until they receive approval by the Legislative Budget Commission.

Ensuring that entities utilizing land-application of animal manure develop a resource management system level conservation plan

The land application of animal manure rule became effective in February 2009. Provisions of this rule were modified slightly and incorporated into Chapter 5M-3, F.A.C.

Implementing a source control monitoring program to measure the collective performance and progress of the coordinating agencies' programs, support adaptive management within the programs, identify priority areas of water quality concern and BMP optimization, and provide data to evaluate and enhance performance of downstream facilities

- The SFWMD continued developing the supporting technical information to expand its regulatory source control program in the Northern Everglades (see Chapter 4 of this volume). This included defining and evaluating the watershed monitoring networks to be used for regulatory purposes, consistent with Chapter 40E-61, F.A.C., and the BMAP adopted by the FDEP.
- The SFWMD's collection of stream gauging flow measurements for St. Lucie tributary stations in support of a regulatory source control program concluded in WY2014. The additional measured flow conditions were used to optimize the flow rating curves and improve the historical datasets.
- For the St. Lucie River Watershed, the SFWMD has coordinated with local entities to refine basin drainage boundary delineations to better align with representative

monitoring stations to be used under the regulatory source control program. These changes were also reflected in the SLRWPP boundaries discussed previously.

- In support of the future regulatory program for both river watersheds, the SFWMD conducted statistical analyses to consider background nitrogen levels when estimating progress toward achieving water quality goals (see Chapter 4 of this volume).
  The organic component of total nitrogen is primarily found in natural lands that have not been impacted or altered (wetlands, etc.). The inorganic component is primarily introduced to the environment through anthropogenic forms (fertilizers, waste materials, detergents, etc.). Water quality, land use, and soil data were analyzed to develop background nitrogen thresholds as a function of the fraction of organic nitrogen in the total nitrogen runoff.
- The SFWMD made improvements and additions to the St. Lucie River Watershed monitoring network to be used for regulatory purposes consistent with Chapter 40E-61, F.A.C., and the BMAP adopted by the FDEP. Water quality monitoring at twelve additional tributary stations began in May 2013. The twelve new stations supplement the existing monitoring network and allow full representation of all land uses in each sub-watershed and gains 75,000 acres of monitored area, or 68 percent of the St. Lucie Watershed unmonitored area.
- The District performed a three-year synoptic monitoring effort within the C-23 and C-24 sub-watersheds which justified the need for continued upstream monitoring for regulatory purposes consistent with Chapter 40E-61, F.A.C., and the BMAP adopted by the FDEP. As a result, the District is continuing upstream monitoring in select locations within the C-23 and C-24 sub-watersheds, and adding upstream monitoring in the C-44/S-153 sub-watershed, and the East and West Caloosahatchee sub-watersheds for two additional water years. This project is intended to identify priority locations within the river watersheds to be addressed by the coordinating agencies through agency action plans.

Other pollutant source control activities implemented by the coordinating agencies pursuant to their respective authorities include outreach activities, planning, and issuance and oversight of NPDES and Concentrated Animal Feeding Operation (CAFO) permits for point sources, and Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) project permits.

WATERSHED EFFORTS

FDEP BASIN MANAGEMENT ACTION PLANS: BLUEPRINT TO MEET TOTAL MAXIMUM DAILY LOADS

A Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant that a water body or segment can assimilate from all sources without exceeding water quality standards. TMDLs were adopted for the Caloosahatchee Estuary in 2010 and the St. Lucie Estuary in late 2009 (http://www.dep.state.fl.us/water/tmdl/docs/tmdls/final/gp2/stlucie-basin-nutr_do-tmdl.pdf and http://www.dep.state.fl.us/water/tmdl/docs/tmdls/final/gp3/tidal-caloosa-nutr-tmdl.pdf, respectively). Once TMDLs have been adopted, the FDEP may begin a Basin Management Action Plan (BMAP) development process.

A BMAP is the blueprint for restoring impaired waters by reducing pollutant loadings to meet a TMDL. These broad-based plans are developed in cooperation with local stakeholders, and they are adopted by FDEP Secretarial Order to be enforceable. FDEP's BMAPs in the Northern

Everglades serve as the overarching water quality restoration plans. Through BMAP development and implementation, the FDEP works with stakeholders and coordinating agencies to identifying projects necessary to achieve the TMDLs and estimate nutrient reduction benefits for these projects. The protection plans will use this information as appropriate.

Two important BMAP milestones occurred since the 2012 RWPP updates. The Caloosahatchee Estuary BMAP was adopted in November 2012 (FDEP et al., 2012) and the St. Lucie River and Estuary Basin BMAP was adopted in June 2013 (FDEP et al., 2013). Both BMAPs' development and adoption processes were stakeholder-driven and focused on identifying projects that had been constructed since 2000 or are planned to be built within the next five-year period. The Caloosahatchee Estuary BMAP's five-year period is from November 2012 through November 2017 and the St. Lucie BMAP's five-year period is from June 2013 through June 2018. Further information on these plans is available on the FDEP website at http://www.dep.state.fl.us/water/watersheds/bmap.htm.

Since adoption of the St. Lucie BMAP, the FDEP has held three post-BMAP adoption public meetings (August 2013, February 2014, and August 2014) to set the stage for the future activities over the next five years. These include investigating the use of a new water quality model, updating land use coverages, and continued inventorying of new projects to be applied in the second five-year phase (2018–2023). In addition, the FDEP continues to fund BMAP projects statewide through both its TMDL Water Quality Restoration Grants (http://www.dep.state.fl.us/water/watersheds/tmdl_grant.htm) as well as Clean Water Act 319(h) funds (http://www.dep.state.fl.us/water/nonpoint/319h.htm) and encourages local stakeholders to seek funding for local projects. The draft annual progress report for the first year of BMAP implementation was presented at the annual meeting in August 2014.

The Caloosahatchee Estuary BMAP is also on its first five-year iteration and is focused on TN reductions in the estuarine area west of the S-79 water control structure (FDEP et al., 2012). Seventy-five percent of the current BMAP area is located in Lee County and the remaining 25 percent in Charlotte County and represents a subset of the overall RWPP boundary. It is recognized by FDEP that loads from other Caloosahatchee sub-watersheds outside of the current BMAP boundary will need to be addressed by other efforts (see FDEP et al., 2012)

During the development of the Caloosahatchee Estuary BMAP, it was agreed upon by stakeholders and FDEP that the science and modeling used to develop the initial Caloosahatchee Estuary TMDL needed to be revisited and potentially modified (see FDEP et al. 2012). In addition, numerous freshwater segments in the Caloosahatchee watershed, as well as tidal tributaries are impaired and TMDLs are required for those water bodies (see SFWMD, 2012b). FDEP set out to update the models used to develop original estuary TMDL and will apply them in refining the current TMDL as well as developing new TMDLs for the impaired tidal tributary and freshwater segments in the entire watershed.

To date, the FDEP has held three public meetings over the last year and a half to report on their progress and solicit input. Importantly, the FDEP has also led a technical specific modeling sub-group to assist them in working though the very complex process of calibrating and updating two distinct models that will be coupled for the final results. Based on the May 2014 public meeting, it is anticipated that the FDEP will have a draft TMDLs in the near future; however, any final TMDLs will most likely be adopted after the development this 2015 CRWPP Update. Interested stakeholders are expected to continue to engage the FDEP and participate in any upcoming public meetings and comment periods to ensure that the science and information in the revised and new TMDLs is as accurate and robust as possible. Further information on the Caloosahatchee TMDLs process is presented on the FDEP website at http://www.dep.state.fl.us/water/tmdl/.

CONSTRUCTION PROJECT UPDATE

Reducing nutrient loading and excess fresh water inflow to the SLE and CRE requires action at the regional, sub-regional, and local levels. The Construction Project components include a suite of activities at each of these spatial scales. The focus on water quality and storage is intended to improve hydrology, water quality, and aquatic habitats in both the watersheds and estuaries. The suite of projects builds upon the Source Control Program and includes water quality and quantity projects such as local storm water retrofits, Stormwater Treatment Areas (STAS), reservoirs, and habitat restoration. A comprehensive summary of all projects was included in the original 2009 RWPPs (SFWMD et. al, 2009a; 2009b) and 2012 RWPP Updates (SFWMD et al., 2012a; 2012b).

Since their development, the FDEP BMAPs are considered the primary mechanism for identifying projects that will help achieve the TMDL. The BMAPs are also the forum for estimating project nutrient benefits; therefore, this is no longer done through the protection plan updates as it would be duplicative. However, the RWPPs will continue to report on the coordinating agencies projects and initiatives as well as other related efforts, as applicable.

Coordinating Agencies' Regional and Sub-Regional Projects

Regional and sub-regional projects are critical to achieving the water quality, water storage and restoration goals of the SLRWPP and CRWPP. **Table 10-3** summarizes the coordinating agencies' regional and sub-regional projects currently under way in both the St. Lucie and Caloosahatchee River watersheds, while completed projects were reported in previous RWPP updates. A regional project in the Caloosahatchee River Watershed that has had much anticipated progress over the last three years (**Table 10-3**) is the Comprehensive Everglades Restoration Plan (CERP) C-43 Reservoir (see **Figures 10-7a** and **10-7b**), which received federal authorization via the 2014 Water Resources Reform and Development Act (WRRDA). In 2014, the State of Florida appropriated $18 million to design and construct a C-43 Early Start Project, which would have provided interim water storage on-site until the full reservoir could be completed. The state is now planning to move forward to complete Phase I of the full C-43 Reservoir Project by 2019.

Similarly, the SLE will benefit greatly from the CERP Indian River Lagoon – South (IRL-S) Project, which is a state-federal partnership to restore the southern portion of the lagoon, the SLE, and the associated watershed. The IRL-S Project employs a regional approach to address the Martin and St. Lucie County portions of the lagoon with six features. These features include four new above-ground reservoirs and three Stormwater Treatment Areas (www.evergladesrestoration.gov). An important part of the IRL-S is the C-44 Reservoir and STA (see **Figures 10-8a** and **10-8b**), located in Martin County. With a goal of improving water quality in the St. Lucie River and Estuary, the District's Governing Board took steps in July necessary to expedite construction of the stormwater treatment portion of this project. The Florida legislature has provided $60 million for the District to begin construction on this component of the project.

Table 10-3. Summary of Caloosahatchee (CRE) and St. Lucie Estuary (SLE) watershed construction projects.

Project Name	Sub-Watershed	General Description	Size/Capacity	Water Quality and Quantity Benefits	Year Construction Started and Completed (or expected completion date)	2015 RWPP Status Update
Comprehensive Everglades Restoration Plan (CERP) Caloosahatchee River (C-43) West Basin Storage Reservoir Project (CRE-W Res)	West Caloosahatchee	This project will help capture and store stormwater runoff from the C-43 basin and Lake Okeechobee discharges, reducing discharges to coastal estuaries during wet periods and providing flows to the estuary during dry periods	10,700-acre reservoir	Up to 170,000 ac-ft of storage per year	1) The site was used for short term water storage during the extremely high rainfall events of 2013 and 2014.	1) In June 2014, the federal government authorized this project via the 2014 Water Resources Reform and Development Act (WRRDA) which authorizes the USACE to undertake water resources projects under their jurisdiction, including this project. 2) In 2014, the State of Florida appropriated $18 million to design and construct a C-43 Early Start Project, which would have provided interim water storage on-site until the full reservoir could be completed. The state is now planning to move forward to complete Phase I of the full C-43 Reservoir Project by 2019. 3) An important water reservation rulemaking for the larger CERP project became effective in July 2014.

Table 10-3. Continued.

Project Name	Sub-Watershed	General Description	Size/Capacity	Water Quality and Quantity Benefits	Year Construction Started and Completed (or expected completion date)	2015 RWPP Status Update
C-43 Water Quality Treatment and Testing Facility Project (CRE-10)	East Caloosahatchee	The District and Lee County are partners on the development and implementation of this project. Its purpose is to investigate and test and optimize wetland treatment for removing total nitrogen (TN) and other constituents including total phosphorus (TP) and total suspended solids	TBD	TBD	The initial phase of testing began in fall 2014.	1) In FY2015 the District, will be performing a one-year bioassay study with the overall objective of evaluating the bioavailability of dissolved organic nitrogen in the Caloosahatchee River. This effort involves the collection of water samples along the Caloosahatchee River from Lake Okeechobee through the Estuary and conducting analyses under varying seasons and conditions. Information obtained from the bioassay study will be utilized for the optimization of the design and operation of the mesocosm system discussed below (#2). 2) Pending confirmation of additional funding sources, the design construction, and operation of mesocosms will also take place beginning in FY2015–FY2018. Consisting of water tanks that hold wetland vegetation communities and draw water from the Caloosahatchee River, the mesocosm system is the first step in the District's incremental approach for full facility implementation.

Table 10-3. Continued.

Project Name	Sub-Watershed	General Description	Size/Capacity	Water Quality and Quantity Benefits	Year Construction Started and Completed (or expected completion date)	2015 RWPP Status Update
Lake Hicpochee Hydrologic Enhanceme nt Project - North	East Caloosahatchee	The objective of the Lake Hicpochee Hydrologic Enhancement Project is to provide shallow water storage, rehydrate a portion of the lake bed to promote habitat restoration storage, and increase capacity for ancillary water quality enhancements. It includes a shallow storage feature and a spreader canal to deliver excess stormwater runoff from the C-19 Canal to the northern portion of Lake Hicpochee as needed.	670-acre impoundment;	1,280 acre-ft impoundment area	Construction is scheduled to begin in FY2015.	1) Preliminary surveying and technical investigations are complete; final engineering design is anticipated to be completed in 2015. 2) In addition to 5,300 acres of land already in state ownership, the South Florida Water Management District acquired approximately 715 acres of strategic land north of Lake Hicpochee to be used as part of the shallow storage feature in 2014. 3) The current estimated cost for this project is $18.4 million.

Table 10-3. Continued.

Project Name	Sub-Watershed	General Description	Size/Capacity	Water Quality and Quantity Benefits	Year Construction Started and Completed (or expected completion date)	2015 RWPP Status Update
Comprehensive Everglades Restoration Plan (CERP) Indian River Lagoon South - C-44 Reservoir/STA (LO 14)	C-44/S-153	The objectives of the C-44 Reservoir and STA are to capture, store, and treat runoff from the C-44/S-153basin prior to discharge to the SLE. Implementation of this project is expected to reduce damaging freshwater discharges, decrease nutrient load, and help maintain desirable salinity regimes.	The project includes construction of a 3,400-acre reservoir and an adjacent STA of approximately 7,300 acres with an effective treatment area of 6,300 acres.	1) up to 50,600 ac-ft of storage; 2) Load reduction benefits to the SLE are estimated at 26 metric tons per year (mt/yr) for total phosphorus (TP) and 82 mt/yr for total nitrogen (TN).	Started: 10/1/2011 Estimated Completion Date: 2020	1) In order to expedite completion of the C-44 Reservoir and Stormwater Treatment Areas (STA) Project, the SFWMD Governing Board in July 2014 agreed to construct the C-44 STAs, the pump station and a portion of the system discharge canal. USACE will continue to construct the reservoir and SFWMD will construct the STA and pump station. Both agencies entered into an amended Project Partnership Agreement in July 2014. 2) SFWMD has completed construction of the communications tower. 3) The USACE completed the first construction contract of the project in July 2014. 4) The Florida Legislature appropriated $20.5M 2013 and $40M 2014 for the project. In August, the SFWMD Governing Board awarded the contract for the construction of a spillway that will serve as the single point of water movement out of the entire C-44 project.

Table 10-3. Continued.

Project Name	Sub-Watershed	General Description	Size/Capacity	Water Quality and Quantity Benefits	Year Construction Started and Completed (or expected completion date)	2015 RWPP Status Update
Ten Mile Creek Project (SLE 45)	North Fork	The original purpose of the Ten Mile Creek Water Preserve Area was to capture and store stormwater flows that originated in the Ten Mile Creek Basin prior to discharge into the North Fork of the St. Lucie River. In addition, captured stormwater was intended to pass through a polishing cell for additional water quality treatment before release. However, upon construction the project did not perform as designed.	Originally a 550-acre reservoir	TBD	TBD	1) In an August 11, 2014 letter, the SFWMD requested that the USACE “deauthorize the project, terminate the Project Cooperation Agreements, and extinguish any real estate certifications associated with the project. Following these steps, the SFWMD will take full ownership and responsibility for converting the Ten Mile Creek Project into a functional facility designed to provide necessary storage and water treatment options.” 2) The SFWMD has compiled the necessary information for permit applications to proceed once the deauthorization process is complete.

Table 10-3. Continued.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or expected completion date)	WY2014 Status Update
Hybrid Wetland Treatment Technology (HWTT) (FDACS)	C-25 and Basins 4-5-6 Sub-watersheds and the Lake Okeechobee Watershed	The HWTT technology combines attributes of treatment wetlands and chemical treatment systems. There are currently six operational HWTT systems and one under permitting in the Northern Everglades; five in the Lake Okeechobee Watershed (Nubbin Slough, Mosquito Creek, Lemkin Creek, Grassy Island and Wolff Ditch) and two in the St. Lucie River Watershed (Ideal 2 Grove and Bessey Creek).	Ideal 2 Grove, 1.3 cfs (0.04 m^3/sec); Nubbin Slough, 7.4 cfs (0.21 m^3/sec); Mosquito Creek, 6 cfs (0.17 m^3/sec); Lemkin Creek, 5 cfs (0.14 m^3/sec); Wolff Ditch, 20 cfs (0.57 m^3/sec); and Grassy Island in the Taylor Creek basin, 30 cfs (0.85 m^3/sec). The design capacity for Bessey Creek is 20 cfs (0.57 m^3/sec).	Flow-weighted mean TP concentration reductions of the six active HWTT facilities during the entire study period ranged from 67 to 93 percent.	Ideal 2 Grove, Nubbin Slough, and Mosquito Creek were constructed in WY2008; Lemkin Creek and Wolff Ditch were deployed in WY2011; and Grassy Island was constructed in WY2012 with final expansion in WY2014.	The Grassy Island expansion to 30 cfs (0.85 m^3/sec) was completed in WY2014. Application was submitted to FDEP to operate at Grassy Island at 30 cfs (0.85 m^3/sec). A new facility at Bessey Creek in Martin County is under final design and permitting and is expected to be completed and operational in the fall of 2014.
Floating Aquatic Vegetative Tilling (FAVT) (FDACS)	East Caloosahatchee Sub-watershed and the Lake Okeechobee Watershed	Floating Aquatic Vegetative Tilling (FAVT) systems are operated with an initial growing season during which the FAV assimilate nutrients and grow to a high density. The FAVT is then drained during the dry season, thereby stranding the FAV on the soil. After a natural drying process, the plant material is tilled into the soil, stored in deeper zones, and used to repopulate the wetland for the subsequent growth period. The technology uses the direct assimilation of nutrients from the water column through the use of floating plant roots (as compared to plants rooted in the soil), and all of the biomass is rapidly incorporated directly into the soil through tilling. The FAVT process may result in a reduction of up to 80 percent of land needed for treatment as compared to traditional wetland treatment systems.	The East Caloosahatchee FAVT site is 540 acres (219 ha) and has a capacity of 90 cfs (2.55 m^3/sec). It is designed to treat local agricultural runoff from the Hendry Hilliard Water Control District, the East Caloosahatchee River and Lake Okeechobee. The Fisheating Creek facility is comprised of 100 acres (40 ha) of FAV and 200 acres (81 ha) of managed dispersed flow area and will have a treatment capacity of 120 cfs (3.4 m^3/sec).	16.2 mt from the Fisheating Creek FAVT. The East Caloosahatchee FAVT facility is anticipated to remove approximately 6 mt of TP.	The East Caloosahatchee facility was completed in June 2014. The Fisheating Creek facility has an expected completion date in 2015.	The East Caloosahatchee FAVT project is operational. Legislative funding has been appropriated for a FAVT site to treat water from the Fisheating Creek Sub-watershed.

Figure 10-7a. Location of the Comprehensive Everglades Restoration Plan (CERP) West Basin Storage Reservoir Project.

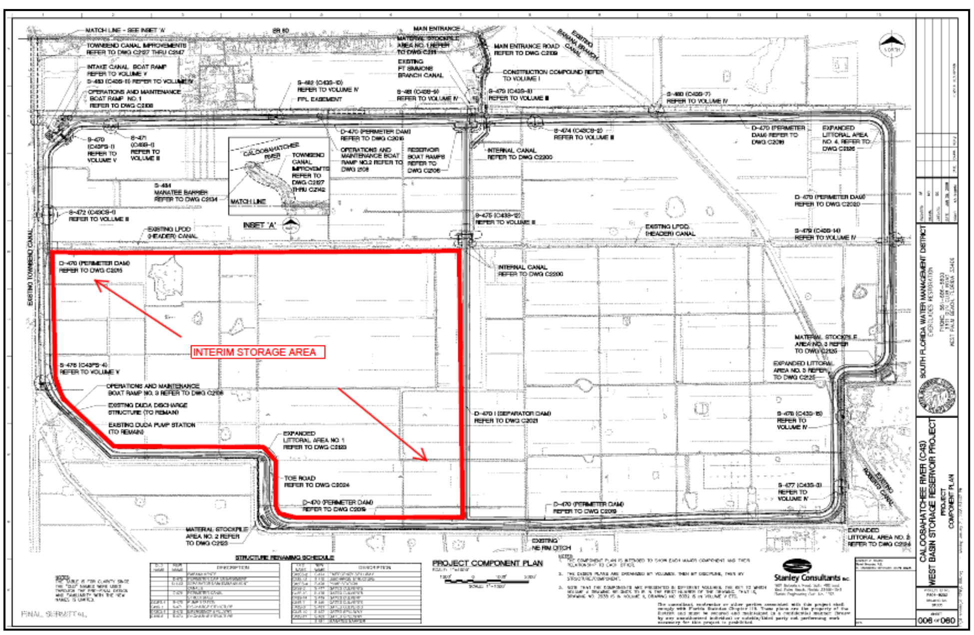

Figure 10-7b. Major components of the CERP C-43 West Basin Storage Reservoir Project. The black outline represents the area of the entire congressionally authorized project and the red line shows the interim storage area.

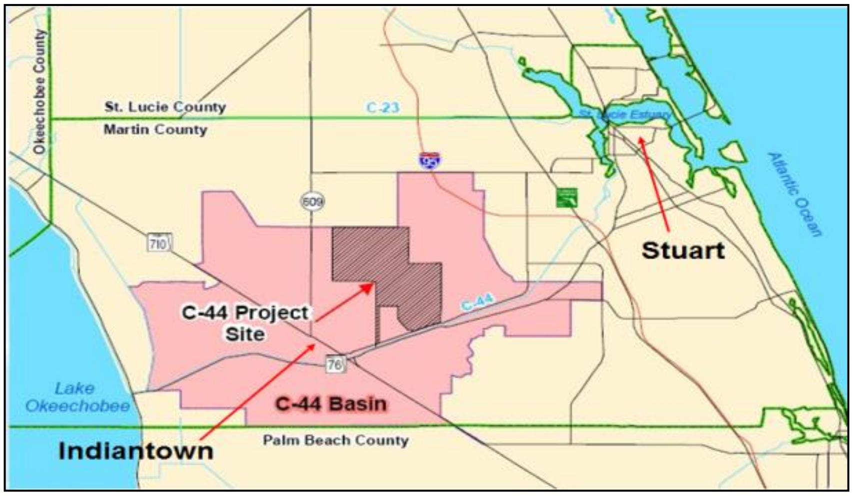

Figure 10-8a. Location of the CERP Indian River Lagoon (IRL) - South C-44 Reservoir/ Stormwater Treatment Area (STA) Project.

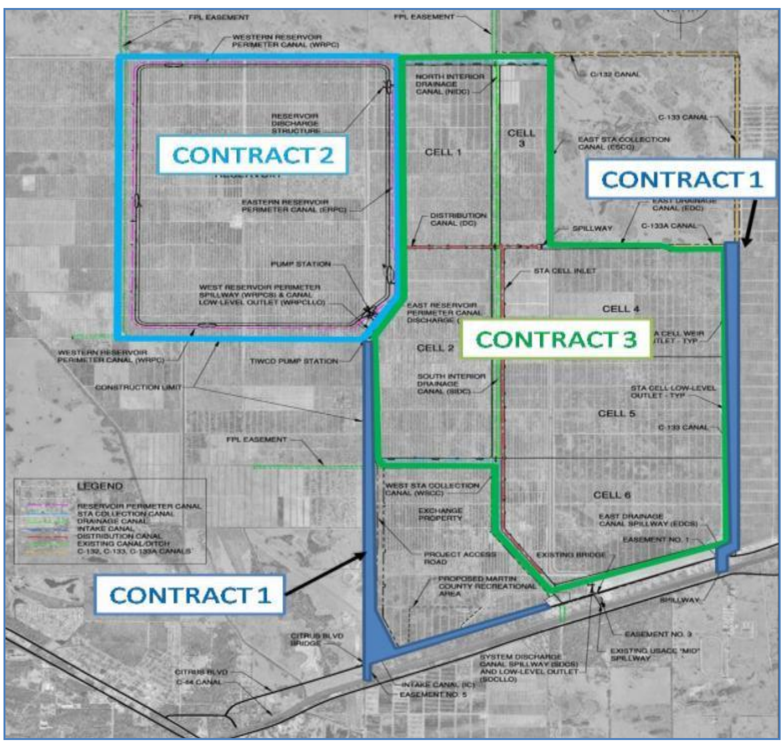

Figure 10-8b. Major components of the CERP IRL - South C-44 Reservoir/STA Project. Contracts 1 and 2 represent the U.S. Army Corps of Engineers' Reservoir construction areas. Contract 3 represents the SFWMD's STA construction area.

DISPERSED WATER MANAGEMENT PROJECTS

The legislative intent of the NEEPP includes encouraging and supporting the development of creative partnerships to facilitate or further the restoration of surface water resources in the LOW and the St. Lucie and Caloosahatchee River watersheds. One way this is being accomplished is through the Dispersed Water Management (DWM) Program. The goals and objectives of the DWM Program are to provide shallow water storage, retention, and detention to enhance Lake Okeechobee and estuary health by reducing discharge volumes, reducing nutrient loading to downstream receiving waters, and expanding groundwater recharge opportunities.

The DWM Program is a multifaceted approach to working cooperatively with public and private land owners to identify, plan, and implement mechanisms to retain or store water. The four main categories of projects under the District's DWM Program include storage and retention projects on public lands, storage and retention projects on private lands, Northern Everglades Payment for Environmental Services (NE-PES) projects, and Water Farming Payment for Environmental Services (WF-PES) pilot projects. The storage, retention, and detention created by projects within the DWM Program since 2005 will be approximately 93,202 ac-ft. This includes contributions from the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS) Wetland Reserve Program (WRP) and other programs, the FDACS BMP Program, agricultural landowners, agricultural organizations, non-governmental organizations (NGOs), and local governments.

A map of the projects is shown in **Figure 10-9**; **Table 10-4** provides a comprehensive list of the District's DWM projects in the Northern Everglades and their current status and estimated benefits, as of October 1, 2014. The District administers the DWM Program in consultation with the FDEP, FDACS, and USDA NRCS.

Storage and Retention Projects on Public Lands

Projects on public land enhance Lake Okeechobee and estuary health by reducing discharge volumes and nutrient loading to downstream receiving waters through modifications to existing water management structures and implementing operational strategies. In many cases, storage, retention, and detention are obtained by increasing the discharge control elevation of on-site drainage facilities or impounding water in shallow retention and detention areas. These projects are typically conducted on non-District lands where the District provides cost-share funding to other public entities to implement a water management improvement project or on District lands where the District identifies lands that may be available for interim water storage projects while a regional project is being planned, designed, or authorized for construction. Previous analysis of District lands have identified available parcels for interim projects that are currently being used for storage or are in the planning/design phases. The District is conducting an updated review of available District lands for additional interim project sites beginning with the C-23 and C-24 watersheds. This review is anticipated to be completed in FY2015.

Storage and Retention Projects on Private Lands

Projects on private land enhance Lake Okeechobee and estuary health by reducing discharge volumes and nutrient loading to downstream receiving waters through modifications to existing water management structures and implementing operational strategies. In many cases, storage, retention, and detention are obtained through execution of cooperative cost share agreements that maximize the benefits the project can provide. These projects typically have exceptional circumstances such as offering large, cost-effective benefits to the regional system, solving local or regional water resource-related issues, or benefiting multiple watersheds.

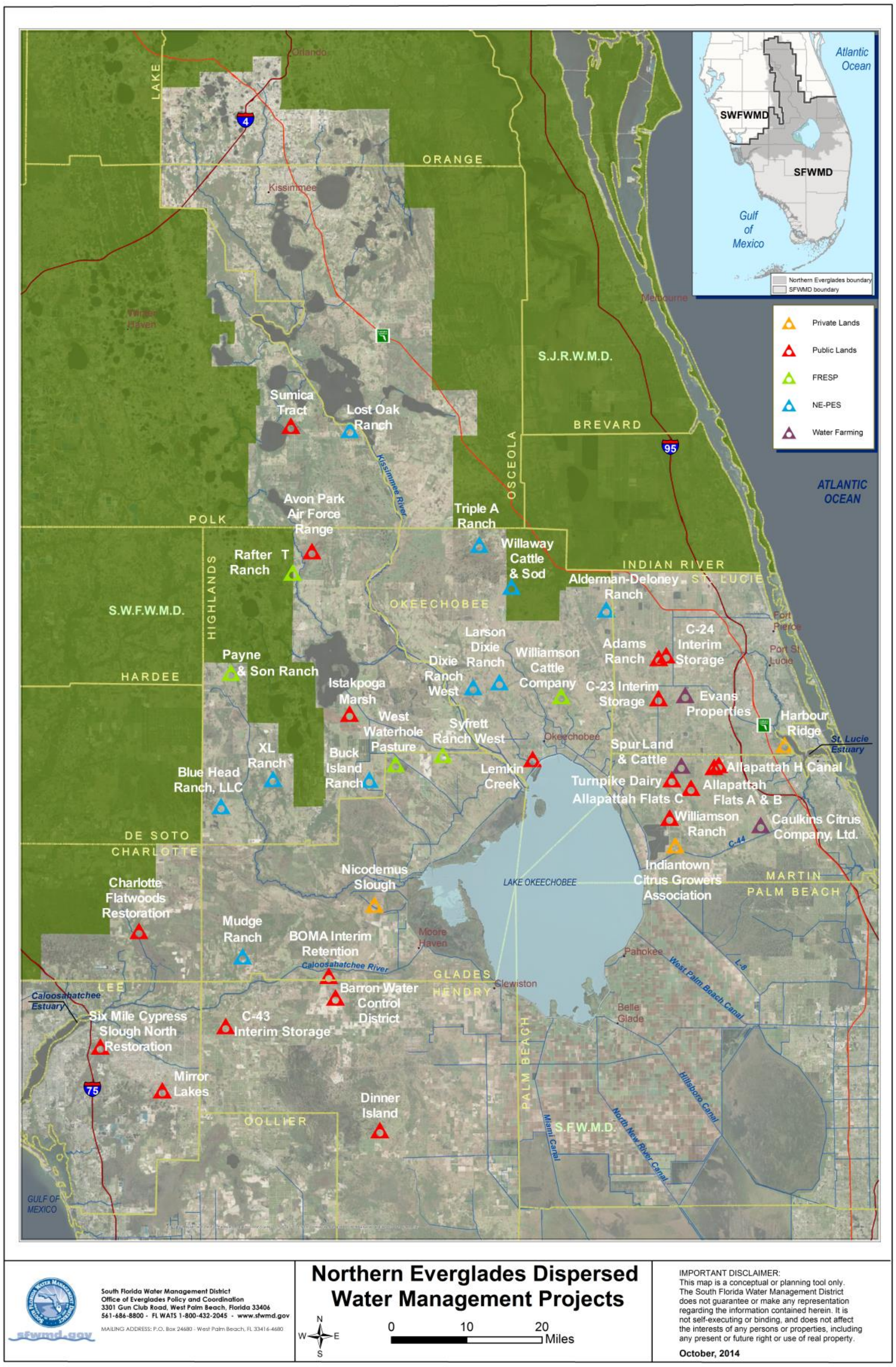

Figure 10-9. Dispersed Water Management (DWM) Projects Located in the Northern Everglades. Projects include water storage on private and public lands, Northern Everglades Payment for Environmental Services (NE-PES), Florida Ranchlands Environmental Services Projects (FRESP), and Water Farming.

Table 10-4. Comprehensive list of the SFWMD's Dispersed Water Management (DWM) projects, watershed and sub-watershed location, status, and estimated storage benefits.

Project Name	**Sub-Watershed**	**Category**	**Status**	**Estimated Storage Benefits (ac-ft/yr)**
Lake Okeechobee Watershed				**60,259**
Buck Island Ranch	Indian Prairie	NE-PES 1	Operational	1,573
Dixie West	Lower Kissimmee	NE-PES 1	Operational	315
Dixie Ranch	Taylor Creek Nubbin Slough	NE-PES 1	Operational	856
Lost Oak Ranch	Upper Kissimmee	NE-PES 1	Operational	374
Triple A Ranch	Lower Kissimmee	NE-PES 1	Construction	397
Willaway Cattle & Sod	Lower Kissimmee	NE-PES 1	Operational	229
XL Ranch	Fisheating Creek	NE-PES 1	Operational	887
Blue Head Ranch	Fisheating Creek	NE-PES 2	Construction	3,462
West Waterhole Pasture	Indian Prairie	Private Lands FRESP	Operational	4,848
Rafter T Ranch	Lake Istokpoga	Private Lands FRESP	Operational	1,145
Payne and Son Ranch	Fisheating Creek	Private Lands FRESP/WRP	WRP Operational	932
Williamson Cattle Company	Taylor Creek Nubbin Slough	Private Lands FRESP/WRP	WRP Operational	150
Nicodemus Slough	Fisheating Creek	Private Lands	Construction	33,860
Avon Park Air Force Range	Lake Istokpoga	Public Lands	Operational	10,000
Sumica Tract	Upper Kissimmee	Public Lands	Operational	281
Istokpoga Marsh Watershed Improvement District	Indian Prairie	Public Lands	Construction	950
Lemkin Creek	Taylor Creek Nubbin Slough	Public Lands	Planning	To be determined
Syfrett Ranch West	Indian Prairie	Private Lands FRESP	Non-Operational	Non-operational

Project Name	Sub-Watershed	Category	Status	Estimated Storage Benefits (ac-ft/yr)
St. Lucie Watershed				**23,061**
Alderman-Deloney Ranch	C-25	NE-PES 1	Operational	147
Caulkins Citrus	C-44/S-153	Water Farming	Operational	6,780
Evans Properties (Alt. E-1)	C-24	Water Farming	Construction	3,635
Spur Land & Cattle/Bull Hammock Ranch	C-23	Water Farming	Construction	870
Harbour Ridge	North Fork St. Lucie	Private Lands	Operational	667
Indiantown Citrus Growers Phase I and II	C-44/S-153	Private Lands	Operational	3,550
Adams Ranch Cattle and Citrus Operations (C-23/C-24 Complex)	C-24	Public Lands	Operational	190
C-23 Interim Storage (Section D - PC55)	C-23	Public Lands	Operational	110
C-23 Interim Storage (Section C)	C-23	Public Lands	Construction	212
C-24 Interim Storage	C-24	Public Lands	Planning	To be determined
Williamson Ranch/Turnpike Dairy	C-44/S-153	Public Lands WRP	Operational	547
Allapattah Parcels A and B - Phase I	C-23	Public Lands WRP	Operational	3,500
Allapattah Parcels A and B - Phase II	C-23	Public Lands WRP	Construction	1,243
Allapattah Parcel C	C-23	Public Lands	Planning	To be determined
Allapattah H Canal	C-23	Public Lands	Operational	1,610
Caloosahatchee Watershed				**9,882**
Mudge Ranch	West Caloosahatchee	NE-PES 2	Operational	396
Barron Water Control District	East Caloosahatchee	Public Lands	Operational	5,000
ECWCD Mirror Lakes/Halfway Pond Phase I	Tidal	Public Lands	Operational	1,000
BOMA	East Caloosahatchee	Public Lands	Operational	836
Six Mile Cypress Slough North	Tidal	Public Lands	Construction	1,400
C-43 Interim Temporary Storage	West Caloosahatchee	Public Lands	Operational	1,250
Charlotte Flatwoods Restoration	Tidal, West Caloosahatchee	Public	Planning	To be determined
Everglades Watershed				
Dinner Island Ranch	C-139	Public Lands	Operational	30

Northern Everglades Payment for Environmental Services

As the basis for the NE-PES Program, the Florida Ranchlands Environmental Services Pilot (FRESP) Project was a five-year pilot project to field-test and develop a PES program. FRESP partners included eight ranchers, World Wildlife Fund, Florida Cattlemen's Association, FDACS, FDEP, University of Florida Institute of Food and Agricultural Services (UF/IFAS), USDA NRCS, MacArthur Agro-ecology Research Center, and SFWMD. Further details of the FRESP Program are provided in Section 5 of the 2011 LOWPP Update.

An example of a very successful FRESP project that has continued operation through an extended agreement is the West Waterhole Pasture Project. It is a 2,370-acre marsh located in Glades County that drains into the C-40 (Indian Prairie) Basin. The project's goal is to remove phosphorus from on-site water (citrus grove) and regional water from the C-40 Canal by pumping canal water into the marsh and allowing the nutrients to be filtered out before gravity discharging back to the C-40 Canal. In 2013, a total of 5.5 billion gallons of water were pumped into the marsh. Twenty five percent of the total inflow volume was retained in the marsh. Monitoring data indicates that 6.4 metric tons of TP (87 percent of the total inflow) was retained in the marsh. Also, 16.12 metric tons of TN (30 percent of the total inflow) was retained in the marsh.

The coordinating agencies have expanded opportunities for DWM in the Northern Everglades watersheds whereby private landowners manage water on parts of their property to provide two different water management services: water retention/storage or nutrient (TP or TN) load reduction through the District's NE-PES Program. Solicitations released through this program allow for an innovative approach by offering eligible cattle ranchers the opportunity to compete for contracts for water and nutrient retention. The goal of the NE-PES Program is to establish relationships via contracts with private landowners to obtain the water management services of water retention and nutrient retention to reduce flows and nutrient loads to Lake Okeechobee and the estuaries from the watersheds. The NE-PES is a working program that keeps ranchers working and reduces pressure to convert ranchlands to development or other more intense agricultural uses. The District is responsible for administering this program in coordination with the FDACS, FDEP, and USDA NRCS.

The first NE-PES solicitation was released in January 2011 offering eligible cattle ranchers the opportunity to compete for contracts for water and nutrient retention. Eight water retention contracts were awarded as a result of that solicitation. All eight projects are operational. The total estimated retention is 4,778 ac-ft.

The second NE-PES solicitation was released in December 2012, once again offering eligible cattle ranchers the opportunity to compete for contracts for water and nutrient retention. Nineteen submittals were received. The proposals were evaluated and ranked based upon defined evaluation criteria. The SFWMD Governing Board, at its July 11, 2013 meeting, authorized agency staff to begin negotiating with the respondents in ranked order.

As of October 1, 2014, the first two ranked projects, Blue Head Ranch and Mudge Ranch, entered into agreements with the District for a total estimated retention volume of 3,858 ac-ft. Mudge Ranch is operational and the Blue Head Ranch contract was assigned to a new landowner and is in the final design and permitting phase. Additional funding was not available to continue negotiations in ranked order. However, during the 2014 legislative session, additional funding was appropriated for FY2015 that enabled the District to resume negotiations in ranked order for execution of additional contracts and, as a result, six additional NE-PES contracts were executed. These additional projects are expected to be reported in the next SFER. NE-PES projects will be operated as long as funding is available for up to 10 years, as stated in the contracts.

Water Farming Payment for Environmental Services Pilot Program

An innovative approach to delivering environmental services, similar to NE-PES, is the Water Farming Payment for Environmental Services (WF-PES) pilot program. This concept seeks to field test the potential for retaining water on fallow citrus lands. Two feasibility analysis were completed; in April 2012 by the Indian River Citrus League, and in October 2013 by the Gulf Citrus Growers Association, both under cooperative agreements with the District. The DWM Program WF-PES pilot projects will help determine the cost-effectiveness and benefits associated with retaining water on fallow citrus lands. A WF-PES pilot project request for proposal solicitation for the SLE Watershed area (Martin and St. Lucie counties) closed on June 5, 2013, with five submitted proposals. On July 11, 2013, the District's Governing Board authorized agency staff to begin negotiating with the respondents in ranked order, resulting in three executed contracts. This program is partially funded through a Clean Water Act Section 319(h) grant agreement with the FDEP. The estimated total storage available is 11,285 ac-ft. The projects will be constructed and then operated for two years to gather data and identify lessons learned for any future WF-PES projects.

LOCAL WATER QUALITY AND RESTORATION PROJECTS

These projects are local government led initiatives that individually provide local benefits, but collectively can provide benefits on a sub-regional to regional scale. There are several local water quality and restoration projects identified in both the St. Lucie and Caloosahatchee RWPPs including storm water improvements and retrofits, wastewater improvement projects (septic to sewer), and habitat restoration projects (e.g., muck sediment removal, oyster habitat creation, and wetland restoration). A comprehensive list local projects was previously identified in the St. Lucie RWPP and Caloosahatchee RWPP (SFWMD et al. 2009 a,b), as well as the 2012 updates (SFWMD et al. 2012 a,b).

As part of the St. Lucie River and Estuary Basin Management Action Plan (BMAP), the Florida Department of Environmental Protection (FDEP) produced an inventory of local water quality projects conducted since 2000. Many of the projects had been previously identified in the SLRWPP process. These projects have been completed or will be by mid-June 2018 and include storm water improvements, retrofits, and waste water improvement projects (septic to sewer; FDEP, 2013). Appendix D (BMP Efficiencies and Projects to Achieve the TMDL, FDEP 2013) of the final BMAP includes a list of adopted projects to reduce TN and TP loading in the first five-year iteration of the BMAP. The FDEP performed a similar inventory with the same time frame (2000) for the Caloosahatchee Estuary BMAP and those projects can be found in Appendix E of the Caloosahatchee Estuary BMAP (FDEP 2012). Similar to the St. Lucie, many of the local projects used in the Caloosahatchee Estuary BMAP had been identified in the RWPP process. For both watersheds, tracking the inventory of projects, both funded and unfunded, and estimating project nutrient benefits is now done through implementation of the BMAPs. Typically, however, since BMAPs are enforceable and entities are bound to implement the projects within, only projects with a high level of implementation certainty are included in the actual BMAPs.

In many cases, the inclusion of projects in an approved watershed protection plan or a BMAP increases the probability of receiving grant funding (e.g., TMDL or Clean Water Act Section 319 grant). To assist local entities with quests to secure funding for their construction projects that will improve the water quality, quantity, and habitats in the river estuaries and watersheds, **Table 10-5** incorporates several projects (both specific and generic) into the watershed protection plans. It should be noted that this list is designed to allow for any water quality, water quantity, or habitat restoration project within the river watershed boundaries to be included in an approved watershed plan either by specific reference or incorporation into the generic project descriptions.

However, this is not intended to be a comprehensive list of local projects. The information for specific projects was conveyed to the SFWMD through means such as the Caloosahatchee Community Forums or the St. Lucie and Indian River Lagoon Issues Team Processes. Both of these processes are examples of efforts that identify and prioritize local projects. Other projects not specifically referenced fall under the generic project descriptions. Also, to assist stakeholders further, a list of potential funding sources is provided in Appendix 10-1 of this volume.

Table 10-5. Example local water quality and restoration projects in the Caloosahatchee and St. Lucie Watersheds.

Project Name	Project Description	Project Status	Entity
Generic Project Descriptions			
Water Quality/ Quantity Monitoring	Potential need for future water quality or quantity by local stakeholders to assess local projects and/or water resources	This project is in the conceptual stage.	Any local entity in the river watersheds
Septic Tank to Wastewater Collection System Conversion Projects	This recognizes projects to convert properties currently on septic tanks to municipal wastewater collection systems. The specific technology as well as scale and magnitude will vary per project. This may also include vacuum system conversions.	Some phases have been implemented by various entities (e.g., Martin County) and several are planned (e.g., City of Stuart, Martin County, St. Lucie County, and City of Cape Coral). Numerous entities are actively pursuing funding opportunities.	Any local entity in the river watersheds
Stormwater Retrofits	The implementation of new stormwater project(s), or the improvement of existing ones, in a previously developed area (e.g., baffle box installation)	The status will be project specific.	Any local entity in the river watersheds
Canal Dredging & Ditch Improvements	The removal of material (e.g., bottom sediments) from water bodies for purposes which may include improvements in water storage and/or quality, and habitat enhancements.	The status will be project specific.	Any local entity in the river watersheds
Habitat Restoration	The restoration of degraded ecological habitats. (e.g., oyster reef construction).	The status will be project specific.	Any local entity in the river watersheds
Hydrologic Restoration	The restoration of altered hydrological patterns (e.g., the filling in of channelized waters and replacing with constructed river oxbows).	The status will be project specific.	Any local entity in the river watersheds
Other Water Storage Projects	The enhancement of opportunities for storing excess surface water on private and public lands (e.g., enhancing a weir structure to store water).	The status will be project specific.	Any local entity in the river watersheds
Specific St. Lucie Watershed Projects			
Indian Hills Stormwater Retrofit formally known as Heathcote Park/Virginia Ave. Canal Stormwater Retrofit	The project will construct a treatment train including installation of six different Stormwater BMPs on 60-acres of land jointly owned by St. Lucie County and the City of Fort Pierce.	This project is currently under construction. Anticipated completion date is March 2015.	City of Fort Pierce & St. Lucie County
E-8 Waterway Phase 3 Water Quality Retrofit	This project is the third phase of a stormwater quality retrofit for the existing E-8 Waterway that discharges into the C-24 Canal.	This is the third and final phase of a multi-phase project. Phases 1 and 2 have been completed.	City of Port St. Lucie
Kingsway Waterway Stormwater Quality Retrofit	This is a stormwater quality retrofit BMP consisting of baffle boxes, control structure improvements, removal of exotic vegetation and accumulated sediment.	The project has been delayed.	City of Port St. Lucie
McCarty Ranch Preserve Water Storage and Rehabilitation Project	The project's first phase includes construction of on-site facilitates to hold stormwater runoff on site and detain it from entering the C-23 Canal. It also help rehydrate on-site wetlands and assist in the re-establishment of historic hydrology.	This is a multi-phased project. Planning and preliminary design are under way. The city is actively pursuing funding opportunities.	City of Port St. Lucie

Table 10-5. Continued.

Project Name	Project Description	Project Status	Entity
Port St. Lucie Waterway and Canal Dredging Project	The project entails the removal of muck and accumulated sediments from the waterways of the City along with the construction of the associated disposal site, benthic habitat restoration, and water quality enhancement.	The project is currently unfunded but the city is actively pursuing funding opportunities.	City of Port St. Lucie
Veterans Memorial Storm Water Quality Retrofit	The project will consist of the installation of discharge control structures at the existing outfalls leading to the North Fork of the St. Lucie River and expansion of the existing swales upstream of the control structures and creation of additional wet detention ponds to provide additional stormwater storage.	The city is currently in the design/permitting phase of the project and is actively pursuing funding opportunities.	City of Port St. Lucie
All American Ditch Water Quality Improvement Project	The project proposes to install a water quality weir and fill, and re-grade a portion of All American Ditch to divert stormwater runoff to a proposed pipe system that will convey the flows south to a lake and STA, configured in a treatment train system, located on a 36-acre parcel, currently owned by the SFWMD.	The county just executed a St. Lucie River Issues Team Contract with the FDEP for this project. Construction is anticipated to start in October 2016.	Martin County
Danforth Creek Muck Removal Project	This is a construction and habitat restoration dredging project to improve water quality of the Danforth Creek discharge to the St. Lucie River Estuary.	The project is currently unfunded but the county is actively pursuing funding opportunities.	Martin County
Jensen Beach CRA Phase 1 - Retrofit - Urban Section	The goal of this project is to provide a water treatment area for future developments within the Jensen Beach area. In addition, this project will include a Phase 1 exfiltration/inlet/baffle box system. t.	This project is part of the Community Redevelopment District's Master Plan for Jensen Beach and is currently on the county's Second Priority Project List of Stormwater and Water Quality Needs Assessment.	Martin County
Manatee Pocket SW Prong Baffle Box Project	The project entails the installation of a nutrient separating baffle box within County road right-of-way, at the intersection of SE Cove Road and SE 45th Street that will provide sediment and nutrient treatment over an approximately 90-acre basin.	The County just executed a St. Lucie River Issues Team Contract with FDEP for this project. Construction is anticipated to be completed October 2015.	Martin County
Martin Golf Course Water Quality Improvement Project	This project will retrofit three existing culverts with risers each equipped with a weir and bleeder, and the installation of a 6" diameter bleeder pipe at a fourth location in order to achieve water quality treatment within existing lakes on the original 18-hole golf course.	This project received funding from the St. Lucie River Issues Team, contract pending.	Martin County
Old Palm City Retrofit Phase IV - Mapp Road	The goal of this project is to reduce stormwater pollution by redirecting the Mapp Road corridor's untreated stormwater from flowing east through a residential watershed directly into the St. Lucie estuary.	This project is part of the Community Redevelopment District's Master Plan for Old Palm City and is currently on the county's First Priority Project List of Stormwater and Water Quality Needs Assessment.	Martin County
Port Salerno Storm Water Retrofits	This project entails construction of swales as well as exfiltration and baffle boxes for three residential streets.	The project is currently unfunded but it is listed on the county's priority list for Stormwater and Water Quality Needs Assessment.	Martin County
Warner Creek Muck Removal Project	This is a construction and habitat restoration dredging project to improve water quality conditions of Warner Creek that connects to the St. Lucie River Estuary.	The project is currently unfunded but the county is actively pursuing funding opportunities.	Martin County

Table 10-5. Continued.

Project Name	Project Description	Project Status	Entity
Willoughby Creek Stormwater Quality Improvement Project	This project proposes to install additional stormwater quality control structures further upstream and create shallow STAs with deep, wet detention lakes. The project will be configured in a treatment train system.	This project is currently unfunded but it is on the county's Second Priority Project list for Stormwater and Water Quality Needs Assessment; the county is actively pursuing funding opportunities.	Martin County
Harmony Heights Stormwater Improvements	This project will treat one inch runoff volume for a 300+/- acre stormwater sub basin in dry detention ponds. Additional treatment will be provided through swales.	Phase 1 of this project has been completed. Phases 2-5 are in various phases of design and planning.	St. Lucie County
Paradise Park Stormwater Improvements Phase 4-Construction	This project is phase 4 of a multi-phase project to retrofit an older subdivision with drainage improvements and water quality BMPs. This phase will include stormwater conveyances and treatment systems as well as road grading and paving.	This project has received funding from the Indian River Lagoon Issues Team; the contract is pending.	St. Lucie County
White City Drainage Project	The project includes the construction of a +/- 4-acre wet detention pond to treat and attenuate stormwater runoff from the low-lying neighborhood that also has historic flooding problems.	This project is currently under construction and is anticipated to be completed in March 2015.	St. Lucie County
South Sewall's Point Road Baffle Boxes	This project addresses 9 of the 51 outfalls in Town of Sewall's Point Stormwater Management Plan which will be retrofitted with baffle boxes to remove sediments from approximately 18-acres of developed land.	This project is currently unfunded but the town is actively pursuing funding opportunities.	Town of Sewall's Point
So. Sewall's Point Road Mandalay to Marguerita	The proposed project entails providing a stormwater retention area in a low-lying area to provide water quality treatment and to protect a major town collector roadway.	The town is actively pursuing funding opportunities.	Town of Sewall's Point
Phillip C. Gates Structure Retrofit	This project will retrofit the ultimate discharge structure for the Fort Pierce Farms Water Control District with split gates enhancing its ability to release water without releasing sediment.	This project has received funding from both the Indian River Lagoon Issues Team and the Indian River Lagoon License Plate Program; contracts are pending.	Treasure Coast Resource Conservation Development Council
Specific Caloosahatchee Watershed Projects			
Babcock Ranch Preserve Water Storage Project	The project will provide shallow water storage by improving existing berms, constructing new berms, modifying existing water control structures and installing new water control structures.	Design is to be conducted in FY2014/2015; funded by Florida Department of Agriculture and Consumer Services (FDACS). Construction funding will be required in FY2015/2016.	FDACS and multiple partners
SR 29 Improvements	Additional stormwater improvements to be incorporated into SR 29 road improvements located between the City of LaBelle and US 27.	Project in design and construction anticipated within next five years. Florida Department of Transportation (FDOT) coordinating potential collaboration with other entities for project enhancements.	FDOT and multiple partners
Charlotte Harbor Flatwoods Initiative	This is multi-phased regional hydrologic restoration effort with the overall goal to restore historical flows to Charlotte Harbor. The project involves the development of regional water storage and treatment facilities, establishment of conveyance systems and restoration of habitat to restore sheetflow across five watersheds encompassing approximately 90 square miles.	Potential land acquisition of 670 acres in conjunction with I-75 improvements is anticipated in 2014 (funding in place). Funding for final design and construction of storage facility is required. Funding for conceptual design is expected to be provided by Southwest Florida Water Management District (SWFWMD) and FDOT and to begin in winter 2014. Additional design and construction funding will be required.	FDOT, SWFWMD, and multiple partners

Table 10-5. Continued.

Project Name	Project Description	Project Status	Entity
Carlos Waterway Conveyance	A conceptual habitat enhancement and water quality improvement project to use an existing waterway owned by East County Water Control District (ECWCD) to convey water from C-43 West Basin Storage Reservoir into the Caloosahatchee River	A conceptual design study is required.	TBD: Potential entities include ECWCD
Lee-Charlotte County Border Area Hydrologic Improvement	This project involves reconnecting and improving the hydrology of the area through the construction of a series of filter marshes and weirs within and adjacent to the FPL transmission line.	A conceptual design study is required. It is unknown at this point if land acquisition will be required. The project requires collaboration with Florida Power & Light (FPL) and multiple land owners.	TBD: FPL and multiple partners
Harns Marsh Improvements – Phase III (West Marsh) Project	The project involves an existing 578-acre ECWCD stormwater treatment facility. Phase III includes designing the West Marsh (additional 202+/- acres) to expand the marsh treatment facility to reduce freshwater discharges to the Caloosahatchee River.	All necessary lands have been acquired. Project design is currently under way. The project involves collaboration with multiple agencies including FDOT as a potential source for construction funding.	ECWCD and potential partners
Nalle Grade Stormwater Park Project	Lee County project proposes to restore/modify an existing degraded marsh system and design a stormwater retention facility to minimize flooding in the Bayshore Creek Watershed.	Project is in design and permitting. $500,000 in Legislative funding was appropriated. Construction is scheduled to begin in 2016.	Lee County
Ford Canal Filter Marsh (Ford Street Preserve) Project	This project creates a filter marsh to improve overall quality of storm water discharging into Billy Creek; marsh is intended to work collectively with other treatment areas along Billy Creek and its tributaries.	Phase 1 has been completed; Phase has been 2 awarded with construction to begin in August 2014; Phase 3 is being permitted.	Ft. Myers
Fichter's Creek Restoration Project	This project provides ecosystem restoration through hydrologic and water quality improvements in Fichter's Creek, and provides flood protection for neighboring areas;	No land acquisition is required. Project has been permitted; construction is planned to begin in FY2016.	Lee County
Aquifer Benefit and Storage for Orange River Basin (ABSORB) Project	This project involves increasing stormwater storage capacity and groundwater recharge in the Southwest area of Lehigh Acres by constructing 27 weirs.	Project is designed and permitted. Construction is slated to start by the end of 2014. Partial funding is in place (FDEP $1.2M) and remainder being coordinated with an FDOT agreement.	ECWCD, FDOT, FDEP
Hickey Creek Canal Widening Project	This project includes the canal widening and construction of littoral zones along three miles of Hickey Creek Canal.	Project is designed and permitted. Construction is waiting on funding and coordination of fill material removal	ECWCD
Hendry Extension Canal Widening Project	This project provides additional water quantity storage within existing canal right-of-way to help provide more stormwater storage in the 5.5 mile section of Hendry Extension Canal.	Project permitted and designed, construction projected in FY2015.FDOT providing funding through SR82 expansion.	ECWCD, FDOT
City of LaBelle Stormwater Master Plan Implementation	This project includes stormwater conveyance and water quality storage improvements, some of which have been implemented (e.g., retrofits)..	Funding required to continue design and construction of additional projects.	City of LaBelle
North Ten Mile Canal Stormwater Treatment System Project	This project provides stormwater storage and treatment for an urban and commercial area with the City of Ft. Myers.	FDEP permit is being reviewed for a modification. Project scheduled to begin in next five years.	Ft. Myers
Sunniland/Nine Mile Run Drainage Improvements	This project involves the restoration of historical flows to Buckingham Trails Preserve through the removal of manmade alterations to correct the natural sheetflow and hydrology.	Requires land acquisition. Project design scheduled during FY2014/2015 with construction in FY2015/2016.	Lee County

Table 10-5. Continued.

Project Name	Project Description	Project Status	Entity
Yellow Fever Creek/Gator Slough Transfer Facility Project	This project involves the hydrologic restoration of the historical flows to the headwaters of Yellow Fever Creek. Project includes the construction of an interconnection facility between Gator Slough Canal and Yellow Fever Creek to transfer surface waters during high flow.	Conceptual design is complete. Permitting to begin in FY2015 pending further coordination between Lee County and City of Cape Coral.	Lee County, Cape Coral
Billy Creek Restoration Dredging	Removal of exotic vegetation and dredging of Billy Creek.	Project is permitted. Project to begin in FY2016.	Ft. Myers
Moore Haven Canal Dredging	Deepening and widening of Moore Haven Canal. Will provide sediment reduction, an increase in wetland habitat, and water quality benefits to the Caloosahatchee River	State and federal permits have been approved. Partially funded in FY2013–FY2014.	Glades County
Greenbriar Preserve Project	This project involves modifications within Greenbriar Swamp and to the connecting canal/swale system to increase surface water connectivity and storage within the swamp, thereby reducing freshwater discharges.	Project is included in the ECWCD FY2014-FY2018 Capital Improvement Plan. Project requires further design work.	ECWCD Lee County
Section 10 Storage Project	This project includes modifying an existing mine pit to allow for additional surface water storage in the ECWCD Water Management System.	Requires land acquisition. Project requires further design work.	ECWCD
Hendry County Storage Project	This project consists of the construction of shallow water storage facility to help reduce nutrient loading to the CRE. The project is expected to have the capability of providing timed releases of water to the estuary.	Project was included in the ECWCD FY2010-FY2014. Capital Improvements Plan and ECWCD have evaluated three sites for possible acquisition. Funding will be required for land acquisition, design and construction.	ECWCD
Spanish Creek Preserve Restoration	This project involves the acquisition of agricultural lands to create shallow water storage and wetland flow-way to rehydrate the Ruby Daniels Preserve at Spanish Creek.	Phase 1 involving the rehydration of a portion of Ruby Daniels Preserve was completed in 2014. Design and acquisition of approximately 640 acres land is required for construction	Lee County
Lehigh Wetland Restoration	Undeveloped lots will be purchased to restore remnant wetlands through the construction of one weir. Project is approximately 710 acres located in the Greenbriar Swamp area.	Funding needed to initiate the project.	Local Multiple
Mirror Lakes Storage/Rehydration Project	Multi-phase project intended to rehydrate Mirror Lakes (also named Halfway Pond), reduce peak flow discharges to the Orange River, and restore flows to the headwaters of the Estero River.	Phase I completed October 2012 Phase II and III involves moving water south under SR 82, and is in the planning and preliminary design stage.	ECWCD, FDOT, SFWMD
Cape Coral Canal Stormwater Recovery by Aquifer Storage and Recover (ASR) Project	This project uses ASR wells in Cape Coral to overcome water shortfall in the dry season and provide flood attenuation in the wet season. Project is expected to provide multiple benefits including flood control,	Three ASR wells were constructed in 2007; however, cycle testing has not started and construction of pumping stations and associated connections is not anticipated until 2015 due to budgetary constraints.	Cape Coral
Stumper Jumper Ranch Land Acquisition	Project involves the acquisition and restoration of 149 acres of disturbed land located within the Spanish Creek watershed in northeast Lee County.	Project design and acquisition required. Former Lee County Conservation 20/20 nomination.	Lee County
Lehigh Acres Stormwater Retrofit Project	Project involves installing stormwater treatment features in Lehigh Acres, updating current stormwater management system,	Project requires funding to continue.	Multiple

Table 10-5. Continued.

Project Name	Project Description	Project Status	Entity
Fort Myers-Cape Coral Reclaimed Water Interconnect Project	This project includes installing a 20-inch diameter transmission line from Fort Myers Treatment Plant to Cape Coral Reclamation Treatment Plant.	The feasibility study completed in 2010 found that constructing a disposal well was a less expensive near-term option; however, project is still desirable as a long-term option. Legislative funding for additional study was appropriated for FY2014–FY2015.	Cape Coral Ft. Myers
Shoemaker-Zapato Canal Stormwater Treatment Project	This project includes installing weir/water control structures to increase channel storage and provide peak flow attenuation. It will enhance water quality and reduce erosion and siltation into Billy Creek.	Additional study required	Ft. Myers
Winkler Canal Treatment Marsh Project	This project creates a treatment marsh designed to divert and treat low flows from low-level rain events using a diversion weir.	Project has been permitted but is on-hold pending funding for land acquisition.	Ft. Myers

NORTHERN EVERGLADES STORAGE GOALS AND EFFORTS

STORAGE GOALS

The NEEPP recognizes the importance of managing the quantity, timing, and distribution of water from the three Northern Everglades watersheds to achieve the integrated and comprehensive environmental restoration of Lake Okeechobee and the Caloosahatchee and St. Lucie estuaries. As a result, an analysis has been conducted for each of the three protection plans to determine the amount of water that needs to be stored in each watershed to achieve these objectives. The CRWPP and SLRWPP indicate that 400,000 and 200,000 ac-ft of storage are needed in each of these watersheds respectively in order to address local basin runoff, while the magnitude of storage needed in the Lake Okeechobee watershed varies depending on assumptions regarding delivery and storage volumes south of Lake Okeechobee. In the Lake Okeechobee Phase II Technical Plan (LOP2TP), an analysis was conducted to calculate the amount of water storage needed in the Lake Okeechobee watershed to better manage water levels in Lake Okeechobee and reduce excess damaging freshwater releases to the estuaries. This analysis included several critical assumptions including: no additional water can be sent south, water supply for existing users must be maintained, and additional storage will be needed in each of the estuary watersheds to address local basin runoff. Based on these assumptions, modeling analyses conducted using the Northern Everglades Regional Simulation Model (NE-RSM) indicated that approximately 900,000-1,300,000 ac-ft of storage was needed in the Lake Okeechobee Watershed to help manage lake levels and reduce discharges to estuaries. The analysis indicated there was a breakpoint between 900,000 and 1,300,000 ac-ft of storage, above which additional increases in storage capacity would provide relatively small improvements in damaging releases to estuaries.

Since the time of the original LOP2TP storage analysis, several other regional planning efforts have been conducted that have also evaluated flow and storage needs north or south of Lake Okeechobee. For example, during the River of Grass Phase I planning effort, it was recognized that additional flows to the south, specifically to Everglades National Park (ENP or Park) and Florida Bay, were desirable. In recognition of this increased demand for flows south, screening level modeling analyses were conducted to evaluate varying volumes of storage north and south of Lake Okeechobee. The River of Grass modeling indicated that approximately 700,000-1,100,000 ac-ft of storage was needed in the Northern Everglades and EAA. The analysis also showed that there are certain combinations of storage north and south of the lake that perform better at environmental objectives, such as managing lake levels and reducing harmful discharges to the estuaries, and that approximately 450-575,000 ac-ft of storage is needed north of Lake Okeechobee. More recently, the Central Everglades Planning Project (CEPP) has evaluated sending approximately 210,000 average annual ac-ft of additional Lake Okeechobee water to the south through a series of new project features. The modeling conducted for CEPP indicated that the proposed project features and operations could significantly reduce damaging discharges to the estuaries.

It is clear from all these modeling efforts that additional storage is needed in the Everglades system and most analyses seem to indicate that at least an additional million acre-feet of storage is needed throughout the system. Regardless of the assumptions used, it is evident that the Lake Okeechobee Watershed still needs significantly more storage, on the order of several hundred thousand acre-feet or more.

Starting in late FY2014, the District kicked off an effort to reevaluate storage needs north of the Lake with varying storage south of the lake to minimize damaging discharges to the estuaries, maintain the lake within ecologically desirable range, and send water south for restoration. The focus of this effort is on the north storage needs, and the effort will identify the storage goals for the sub-watersheds north of the lake and determine the best tools to accomplish these goals (suitability analysis and cost effectiveness analysis). It is anticipated that this effort will take 1.5 to 2.5 years to complete.

STORAGE EFFORTS

Storage in the Northern Everglades will need to be accomplished through a strategic combination of regional and dispersed storage distributed throughout the watershed. The St. Lucie and Caloosahatchee River Watershed Protection Plans identify several measures to increase storage within the watersheds. Additionally, the Lake Okeechobee Watershed Protection Plan identifies several measures to improve both water levels within the Lake and the quantity and timing of discharges from Lake Okeechobee to the northern estuaries to achieve more desirable salinity ranges. These measures are being implemented in various ways and scales throughout the Northern Everglades.

Many of the regional storage components in the Northern Everglades are part of CERP, which provides a framework and guide to restore, protect and preserve the water resources of central and southern Florida, including the Everglades. The USACE is the federal partner and the District is the local sponsor. The C-44 Reservoir and STA Project, a CERP IRL-S PIR feature in the St. Lucie Watershed, is currently being constructed in phases, with the storage capacity of the reservoir being 50,600 ac-ft. Once implemented, the entire SLRWPP CERP IRL-S PIR features are anticipated to provide the 200,000 ac-ft of storage estimated to be needed in the St. Lucie Watershed. Of particular interest in the Caloosahatchee River Watershed is the C-43 West Basin Storage Reservoir, which is anticipated to provide up to 170,000 ac-ft of storage when fully completed. This important storage project received federal authorization within the 2014 Water Resources Reform and Development Act. Also in 2014, the State of Florida appropriated $18 million to design and construct a C-43 Early Start Project, which would have provided interim water storage on-site until the full reservoir could be completed. The state is now planning to move forward to complete Phase I of the full C-43 Reservoir Project by 2019.

The storage, retention, and detention created by projects within the DWM Program since 2005 will be approximately 93,202 ac-ft. In addition, there are regional projects in the Northern Everglades currently under construction that will contribute towards achieving storage goals. Further exploring opportunities to store water, the District is investigating an innovative approach to delivering environmental services, similar to NE-PES, known as the WF-PES pilot program (as previously discussed). This concept seeks to field test the potential for retaining water on fallow citrus lands. Also, utilization of publicly owned lands for interim storage until the large regional projects are built provides a short-term opportunity for water storage. Accordingly, the District is planning to implement two interim land projects on the C-23/C-24 Complex and Allapattah Flats properties in the St. Lucie River Watershed. In the Caloosahatchee River Watershed, the District uses portions of the BOMA and Berry Groves properties to store excess water. There are also several cooperative projects in the Caloosahatchee River Watershed that will restore natural flow paths and divert water away from the C-43 River. One such effort is the Charlotte Flatwoods Hydrologic Restoration Project, which will restore the flow pathways from Cecil Webb Water Management Area (WMA) to Yucca Pens, thereby diverting excess water that currently flows from the WMA to the Caloosahatchee River. Another is the Six Mile Cypress Watershed Initiative, which will restore flow from portions of the Six Mile Cypress Slough Preserve that currently flow north into the Orange River and then the Caloosahatchee River back to the historical southerly flow path.

Also, several other efforts will contribute to helping achieve a balance between the storage needed north and south of the lake. South of the lake, the Central Everglades Planning Project is estimated to provide the capacity to send an additional 210,000 ac-ft of water south by implementing CERP features. On August 8, 2014, the USACE released the revised final report for the CEPP for public comment and, following the public comment period, the USACE is working toward finalizing the Chief's Report. In the Lake Okeechobee Watershed, the Kissimmee River Restoration Project, currently scheduled to be completed in 2017, is estimated to provide up to 100,000 ac-ft of dynamic storage north of the lake.

The Lake Okeechobee Phase II Technical Plan relied heavily on the CERP Lake Okeechobee Watershed (LOW) Project for achieving the plan goals of maintaining the lake within ecologically desirable range and minimizing damaging discharges to the Northern Estuaries. The LOW Project objectives are to provide better management of lake water levels, reduce damaging discharges to the downstream estuaries, restore isolated wetlands, and resolve water resource problems in Lake Istokpoga. Reservoirs, STAs, wetland restoration, and a modified Lake Istokpoga regulation schedule were anticipated components. The project delivery team presented the Tentatively Selected Plan (TSP) to the USACE in February 2007. However, the project formulation phase was subsequently put on hold due to water quality cost-sharing policy challenges. To date, these challenges have not been resolved. Moreover, an increased understanding of the appropriate location and distribution of regional storage within the Lake Okeechobee Watershed gained through other subsequent initiatives may warrant reformulation of the draft 2007 TSP.

The District is considering re-initiating formulation of the storage components of the LOW Project within the next several years; however, this requires concurrence from the federal partner (USACE). The first steps of this process will be to approach the federal partner on initiating reformulation and assess the impacts on the overall CERP Integrated Delivery Schedule (IDS) and CERP cost-share crediting. If the USACE is amenable and impacts to the IDS and cost-share crediting are acceptable to the partners, then the District anticipates re-initiating formulation within the next several years. In the past, plan formulation has ranged from six to eight years; however, the USACE has streamlined their planning processes and are working to complete these types of planning efforts within a three-year timeframe.

WATERSHED RESEARCH AND WATER QUALITY MONITORING

ESTUARINE HABITATS AS INDICATORS OF INFLOW

Knowledge of the environmental conditions that favor biologically productive estuarine habitats can be used to help establish freshwater inflow criteria for better decision making (Doering et al., 2002; Wolanski et al., 2004; Volety et al., 2009; Adams et al., 2009). This is a concept that is being applied particularly to water management in coastal Texas, Australia, South Africa, and South Florida. The management challenge for these subtropical coastal landscapes is to maintain valuable estuarine goods and services (e.g., fishery production, water quality improvement, shoreline stabilization), while balancing the management of other significant water resource needs in the watershed such as water supply and flood protection. The Coastal Ecosystems Research Plan Update presented in Appendix 10-2 discusses some of the efforts to assist the management challenges.

Historically, seagrass meadows and oyster reefs are salient features of the landscape in South Florida estuaries. To evaluate the ecological conditions of the SLE and CRE, SAV and oysters are routinely monitored. SAV are commonly monitored to gauge the health of estuarine systems (Tomasko et al., 1996; Duarte et al., 2008; Buzzelli et al., 2012) and their environmental requirements can form the basis for water quality goals (Dennison et al., 1993). Oyster beds are a good indicator of estuarine condition as the distribution and abundance of the eastern oyster have ecosystem-scale implications. Oyster beds filter water and suspended solids, couple the water column to the benthos, and provide living aquatic habitat (Peterson et al., 2003; Coen et al., 2007; Buzzelli et al., 2012).

Different species of SAV have different tolerances for environmental variables including temperature, submarine light penetration, inorganic nutrient availability and salinity (Short et al., 1993; Lirman and Cropper, 2003; Lee et al., 2007; Duarte et al., 2007). While all these variables are important and inter-related, salinity is a useful explanatory tool (Lirman et al., 2008; Buzzelli et al., 2012). In the case of the CRE, the freshwater SAV tape grass (*Vallisneria americana*) provided the indicator habitat to help prescribe freshwater delivery through S-79 (Doering et al., 2002). Tape grass is very sensitive to both increased salinity and decreased submarine light availability (Bortone and Turpin, 2000; French and Moore, 2003).

The SLE and CRE have different inflow and salinity optima given differences in estuarine geomorphology, volume, flushing, and inflow characteristics (Buzzelli et al., 2013d). Oyster habitat provides the biotic indicator of salinity and freshwater discharge in the SLE (USACE and SFWMD, 2004; Buzzelli et al., 2012; 2013c). Oyster physiology, survival, and growth are optimal when salinity fluctuates from 8 to 25 in many estuaries, including the SLE and CRE. Systematic analyses of inflows determined that discharge ranging from approximately 350 to 2000 cfs can help to maintain salinity of 8 to 25 in both estuaries (USACE and SFWMD, 2004; Wilson et al., 2005; Volety et al., 2009; Buzzelli et al., 2013a).

To protect valuable resources, critical salinity criteria have been established at Fort Myers as part of the Caloosahatchee River Minimum Flows and Levels (MFLs) (SFWMD, 2000; SFWMD, 2003). Additional salinity data collected at the I-75 Bridge supports implementation of the Lake Okeechobee Regulation Schedule. The Fort Myers location has two salinity criteria: (1) maintaining daily salinity averages of less than 20, and (2) 30-day salinity averages of less than 10, while the critical salinity criteria at I-75 is less than 5. At the estuary-scale, average monthly inflows of 300–2,800 cubic feet per second (cfs) at S-79 are conducive both to tape grass and favorable for seagrass and oyster habitats in the polyhaline CRE (Chamberlain and Doering, 1998; Doering et al., 2002; SFWMD, 2003).

SLE HYDROLOGY, WATER QUALITY AND AQUATIC HABITAT

Methods

A suite of external drivers and ecological responses are monitored in the St. Lucie River Watershed, St. Lucie Estuary, and the southern Indian River Lagoon (SIRL). These variables include rainfall, freshwater discharge, and nutrient loads as external drivers, and patterns of salinity, estuarine nutrient concentrations, oyster habitat status, and SAV community composition as the estuarine ecological responses. Salinity gradients are a conservative property of the water body, which are useful to connect sources of freshwater inflow, circulation, and biological indicators (Wilber, 1992; Jassby et al., 1995; Hagy and Murrell, 2007; Pollack et al., 2011).

Daily rainfall data for stations in the St. Lucie watershed were downloaded from DBHHYDRO on the District's website at www.sfwmd.gov/dbhydro. Missing rainfall values were estimated using an interpolation method based on data from neighboring stations. The amount of rainfall across each basin was estimated using the Thiessen Polygon method. This method divides the basin containing the rainfall stations into straight-edged polygons. Each reference point within the basin is associated with its nearest rainfall station. The value from each station is divided by the total or fractional area of the basin depending upon the overlap between the polygon coverage and the basin extent.

Freshwater discharge is monitored at the major structures of S-80 (C-44 sub-watershed), S-48 (C-23 sub-watershed), S-49 (C-24 sub-watershed) and Gordy Rd. (Ten Mile Creek Basin; **Figure 10-3**). Inflows at Gordy Road from WY1997–WY1999 were simulated. Freshwater inflows are in units of cubic feet per second (cfs), where 1 cfs = 1.9835 acre-feet (ac-ft) per day = 2445.1 cubic meters (m^3) per day. All spatial references are in acres, where 1 acre = 0.405 hectares. The standardized units and definitions for the entire S*outh Florida Environmental Report* (SFER) appear in the document front matter. Salinity is derived from a dimensionless ratio and therefore has no units in reporting (Millero, 2010). Total daily inflows from WY1997–WY2014 at these structures were summed and used to quantify total inflow to the SLE each water year, evaluate intra- and inter-annual variations in inflow, and estimate the contributions of the sub-watersheds to total inflow. Total daily discharges were categorized by water year and season. The concentrations of TN and TP are monitored at S-80, S48, and S-49. Concentrations at Gordy Road were simulated for use in TN and TP loading estimates. The daily loads of TN and TP are calculated as the product between the total daily flow and the estimated daily nutrient concentration. For phosphorous, the daily concentrations are estimated based on the auto-sampler results first or, if these are missing, they are based on the grab samples on the days with freshwater inflow. Nitrogen values tend to vary over time even in an enclosed container; therefore, the daily nitrogen concentrations are estimated only based on grab samples on the days with flow. Nutrient concentrations are estimated through linear interpolation for the days between sampling events. While TP concentrations are directly measured during sampling events, TN is calculated as the sum of the measured concentrations of total Kjeldahl nitrogen (TKN) and nitrite + nitrate (NO_2^- + NO_3^-).

The relative contributions of Lake Okeechobee and the St. Lucie Watershed on freshwater inflows and nutrient loads to the SLE were calculated using the outflow from the lake at S-308 and inflows at S-80(C-44), S48 (C-23), S-49 (C-24), and Gordy Rd (Ten Mile Creek). The contribution of the coastal watershed downstream of the water management structures (e.g., Tidal Basin) to freshwater inflow and nutrient loads was estimated using a modeling approach (Wan et al., 2006). Tidal Basin flow was simulated using the SLE Tidal Basin Lin-Res Model calibrated to the SLE WaSh Model and data collected in the nearby basins. The Tidal Basin TN and TP loads were calculated using the simulated flow data along with observed concentrations of TN and TP, when available. Simulated TN and TP concentrations were used when measured data were not available. Annual flow-weighted mean TN and TP concentrations were calculated by dividing the monthly concentrations observed at the inflow structures (S-80, S-48, S-49) by the monthly inflow volume to derive mass. The monthly masses of TN and TP were summed for each water year and divided by the total annual inflow volume to derive the flow-weighted values. Because the determination of flow-weighted concentrations are derived using point-source measurements of concentration and flow over finite time intervals at the structures, this calculation was not extended to the modeled estimates of concentration and inflow across the entire Tidal Basin. Table 10-6 describes the major contributing areas of the St. Lucie Watershed and the methodology associated with the reported flows and loads.

Table 10-6. Major contributing areas of the St. Lucie Watershed.

Total Contributing Areas	St. Lucie Watershed	Flows and Loads
Tidal Basin	SLE North Fork	Modeled
	Basin 4,5,6	Modeled
	South Fork	Modeled
	Ten Mile Creek	Modeled and Measured
St. Lucie Basin	S153/C44	Measured
	C23	Measured
	C24	Measured
Lake Okeechobee	S-80 and S-308	Calculated

Surface and bottom salinity observations are recorded every 30 minutes at three stations in the SLE: HR1, US1 at the Roosevelt Bridge, and the A1A Bridge that crosses the SIRL (**Figure 10-10**). Data reporting and analyses focused on WY2012–WY2014 at US1. Daily surface and bottom salinity recordings were averaged to produce a time series over the past three water years. The percentages of days for different salinity criteria were calculated over the long-term period of record as well as WY2012, WY2013, and WY2014. The time series for average daily salinities at US1 and the A1A Bridge were superimposed with the oyster habitat attributes and SAV community composition, respectively.

Water was sampled at mid-depth at 12 stations in the SLE at approximately monthly intervals (**Figure 10-10**). To evaluate water quality, three representative stations were chosen in the North Fork (HR1), the middle estuary (SE03), and near the St. Lucie Inlet (SE11). Concentrations of TN, TP, and chlorophyll *a* (Chl-*a*) for WY1997–WY2014 from each of the stations were included in the analyses (SFWMD, 2011). To further characterize the status of water quality in the SLE, concentrations were referenced relative to the target TMDL concentrations of 0.72 mg/L TN and 0.081 mg/L TP at stations HR1 and SE03.

The community composition of SAV habitat was monitored at Willoughby Creek (WC) in the SLE and Boy Scout Island (BSI) in the SIRL (**Figure 10-10**). The sizes of seagrass habitats ranged from 1 to 2 acres, with average depths of 0.4–0.8 m. At each monthly or bimonthly sampling, a total of 30 quadrats were deployed randomly throughout each site. SAV percent occurrence per quadrat was determined by dividing the number of quadrants occupied by a particular species by the total possible quadrants (25) then multiplying by 100. To determine the percent occurrence for the entire site, the quadrat percent occurrences (N=30) were averaged by date of field sampling. The percent occurrences for the different species were calculated for each sampling date at WC and BSI from WY2007–WY2014.

Oyster monitoring has been ongoing in three segments of the SLE (middle estuary or central, South Fork, and North Fork) since WY2007 (**Figure 10-10**). Four basic oyster population metrics were included for interpretation. The first are live oyster densities which are determined seasonally. Second, the settlement rate for oyster larvae (e.g., spat) shells that settle from the water column as the number of spat/shell/month were determined every 1 to 2 months at each sampling site. Finally, the prevalence and intensity of the protozoan pathogen Dermo (*Perkinsus marinus*) at each sampling site were assessed at monthly intervals. Seasonal time series for each of these variables were derived for each site from WY2007–WY2014 for inclusion in this report.

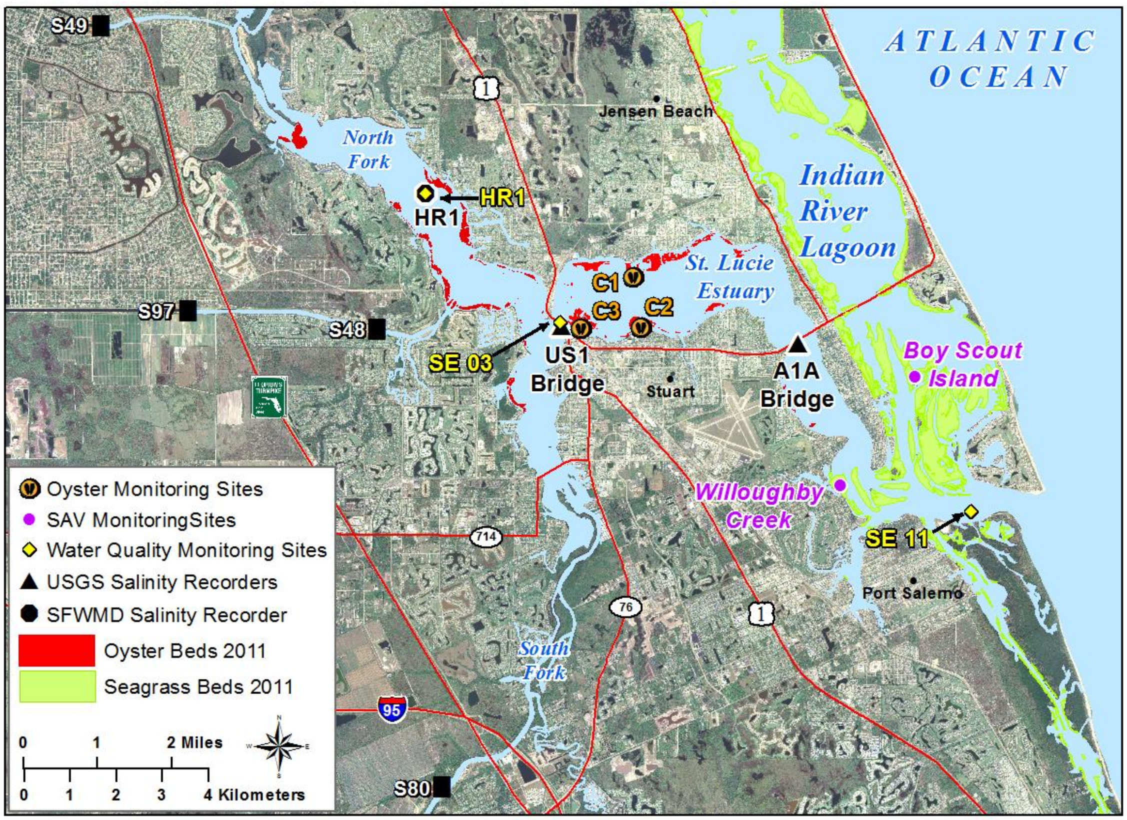

Figure 10-10. Locations for the monitoring of salinity, water quality, and living aquatic habitat (oysters and SAV) for the SLE. Map includes depiction of the distribution of SAV habitat in St. Lucie Inlet and the southern Indian River Lagoon.

Results and Discussion

Rainfall

During WY2014, rainfall was at near historical levels including the wettest April–July period on record in South Florida since 1932 (http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/nr_2013_0802_july_rainfall.pdf). Daily rainfall to the St. Lucie Watershed ranged from 0 to ~3.0 inches per day (0 to 7.6 centimeters per day) during WY2012–WY2014 and was generally less than 1.0 inch per day except in December 2011, September 2012, August 2013, and February 2014 (**Figure 10-11**). The long term annual average (WY1997–WY2014) was 48.8 inches, with 27.1 percent occurring in the dry season versus 72.9 percent in the wet season (**Figure 10-12**). While total rainfall was relatively low in WY2012 (42.6 inches), it increased to 51.2 inches in WY2013 (105 percent of the long-term average) and 56.3 inches in WY2014 (115 percent of the long-term average). Rainfall in both the dry (17.4 versus 13.2 inches) and wet (38.8 versus 35.6 inches) seasons in WY2014 were greater than the long-term averages (**Figure 10-12**). There was an unexpected spike in rainfall in February–March 2014 that accounted for the greater percentage of dry season rainfall in WY2014 (31.0 percent) relative to the long-term average (27.1 percent). Average annual rainfall was generally greatest in the C-23 and C-24 (~50 inches) sub-watersheds and least in the C-44 (~46 inches) sub-watershed. The overall pattern of higher than long-term average rainfall in 2014 also was the case for the C-23 and C-24 sub-watersheds and the Ten Mile Creek basin (**Figure 10-13**). Rainfall in the C-44 and the Tidal Basin was generally similar between WY2013 and WY2014.

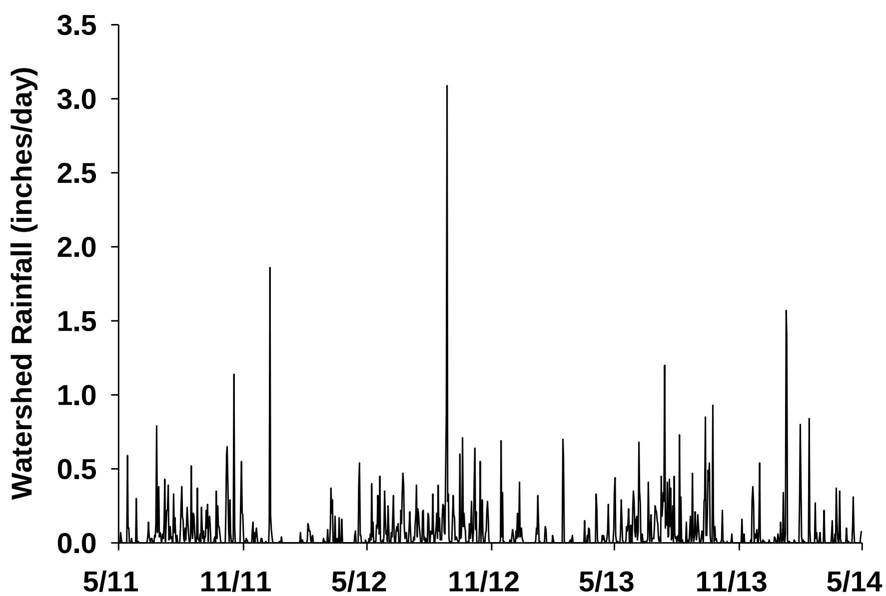

Figure 10-11. Time series of total daily rainfall to the SLE watershed and estuary WY2012–WY2014.

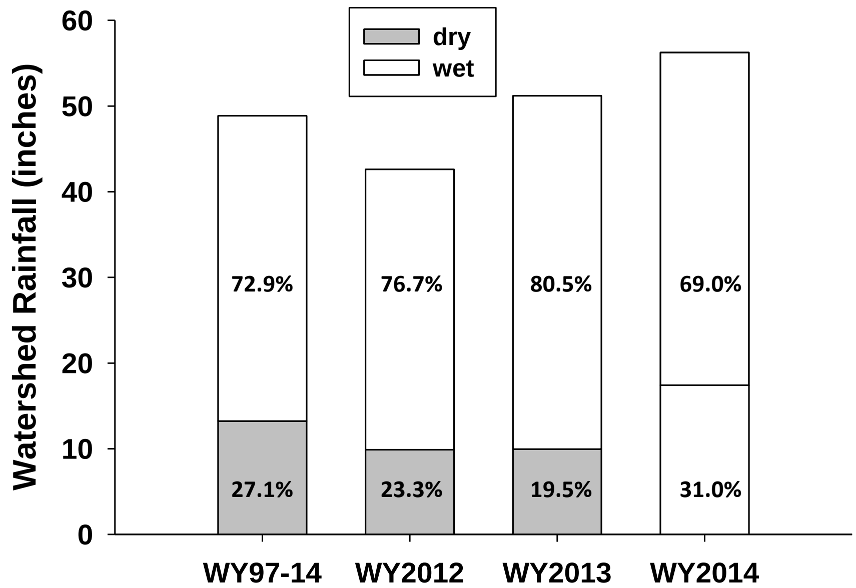

Figure 10-12. Total rainfall to the St. Lucie watershed by water year and season, including long-term average from WY1997-WY2014, WY2012, WY2013, and WY2014.

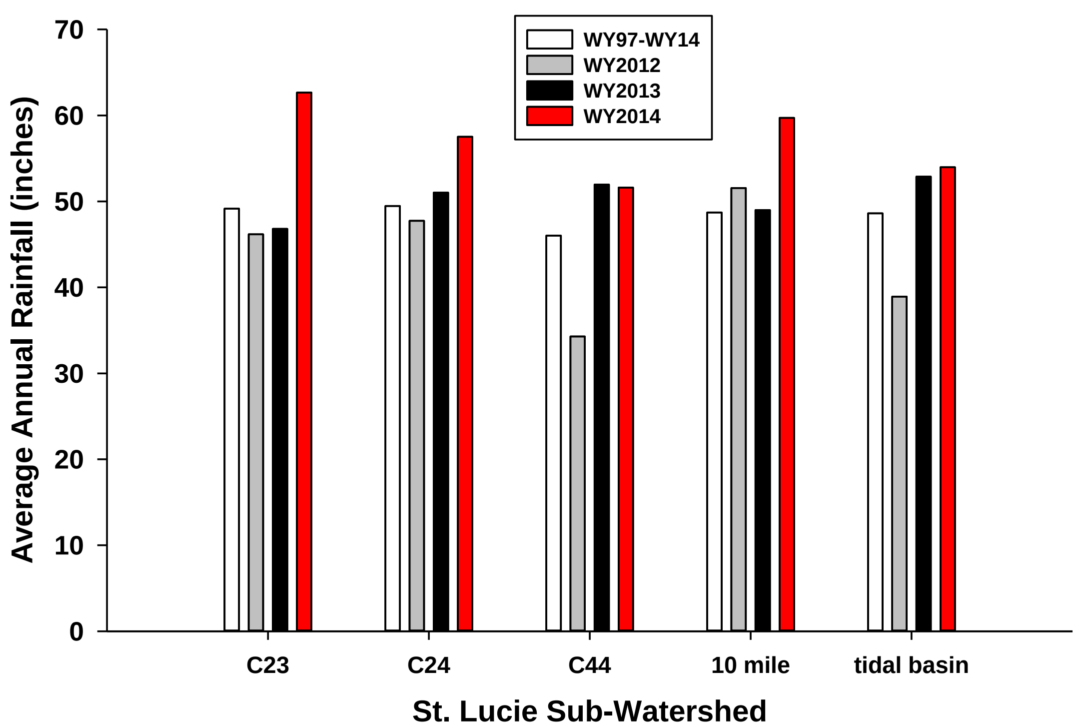

Figure 10-13. Average annual rainfall to the St. Lucie sub-watersheds, including long-term average from WY1997-WY2014, WY2012, WY2013, and WY2014.

Inflow

Total freshwater inflow is composed of inflow from Lake Okeechobee, the St. Lucie Basin (C-44, C-23, C-24), and the estimated inflows from the Tidal Basin (Basins 4,5,6; North Mid Estuary; South Coast; South Fork; North Fork; Ten Mile Creek). During the wet season, water may be released from Lake Okeechobee to control water level and offer flood protection across the south Florida landscape. In the dry season, water may be released to the SLE in order to promote favorable estuarine conditions in the estuary.

Inflow from the gauged portions of the watershed (St. Lucie Basin) was generally less than 2,500 cfs for much of WY2012–WY2014, except for peaks in August and October 2013 (**Figure 10-14**). Nevertheless, the upper limit of the flow envelope (2000 cfs) was exceeded in the wet season of each of the three water years (**Figure 10-14**).

Interannual differences in total inflow mirrored rainfall patterns, increasing each year from WY2012–WY2014. The long-term average total inflow (WY1997–WY2014) was 1.1 x 10^6 ac-ft (**Figure 10-15**, panel a). Total inflow was relatively very low in WY2012 (0.65 x 10^6 ac-ft), slightly higher in WY2013 (0.74 x 10^6 ac-ft), and exceeded the long-term average in WY2014 (1.4 x 10^6 ac-ft) due to much greater inflow in the wet season. The long-term average contributions of Lake Okeechobee, the St. Lucie Basin, and the model estimates for the Tidal Basin were 23.3, 44.5, and 32.2 percent, respectively (**Figure 10-15**, panel a). The Lake Okeechobee contribution varied from 0.0-8.4 percent in WY2012–WY2013. In WY2014 the percent contributions among the three sources were 30.1, 44.5, and 25.3 percent, respectively.

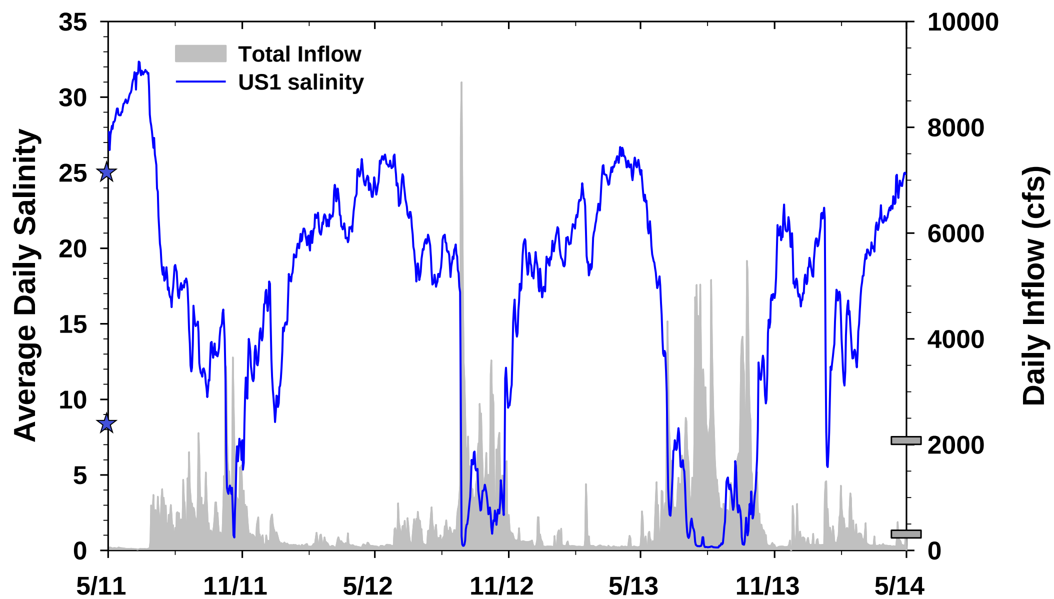

Figure 10-14. Time series of total freshwater inflow (cubic feet per second, or cfs) to and salinity (A1A Bridge) from the St. Lucie Basin to the SLE WY2012–WY2014. Blue stars on the left y-axis denote target salinities of 8-25 (see **Table 10-7**). Grey bars on the right y-axis denote freshwater inflow targets of 350-2000 cfs. The relationship between freshwater inflow and salinity is non-linear and inverse.

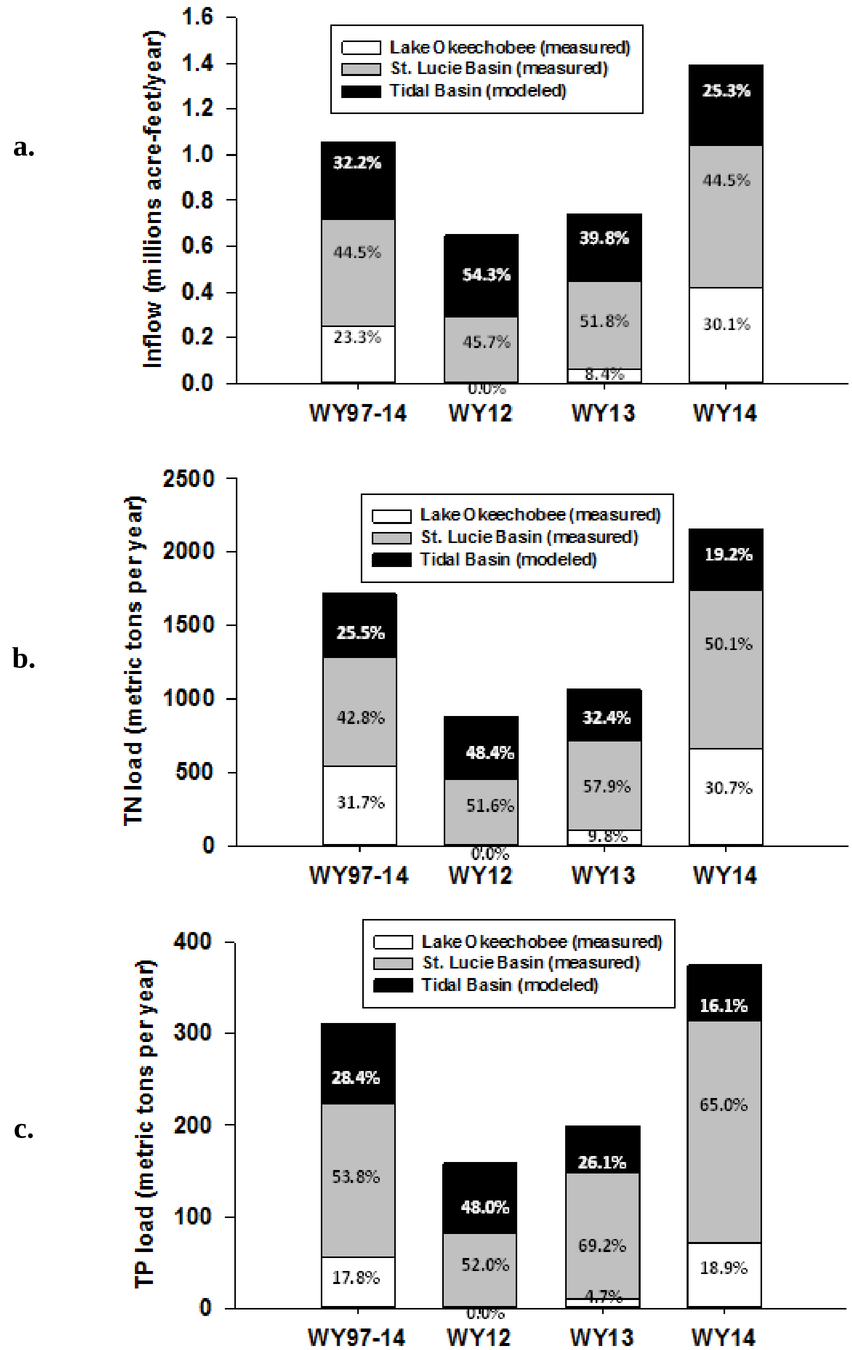

Figure 10-15. Stacked bar chart for the (a) total freshwater inflow (millions of ac-ft/yr), (b) total nitrogen (TN) loading (mt/yr), and (C) total phosphorus (TP) loading (mt/yr) attributable to Lake Okeechobee (white), the St. Lucie Basin (grey), and the Tidal Basin (black); includes the long-term average from WY1997-WY2014, WY2012, WY2013, and WY2014. Tidal basin inflow was estimated using a linear reservoir approach (Wan et al., 2006).

Salinity

Salinity patterns are inversely related to freshwater inflow in estuaries and this was observed in the SLE (**Figure 10-14**). Average daily salinity at US1 was greater than 20 in the dry seasons of WY2013 and WY2014, except for reduced values in January–February 2014. With respect to the salinity envelope of 8-25 established for the US1 Bridge, the long-term (WY1999–WY2014) percentage of days with salinity less than 8, between 8 and 25, and greater than 25 were 23.2, 64.2, and 12.6 percent, respectively (**Table 10-7**). Reflecting the higher rainfall inWY2014, the days salinity was less than 8 (35.5 percent) were higher than the previous two years and the long term average. The inverse was true for days where salinity was greater than 25, with this occurring only 0.3 percent of the time in WY2014. By contrast, during WY2012 when rainfall and inflow were lower, salinity was less than 8 for only 6.8 percent of the days and greater than 25 for 19.7 percent of the days.

Table 10-7. The percentage of days with salinity values at the US1 Bridge either less than 8 or greater than 25 from WY2012–WY2014 and their long-term average (WY1999–WY2014).

	Salinity at US 1 Bridge		
Water Years	**Days Salinity <8**	**Days Salinity 8 to 25**	**Days Salinity >25**
WY1999–WY2014	23.2%	64.2%	12.6%
WY2012	6.8%	73.5%	19.7%
WY2013	16.4%	66.8%	16.7%
WY2014	35.3%	64.4%	0.3%

Nutrient Loads and Inflow Concentrations

Patterns of TP and TN loading to the SLE followed total freshwater inflow (**Figure 10-16**). While the TN:TP loading ratio from Lake Okeechobee is 10.3:1, water entering from the St. Lucie watershed has a TN:TP ratio of 4.9:1. This indicates that water introduced from the St. Lucie watershed is relatively enriched with TP compared to Lake Okeechobee. The long-term averages for total annual TN and TP loading from Lake Okeechobee, the St. Lucie Basin, and the model estimates for the Tidal Basin were 1714.8 and 311.7 mt, respectively (**Figure 10-15**, panels b and c). Lake Okeechobee, the St. Lucie Basin, and the model estimates for the Tidal Basin accounted for 31.7, 42.8, and 25.5 percent of the long-term average TN loading, respectively. These three sources contributed 17.8, 53.8, and 28.4 percent of the long term average TP load, respectively. The St. Lucie Basin accounted for a comparatively higher percentage of TP than TN. The highest annual loads for both TN and TP were observed in WY2014 while the lowest was seen in WY 2012 (**Figure 10-15**, panels b and c) reflecting total freshwater inflow patterns observed over the same WYs (**Figure 10-15**, panel a).

Flow-weighted nutrient (TN and TP) concentrations were obtained upstream of water control structures and represent the quality of water exiting the specific sub-watersheds of the St. Lucie Basin and Lake Okeechobee (see methodology for further description). The annual average flow-weighted TN concentrations varied from 0.0 to 2.3 mg/L from WY1997–WY2014 (**Figure 10-17,** panel a). TN concentrations incoming from the four sources were between 1.0 and 2.0 mg/L throughout much of the period of record. The absence of a freshwater contribution from Lake Okeechobee in WY2008 or WY2012 resulted in flow-weighted concentrations of 0.0. The flow-weighted TN concentration at S-49 from the C-24 sub-watershed was the least variable over the period of record. The annual average flow-weighted TP concentrations varied from 0.0 mg/L to 0.65 mg/L from Okeechobee and the sub-watersheds (**Figure 10-17**, panel b). As with TN, the minimum TP concentrations occurred in WY2008 and WY2012 when there was no freshwater inflow from Lake Okeechobee to C-44. The flow-weighted TP concentrations observed at S-48 and S-49 were comparatively higher.

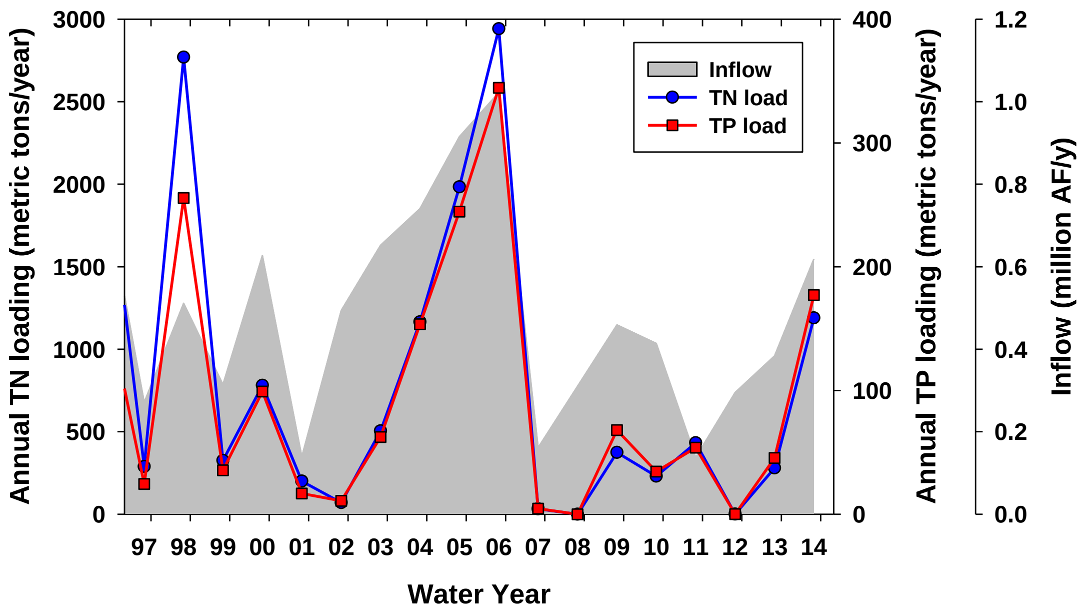

Figure 10-16. Time series of average annual freshwater inflow (shaded area), TN (blue) and TP (red) loading from the sum of C-44, S-48, S-49, and Ten Mile Creek to the SLE from WY1997–WY2014.

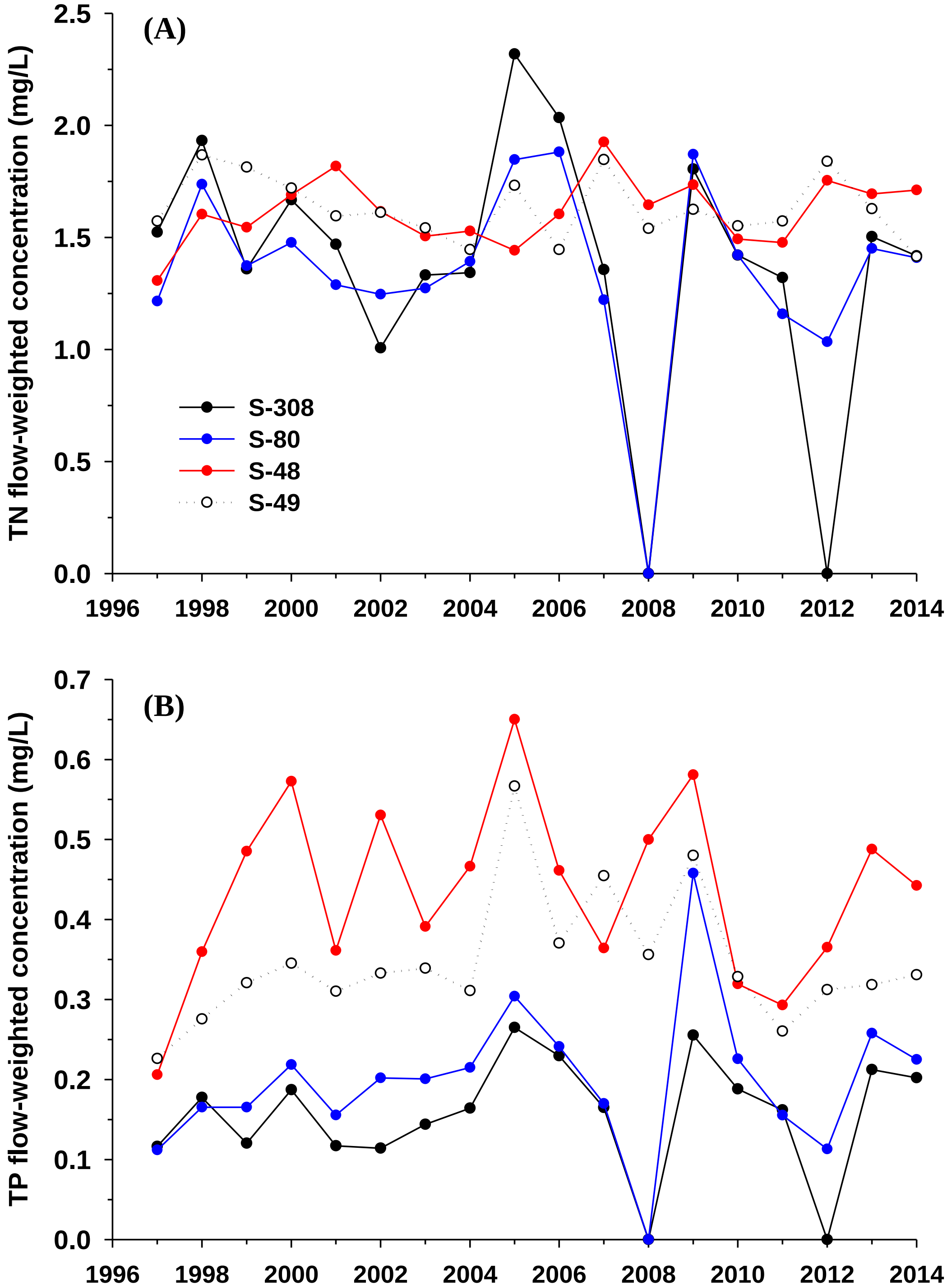

Figure 10-17. Time series of flow-weighted average concentrations of TN (a) and TP (b) from S-308 (solid black), S-80 (blue), S-48 (red), and S-49 (open dash).

Relative Contributions of St. Lucie Sub-Watersheds/Basins

This section is focused on the St. Lucie Watershed and examines the general proportionality of the watershed contributing areas and yield of freshwater flows and loads from each of the primary Sub-watersheds/Basins that drain to the St. Lucie Estuary – C-44/S-153, C-23 and C-24 Sub-watersheds, and the Tidal and Ten Mile Creek basins. [Note: This does not include inputs from Lake Okeechobee.] Flows and loads are not always proportional to the contributing area. This information provides a relative comparison between the size (ac), flows (ac-ft), and loads (mt/yr) from contribution areas. It can be used to define areas for further analysis, help focus restoration efforts, and identify areas of opportunity for water storage or water quality projects that concentrate on removing loads and minimizing excess flows from the local watershed.

It is important to note that the flows and loads from the Tidal Basin are modeled, and missing data from the Ten Mile Creek Basin was also modeled (see *Methods* section). The sizes of the pieces in the pie charts above (**Figure 10-18**) are an indicator of relative proportionality of flows and loads to the size of the contributing areas. The pie charts show the size of the contributing area (panel a), flows, and TN and TP loads for the long-term period of record (panels b, d, and e), and then the same information for WY2014 (panels c, e and g).

Long-Term Period of Record (Water Years 1997–2014)

Flow: Generally the percent contributions of flows from the C-23 and C-24 Sub-watersheds, and the Tidal Basin for the long-term POR are proportional to the percent areal coverage (ac) of these areas. The percent contribution of flows from the Ten Mile Creek Basin (12.6 percent) is disproportionally high compared to the percentage of the watershed it covers (7.6 percent), by almost two times. Conversely, the percent contribution of flow from the C-44/S-153 Sub-watershed (15.2 percent) is disproportionally low compared to the percentage of the watershed it encompasses (25 percent). This is partially due to the fact that water from the C-44 Canal can also flow west into the lake, and this flow is not accounted for in the pie charts. For the long-term POR, on an average annual basis approximately 50,000 ac-ft of water flowed from the C-44 Canal west into Lake Okeechobee through the S-308 structure but, on an annual basis, it was extremely variable, ranging from 0 ac-ft in WY2004 to approximately 189,600 ac-ft in WY2008.

TN Load: The percent contribution of TN loads from the C-23 Sub-watershed for the long term POR is proportional to the percent of areal coverage and flow. While the percent contribution of TN load from the Tidal Basin is proportional to the percent areal coverage of this Basin, the proportionality of flow to load is low indicating that this basin likely has lower TN concentrations, which is supported by previous analysis (SFWMD, 2012). TN load from the Ten Mile Creek Basin is proportionally high, which is likely due, in part, to the proportionally higher flows from this Basin. The TN load from the C-44/S-153 is proportional to the flow, but both flow and TN load are proportionally low compared to the areal extent of this sub-watershed, again in part due to flows back to the lake through the S-308. TN load from the C-24 Sub-watershed is proportionally high compared to its percent of areal extent.

TP Load: The percent contribution of TP loads from all contributing areas compared to the percent of their areal extents were either disproportionately high (C-23 and C-24 sub-watersheds and the Ten Mile Creek Basin) or disproportionally low (C-44/S-153 Sub-watershed and Tidal Basin). Again, for the C-44/S-153 Sub-watershed this is in part due to flows back to the lake through the S-308. In some instances, such as the C-23 Sub-watershed, the disproportionally high load is likely due to higher TP concentrations since the flow is disproportionally low. In other instances it is likely a combination of higher flows and concentrations such as for the C-24 Sub-watershed and the Ten Mile Creek Basin. Modeled estimates for the Tidal Basin TP load are likely due to low TP concentrations, especially since the percent flow for that sub-watershed is

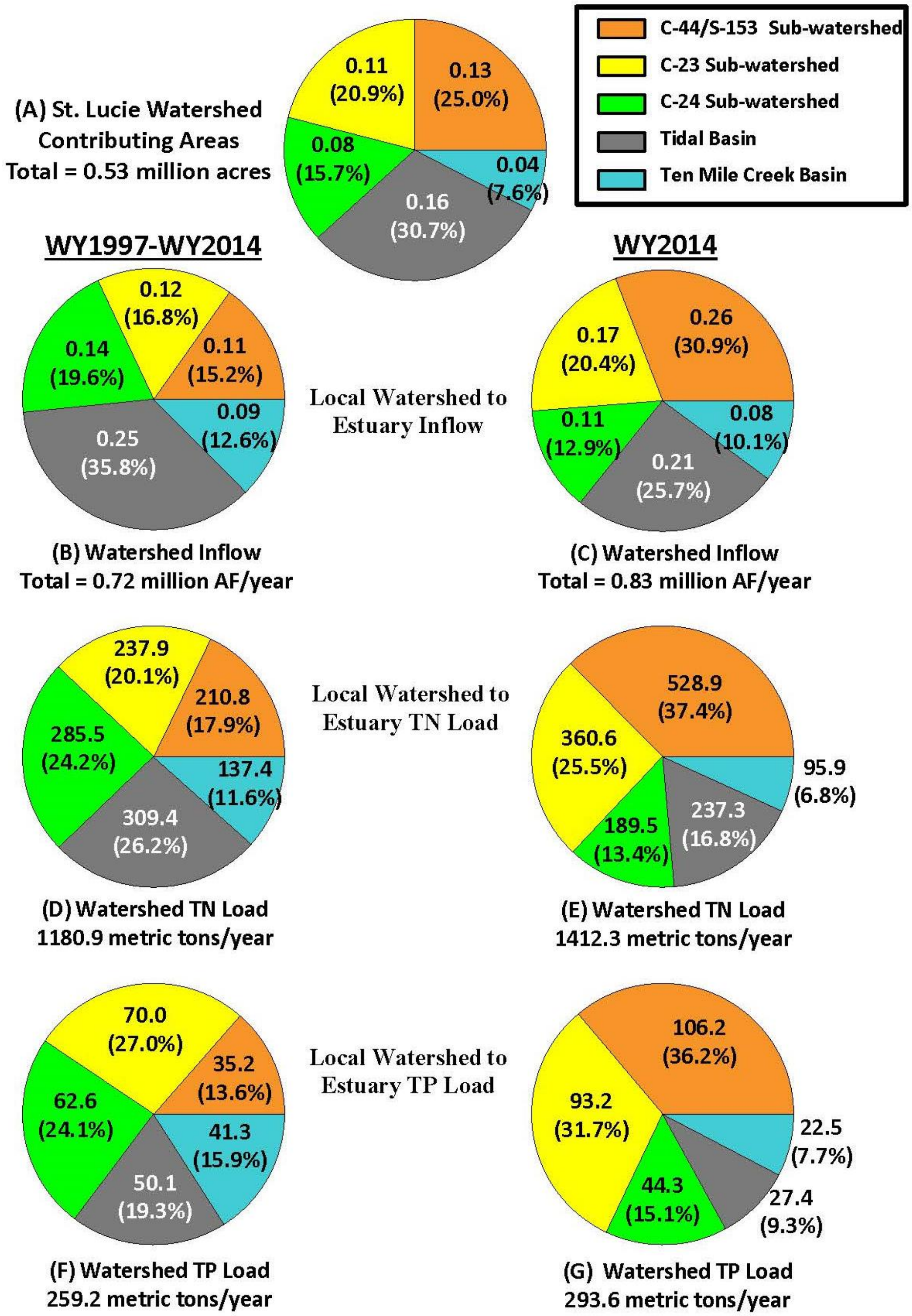

Figure 10-18. Pie charts depicting the relative contributions of the local watershed area (ac), inflow to the estuary, and TN and TP loads to the estuary for the long term period of record (left) and WY2014 (right).

greater than its percent areal extent. As with flow and TN load, the percent contribution of TP loads from the C-44/S-153 Sub-watershed is very low (13.6 percent) especially as it comprises 25 percent of the contributing areas.

Water Year 2014 Comparison to Long-Term Period of Record

In WY2014, there was a noticeable shift in the contributions of some areas compared to the long-term POR. The C-44/S-153 Sub-watershed contributed the highest percent flow (30.9 percent), TN load (37.4 percent), and TP load (36.2 percent) of all the contributing areas, and these percentages were greater than its percent aerial extent (25 percent). Also, the percent contribution of TP and TN loads from the Ten Mile Creek Basin and C-24 Sub-watershed were noticeably lower in WY2014 than for the long-tern POR.

In-Estuary Water Quality Results

Although it is a frequently invoked indicator of estuarine water quality in many estuaries, Chl-*a* is only one of several phytoplankton photo-pigments. Additionally, phytoplankton growth and biomass production fluctuate with a variety of physical (transport, sinking), chemical (nutrient supply and turnover), and biological (grazing by zooplankton and larval organisms) factors (Lucas et al., 2009; Phlips et al., 2011). Due to these complexities, relationships between Chl-*a* and freshwater inflow are difficult to discern in small sub-tropical estuaries such as the SLE (Buzzelli, 2011).

Like many other estuaries, the concentrations of TN and TP in the fresh water entering the SLE are higher than those in the ocean water with which it mixes. Estuarine mixing generally results in a decreasing concentration gradient between upstream and downstream. In addition to spatial gradients, there are often temporal patterns with higher concentrations in the wet season through a combination of increased runoff and increased rates of phytoplankton growth and organic matter recycling with higher water temperature.

There were significant intra- and inter-annual variations in water column Chl-*a* concentrations among the three monitoring locations from WY1997–WY2014 (**Figure 10-19**, panels a–c). As expected there were no clear relationships with freshwater inflow. At SE03 near the US 1 Bridge and at SE11 near the mouth of the estuary, seasonal (wet and dry) and annual concentrations during WY2012–WY2014 were generally lower than long-term averages with one exception (SE11, WY2014 wet season, **Table 10-8**). At HR1 in the North Fork, wet season averages during WY2012–WY2014 were greater than the long-term average, while dry season concentrations were lower. This resulted in annual average Chl-*a* concentrations at HR1 that were comparable to or greater that the long term-average (**Table 10-8**). Overall, Chl-*a* concentrations were variable at all three locations, as the standard deviations were 44-52 percent as large as the annual averages.

As expected, concentrations of both TN and TP in North Fork (HR1) and Middle Estuary (SE03) were greater than those closer to the ocean at the St. Lucie Inlet (SE11). The average annual concentrations of TN at HR1 and SE03 exceeded the TMDL target of 0.72 mg/L. This annual exceedance was caused by high wet season concentrations as average concentrations during the dry season were below the target. The standard deviations were 31-32 percent of the annual average TN concentrations at HR1 and SE03 but increased to approximately 50 percent at SE11. The water column at the St. Lucie Inlet is less influenced by freshwater inflow and more affected by local recycling and oceanic exchange. On a monthly time scale, TN concentrations are quite variable (**Figure 10-19**, panels d–f) with much of the variation associated freshwater inflow (Chamberlain and Hayward, 1996; Doering 1996; Buzzelli et al., 2013d). High concentrations associated with periods of high discharge were evident in with major climatic events such as the 1997–1998 El Niño event and hurricanes in 2004 and 2005 (**Figure 10-19**, panels d–f). At all three stations, annual and seasonal concentrations of TN in WY2014 were lower than the long-term average, respectively (**Table 10-8**).

At HR1 and SE03 both average annual and seasonal concentrations of TP exceeded the TMDL target of 0.081 mg/L (**Figure 10-19**, panels g–i; **Table 10-7**). Annual and seasonal concentrations of TP in WY2014 were equal to or lower than long-term averages (**Table 10-7)**. At SE11 during the wet season of WY2014, the concentration of TP was slightly higher than the long-term average. As expected, wet season concentrations were higher than those in the dry season and concentrations at HR1 and SE03 were higher than those at the St. Lucie Inlet (SE11). Similar to the spatial pattern of TN variability, the standard deviations were 38-39 percent of the annual average TP concentrations at HR1 and SE03 but increased to approximately 57 percent at SE11.

While high concentrations of both nutrients are associated with periods of high freshwater inflow (**Figure 10-19**, panels d –f and g –i), seasonal peaks are still evident during the drought periods of 2000–2001, 2007–2008, and 2011–2012, when freshwater inflow was very low. This suggests that internal processes, driven by spatial variations in sediment organic content and intra-annual fluctuations in temperature, may be significant enough to effect a seasonal cycle in water column nutrient concentrations without external forcing by freshwater inflow.

Table 10-8. Summary of water column concentrations of chlorophyll *a* (Chl-*a*; µg/L), total nitrogen (TN; mg/L), and total phosphorus (TP; mg/L) at three stations (HR1, SE03, SE11) in the SLE; includes dry season, wet season, and total averages and standard deviations (avg±SD) from WY1997–WY2014 and average values for WY2012, WY2013, and WY2014.

HR1	Chl-*a*			TN			TP		
	Dry	Wet	Total	Dry	Wet	Total	Dry	Wet	Total
Avg+SD	9.4±5.1	15.8±6.2	12.6±6.4	0.77±0.26	1.17±0.16	0.97±0.3	0.14±0.03	0.27±0.06	0.21±0.08
WY2012	5.5	20.0	12.8	0.69	1.08	0.88	0.12	0.27	0.20
WY2013	6.4	21.9	14.1	0.62	1.02	0.82	0.10	0.24	0.17
WY2014	**5.9**	**28.2**	**17.1**	**0.56**	**1.07**	**0.82**	**0.11**	**0.21**	**0.16**

SE03	Chl-*a*			TN			TP		
	Dry	Wet	Total	Dry	Wet	Total	Dry	Wet	Total
Avg+SD	6.5±2.8	11.4±4.9	8.9±4.6	0.80±0.33	1.16±0.16	0.98±0.31	0.13±0.03	0.24±0.05	0.18±0.07
WY2012	2.8	7.0	4.9	0.62	1.05	0.83	0.11	0.24	0.18
WY2013	3.8	7.2	5.5	0.55	0.99	0.77	0.09	0.22	0.16
WY2014	**5.6**	**8.8**	**7.2**	**0.57**	**1.15**	**0.86**	**0.11**	**0.19**	**0.15**

SE11	Chl-*a*			TN			TP		
	Dry	Wet	Total	Dry	Wet	Total	Dry	Wet	Total
Avg+SD	2.9±1.5	4.2±1.5	3.6±1.6	0.43±0.32	0.68±0.25	0.55±0.31	0.04±0.02	0.09±0.04	0.07±0.04
WY2012	2.0	3.3	2.7	0.26	0.61	0.43	0.03	0.07	0.05
WY2013	2.0	3.7	2.9	0.19	0.33	0.26	0.03	0.06	0.04
WY2014	**1.8**	**5.1**	**3.4**	**0.15**	**0.62**	**0.39**	**0.02**	**0.10**	**0.06**

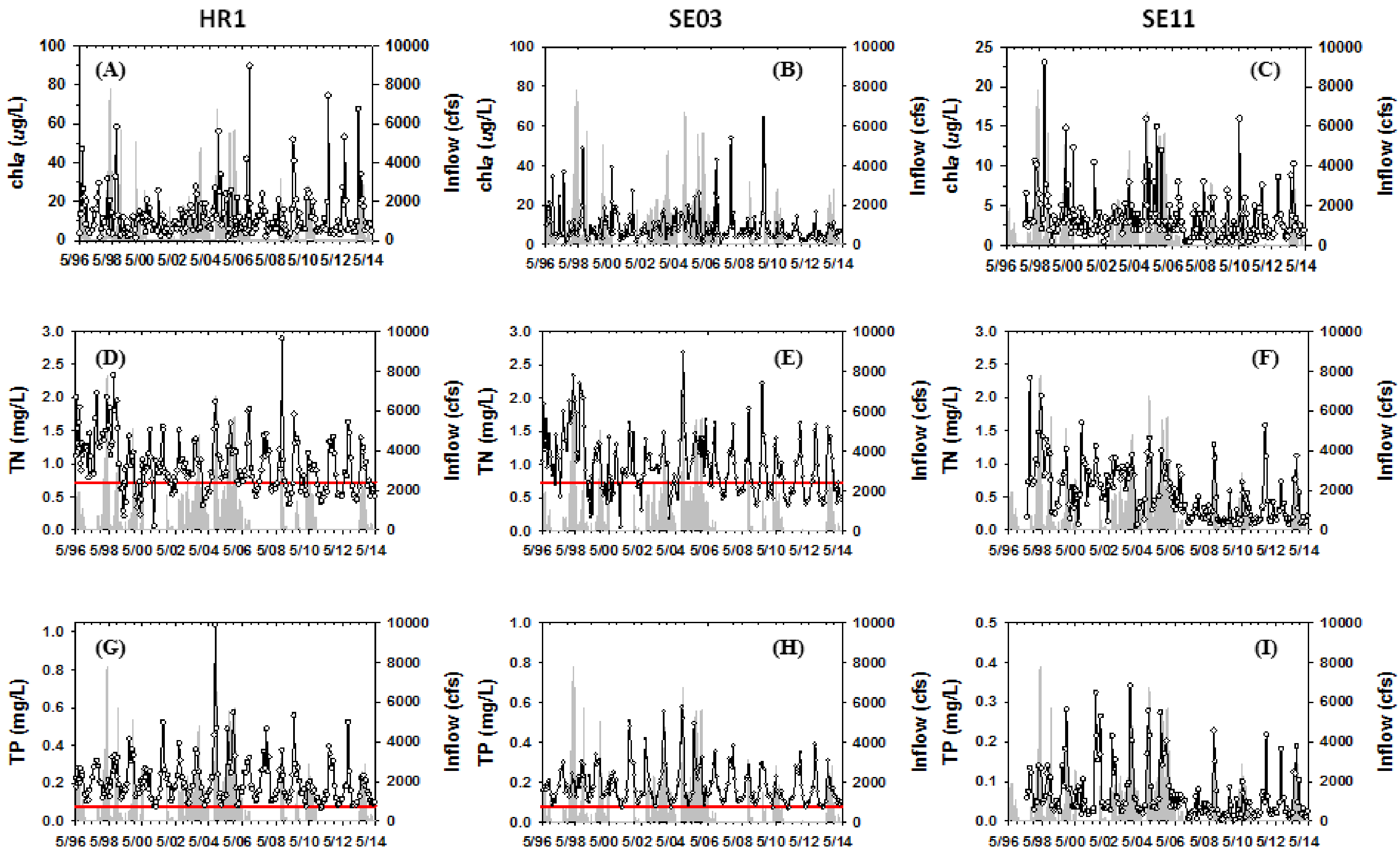

Figure 10-19. Time series of Chl-*a*, TN, and TP at stations HR1, SE03, and SE11 in the SLE from WY1997–WY2014. The reference line shown in red denotes the critical concentrations of TN (0.72 mg/L) and TP (0.081 mg/L) from the TMDL assessment of the estuary.

Ecological Indicators Results

The distribution and abundance of different SAV populations are influenced by the availability of submarine light and nutrients, seasonal shifts in water temperature and plant physiology, grazing by macro- and mega-fauna, and salinity (Duarte et al., 2007; Lee et al., 2007; Lirman et al., 2008; Buzzelli et al., 2012). The occurrences of different species of SAV fluctuated with salinity at Willoughby Creek within the lower SLE from WY2007–WY2014 (**Figure 10-20**, panel a). The effects of variable salinity at the A1A Bridge were particularly acute for shoal grass (*Halodule wrightii*) at the Willoughby Creek location. The percent occurrence of shoal grass at this site was generally between 60-95 percent with only a few outliers. Johnson's grass (*Halophila johnsonii*) is more ephemeral as it exhibited wide variations from 5-80 percent occurrences.

At Boy Scout Island in southern IRL the percent occurrences of shoal grass and Johnson's grass varied greatly while the coverage of manatee grass (*Syringodium filiforme*) remained comparatively stable (60–95 percent). The occurrences of all three species were approximately equal (~ 60 percent) in April–May 2008 (**Figure 10-20**, panel b). Johnson's grass decreased to less than 10 percent occurrence in WY2010 for a comparatively long period until increasing to approximately 50 percent in May 2014. Shoal grass fluctuated from 20-70 percent in WY2010-WY2011 before decreasing to very low levels in WY2012-WY2014. The dominant species at Boy Scout Island was manatee grass with minimum values of ~60 percent in May 2009. Maximum values of 100 percent were maintained during WY2012. Since that time manatee grass has been declining perhaps due to higher wet season flows since WY2012 and increased grazing (**Figure 10-20**, panel b). As it is a definitively halophilic SAV, both the distribution and density of manatee grass decrease following extreme freshwater inflow events (Buzzelli et al., 2002).

The distribution, density, and status of oyster habitat in the SLE varies greatly in time and space depending upon salinity, substrate availability, predation, and disease (Wilson et al., 2005; Buzzelli et al., 2013a; Parker et al., 2013). Oyster density near the Roosevelt Bridge in the SLE exhibited a wide range of values between dry and wet seasons from WY2007-WY2014 (**Figure 10-21**, panel a). The density of live oysters varied from below 50 oysters/m^2 to almost 700 oysters/m^2, with the majority of the time being between approximately 300 oysters/m^2 (WY2008, WY2009, WY2010) to greater than 500 oysters/m^2 (WY2011, WY2012, WY2013). Live oyster density was low (31 oysters/m^2) in December 2013, following extreme freshwater inflow and depressed salinity in July–October 2013. However, the population has begun to recover (**Figure 10-21**, panel a).

The rate of oyster larval abundance (e.g., spat fall) was greater than 2.0 spat/shell/month in July 2006, September 2010, May 2011, July 2012, and May 2013 (**Figure 10-21**, panel b). These samplings occurred during times when both salinity and temperature were relatively high. Spat fall varies greatly with salinity, temperature, predation, disease, sedimentation, and circulation. While spatfall is generally less than 2.0 spat/shell/month, larval supply is sufficient to support a natural re-population after an extreme mortality event. The prevalence of the protozoan disease Dermo (e.g., the percentage of infected oysters) was generally less than 20 percent from WY2007–WY2011 until it increased to 60-80 percent in WY2012 and WY2013 (**Figure 10-21**, panel c). The temporal pattern in the intensity of Dermo infection was reversed with average intensities of 2.0-3.0 in WY2009 and WY2010 and reduced values of 0.5-1.5 throughout much of WY2012–WY2013 (**Figure 10-21**, panel d). As it is a marine parasite, both the prevalence and intensity of Dermo were suppressed with increased freshwater inflow from September–November 2013.

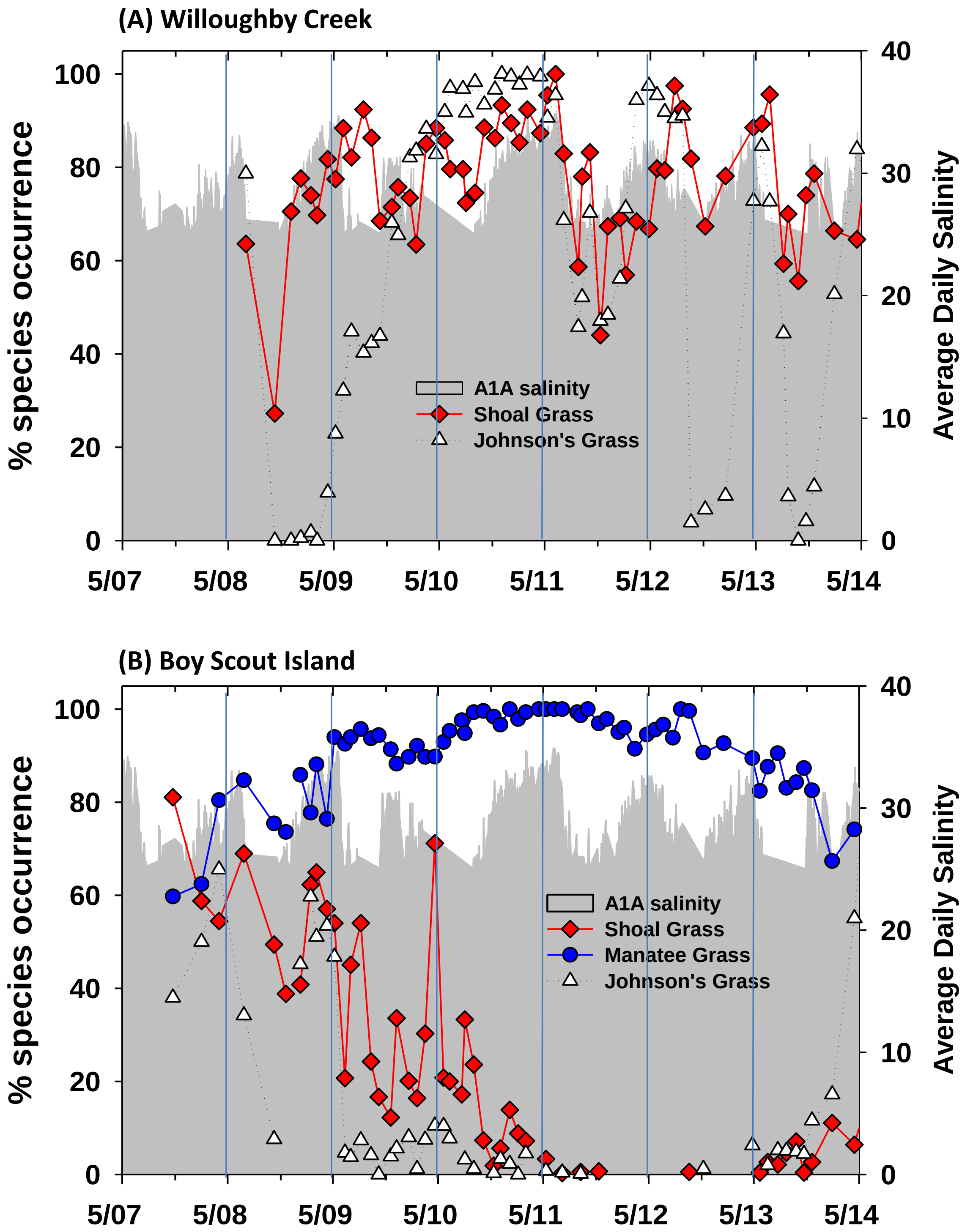

Figure 10-20. Time series of percent species occurrence for the SAV community at Willoughby Creek (a) and Boy Scout Island in the southern IRL (b) from WY2007–WY2014. Includes average daily salinity at the A1A Bridge.

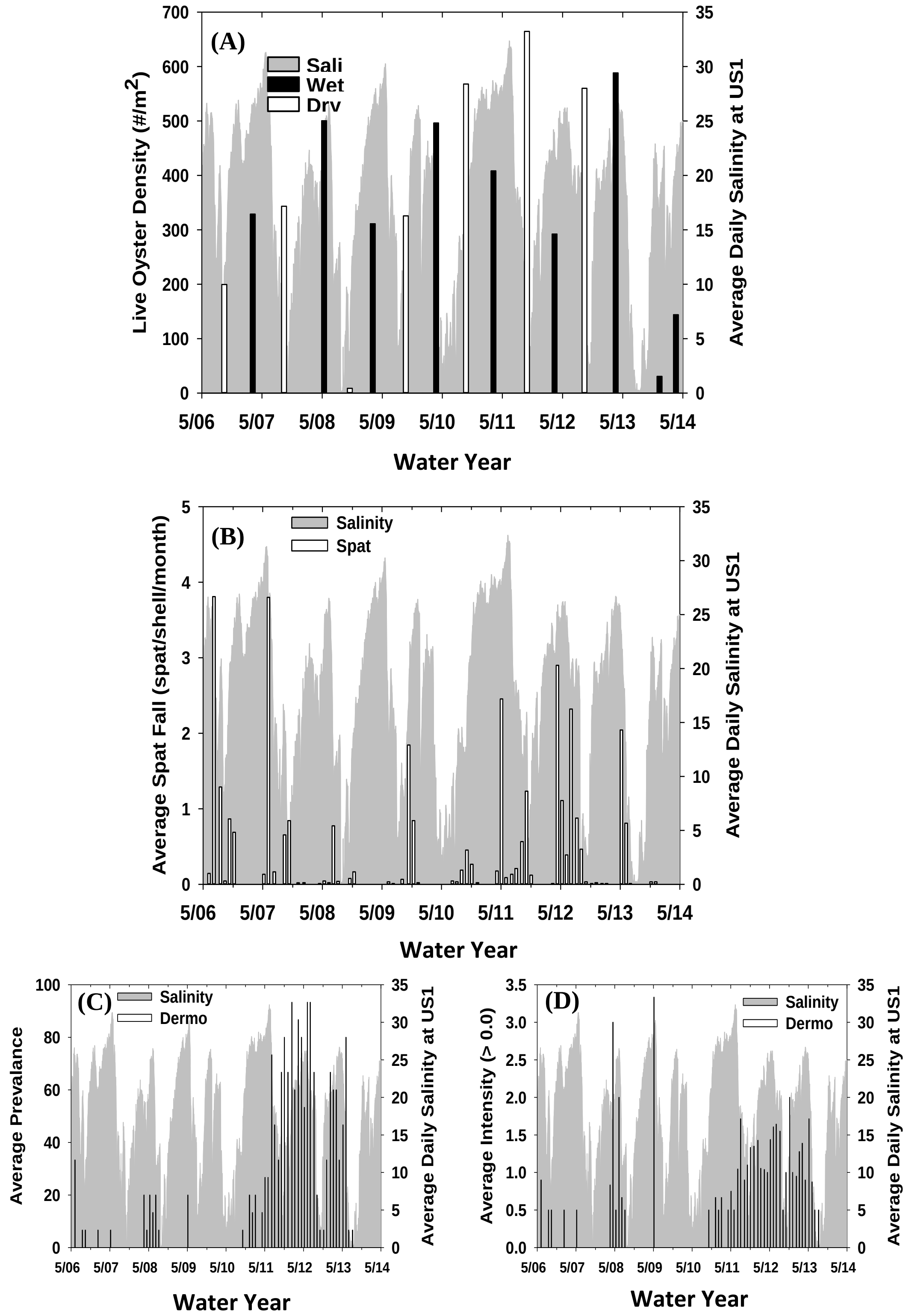

Figure 10-21. Time series for average live oyster density (a), larval abundance (b), and the prevalence (c), and intensity (d) of the oyster-specific pathogen, Dermo (*Perkinsus marinus),* from WY2007-WY2014. The average salinity at the US1 Bridge in the SLE is included in each time series.

Significant Findings

- The total annual rainfall increased from WY2012 through WY2014. WY2014 exceeded the long-term (WY1997–WY2014) average (48.9 inches) due to greater precipitation in both the dry and wet seasons that were near historical levels including included the wettest April-through-July period on record in South Florida since 1932.
- The total annual inflow increased from WY2012 through WY2014 with WY2014 exceeding the long-term average. Total freshwater inflows to the estuary, which exceeded the long-term average (by approximately 400,000 ac-ft), with 70 percent from the St. Lucie Watershed and 30 percent from Lake Okeechobee. While the relative contribution of Lake Okeechobee in WY2014 was greater than the long-term average (30.1 versus 23.3 percent), the contributions from the upstream watershed (44.5 percent) were the same and the Tidal Basin (25.3 versus 32.2 percent) was lower.
- Salinity is inversely related to freshwater inflow in the estuaries. As such, salinity in the SLE was relatively high during reduced freshwater inflows in WY2012 but decreased with increased freshwater inflow in WY2014. In WY2014 salinity was particularly low during the wet season when rainfall and inflows were relatively high.
- Patterns of annual TP and TN loading to the SLE followed total freshwater inflow. Nutrient loading exhibited an overall increase with freshwater inflow from WY2012–WY2014. TN and TP loadings from Lake Okeechobee, the St. Lucie Watershed, and the Tidal Basin increased in WY2014 to 2153.7 and 375.0 metric tons, respectively, with ~69 percent (TN) and ~81 percent (TP) from the St. Lucie Watershed.
- There were significant intra- and inter-annual variations in water column Chl-*a* concentrations among the three monitoring locations from WY1997–WY2014. Chl-*a* concentrations at HR1 were comparable to or greater that the long term-average but, at SE03 near the US 1 Bridge and at SE11 near the estuary mouth, concentrations during WY2012–WY2014 were lower.
- Annual and seasonal concentrations of TN were lower than the long-term average in WY2014. The average annual concentrations of TN at HR1 and SE03 exceeded the TMDL target of 0.72 mg/L. This annual exceedance was caused by increased values in the wet season through a combination of increased inflow and TN loading and increased water temperature and rates of internal cycling.
- Annual and seasonal concentrations of TP in WY2014 were equal to or lower than long-term averages. At HR1 and SE03, both average annual and seasonal concentrations exceeded the TMDL target of 0.081 mg/L. Similar to TN, wet season concentrations were higher than in the dry season.
- The occurrences of different species of SAV fluctuated with salinity at Willoughby Creek within the lower SLE from WY2007–WY2014. The percent occurrence of shoal grass varied from 60 to 90 percent in WY2013–WY2014 in Willoughby Creek. The dominant species at Boy Scout Island from WY2010–WY2014 was manatee grass with maximum values of 100 percent in WY2012. The subsequent declining trend may be a function of high freshwater inflows particularly during WY2014.
- Live oyster density was low (31 oysters/m^2) in December 2013, following extreme freshwater inflow and depressed salinity in July–October 2013. Larval supply appears sufficient to support a natural recovery. Both the prevalence and intensity of Dermo, a marine parasite, were suppressed with increased freshwater inflow in September–November 2013.

CRE HYDROLOGY, WATER QUALITY AND AQUATIC HABITAT

Methods

A suite of external drivers and ecological responses are monitored in the Caloosahatchee River Watershed and Estuary. These variables include rainfall, freshwater discharge, and nutrient loading as external drivers, and patterns of water column nutrient concentrations, oyster habitat status, and SAV community composition as the ecological responses. Salinity provides a conservative property useful to connect freshwater inflow to estuarine flushing time and biological resource tolerances (Wilber, 1992; Jassby et al., 1995; Kimmerer, 2002; Hagy and Murrell, 2007; Pollack et al., 2011).

Daily rainfall data for stations spanning the spatial extent of the Caloosahatchee Watershed were downloaded from DBHYDRO on the District's website at http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu. Missing rainfall values were estimated using an interpolation method based on data from neighboring stations. The amount of rainfall across each basin was estimated using the Thiessen Polygon method. This method divides the basin containing the rainfall stations into straight-edged polygons. Each reference point within the basin is associated with its nearest rainfall station. The value from each station is divided by the total or fractional area of the basin depending upon the overlap between the polygon coverage and the basin extent.

Freshwater discharge is monitored at the major structures along the Caloosahatchee River (C-43 canal): S-77 next to Lake Okeechobee, S-78 near LaBelle, and S-79 at the upstream boundary of the CRE (**Figure 10-4**). For the purposes of this report, the East Caloosahatchee Sub-watershed and the S-4 Sub-watershed were reported together. Freshwater inflows are in units of cubic feet per second (cfs), where 1 cfs = 1.9835 acre-feet (ac-ft) per day = 2445.1 cubic meters (m^3) per day. All spatial references are in acres, where 1 acre = 0.405 hectares. The standardized units and definitions for the entire S*outh Florida Environmental Report* (SFER) appear in the document front matter. Salinity is derived from a dimensionless ratio and therefore has no units in reporting (Millero, 2010). Average daily inflow spanning from WY1997–WY2014 for S-77 and S-79 were used to evaluate intra- and inter-annual variations in inflow, to quantify total inflow to the CRE each water year, and to estimate the contributions of the sub-watersheds to total inflow. This included the relative volume contributions from Lake Okeechobee, and the Caloosahatchee Watershed upstream of S-79 (also known as the C-43 Basin). Total daily discharges and contributions were categorized by water year and season. Daily TN and TP loads were calculated using daily inflows at S-79 and S-77 and TN and TP concentrations determined from water samples at the structure. The contribution of the Tidal Caloosahatchee Sub-watershed (Tidal Basin) to freshwater inflow and nutrient loads was estimated using an approach that applied essentials of linear reservoir modelling (Y. Wan, SFWMD, personal communication; Wan et al., 2006). Flows and loads from the Coastal Sub-watershed were not estimated. The estimated daily loads from WY1997–WY2014 were categorized by water year to evaluate temporal variations at different timescales. Annual flow-weighted TN and TP concentrations from Lake Okeechobee and the East and West Caloosahatchee sub-watersheds were calculated by dividing the monthly concentrations by the monthly inflow volume to derive mass. The monthly masses of TN and TP were summed for each water year and divided by the total volume of inflow that occurred each water year. Because the determination of flow-weighted concentrations are derived using point-source measurements of concentration and flow over finite time intervals at the structures, this calculation was not extended to the modeled estimates of concentration and inflow across the entire Tidal Basin. **Table 10-9** describes the major contributing areas of the Caloosahatchee Watershed and the methodology associated with the reported flows and loads.

Table 10-9. Major contributing areas of the Caloosahatchee Watershed.

Total Contributing Areas	Caloosahatchee Watershed	Flows and Loads
C-43 Basin	S-4 Basin	Measured
	East Caloosahatchee	Measured
	West Caloosahatchee	Measured
Tidal Basin	Tidal Basin	Modeled
Lake Okeechobee	S-77 and S-79	Calculated

The concentrations of Chl-*a*, TN, and TP in the tributaries of the CRE were monitored at 16 stations in the CRE Tidal Basin collaboratively by Lee County and the City of Cape Coral from WY2000-WY2014. These data were requested from the Lee County Department of Natural Resources (http://www.leegov.com/gov/dept/NaturalResources/Pages/NaturalResources.aspx). This site includes an interactive map depicting the monitoring stations from tributaries around the CRE and listings of the routinely monitored water quality constituents. The monitoring data from the 16 stations along with the estimated freshwater inflows from the Tidal Basin were used to derive monthly time series of Chl-*a*, TN, and TP loading to the CRE.

Surface and bottom salinity observations are recorded every 30 minutes at seven stations in the CRE: S-79, Bridge 31, I-75 Bridge (Val I75), Fort Myers, Cape Coral, Shell Point, and Sanibel Island Bridge (**Figure 10-22**). Daily surface and bottom salinity values were averaged together to visualize temporal variations. Additionally, surface salinities at Fort Myers and the I-75 Bridge where critical criteria were derived relative to tape grass habitat requirements (Doering et al., 2002). These data were used to calculate moving averages and the percentage of days above or below the specified critical criteria.

Water column properties are determined from sampling at a depth of 0.5 m at 10 stations in the CRE, San Carlos Bay, and Pine Island Sound at approximately monthly intervals (**Figure 10-22**). Three stations (CES01, CES04, CES06) with the most complete records were selected to characterize estuarine water quality. Concentrations of TN, TP, and Chl-*a* from WY2000 through WY2014 (SFWMD, 2011) were assessed for this report.

Unlike the SLE, FDEP TMDL target concentrations were not used in a comparative analysis for the CRE. This is due to the changes and additions FDEP is currently making to the TMDL and numeric nutrient criteria (NNC). FDEP is currently re-examining the estuary TMDL for TN and is expected to derive a new TN concentration target as well as a revised load target. In addition, FDEP's CRE TMDL revisions are expected to add new TP and Chl-*a* targets to synchronize with FDEP's estuarine NNC development (see FDEP's 2013 Report to the Governor and Legislature, http://www.dep.state.fl.us/water/wqssp/nutrients/docs/NNC-report-governor-legislature.pdf). These changes are expected to be adopted after the development of this RWPP 2015 and will be incorporated into the CRWPP 2016 annual report, if available.

SAV monitoring has been ongoing at multiple sites in the CRE and San Carlos Bay since 1998. There are seven sites (1, 2, 4, 5, 6, 7, and 8; **Figure 10-22**) ranging in size from 1.0 to 2.0 acres (0.4 to 0.8 hectares). A 1.0-m^2 quadrat subdivided into 25 equal quadrants was deployed at 30 randomly selected locations within each site. The percent occurrence for each SAV species within each quadrat is determined by calculating the percentage of quadrants. The average and standard error of percent occurrence for each species is calculated from the 30 locations at each monitoring site for each monitoring event. Sites 1 to 8 were monitored the same way until 2011, however, starting in April 2012 monitoring at site 1 was modified through the use of a large quadrat (3.0 m x 3.0 m = 9.0 m^2 = 0.0009 hectares) subdivided into nine 1.0-m^2 quadrants. Data obtained from the large quadrats is being used to determine presence or absence of tape grass. Sites 2, 4, 5, and 7 were selected for this report because they span the salinity gradient in the CRE and have the most complete data records. Daily salinity at Fort Myers for the POR was superimposed with the SAV community composition at each site from WY2007–WY2014.

Oyster monitoring has been ongoing at multiple sites in the lower CRE since WY2001 (**Figure 10-22**). The primary site for this report is Bird Island near Shell Point (Volety et al., 2009; SFWMD et al., 2012b). The Bird Island site was selected for its central location in the lower CRE and data set completeness. Four basic oyster population metrics were included for interpretation. Live oyster densities, which have been estimated at each of these sites seasonally since WY2005. Oyster larval (spat) abundances were monitored at each sampling site every 1 to 2 months. The prevalence and infection intensity of the protozoan pathogen Dermo (*Perkinsus marinus*) at each sampling site were assessed at monthly intervals. Seasonal time series for each of these variables were derived for each site from WY2007–WY2014. Average daily salinity in the lower CRE for the POR was superimposed with the oyster population metrics.

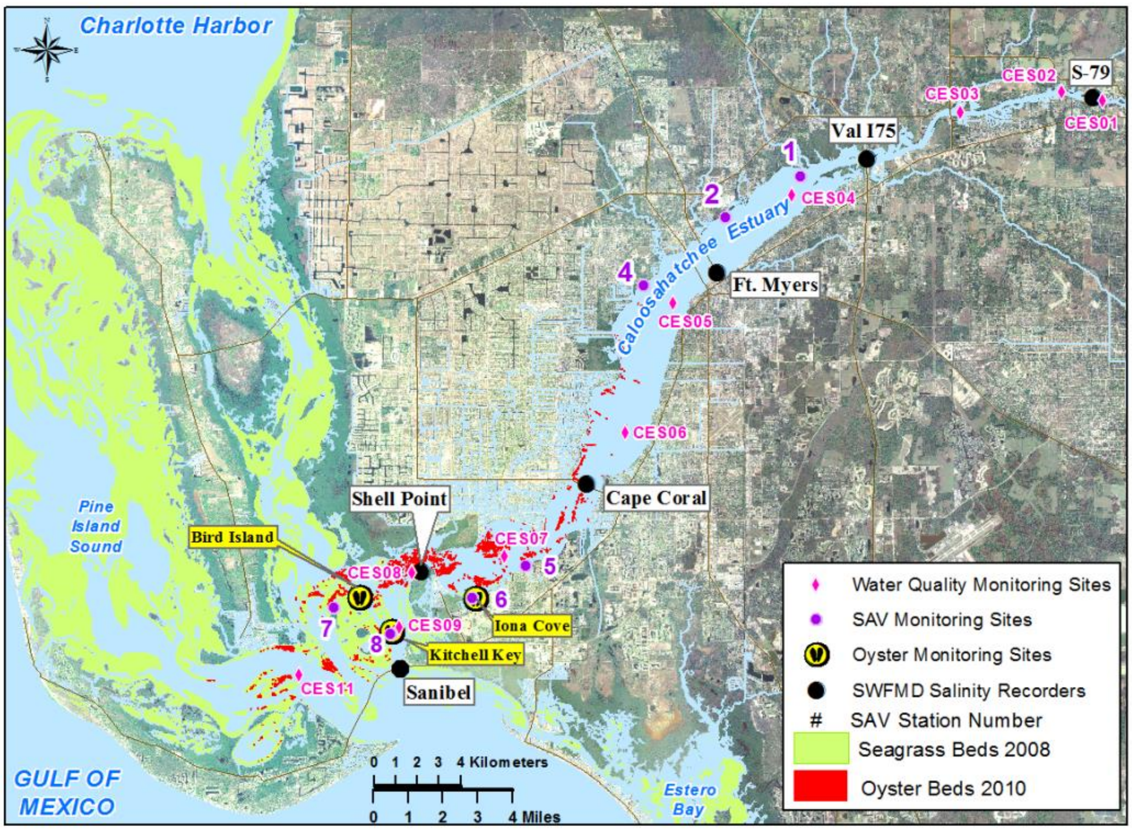

Figure 10-22. Locations for the monitoring of salinity, water quality, and living aquatic habitat (oysters and SAV) for the CRE. Map includes depiction of the distribution of SAV habitat in the lower CRE, Matchalas Pass, and Pine Island Sound.

Results and Discussion

Rainfall

As previously noted, WY2014 rainfall was at near historical levels including the wettest April–July period on record in South Florida since 1932. Daily rainfall to the CRE watershed ranged from 0 to 2.5 inches per day (0–6.4 cm per day) between May 2011 and April 2014 (**Figure 10-23**). Rainfall amounts were generally 0.5 to 1.0 inches per day throughout the POR. The comparatively higher rates of rainfall observed in October 2011 did not occur in the subsequent years. The long term annual average (WY1997–WY2014) was 51.5 inches with 21.9 percent occurring in the dry season versus 78.1 percent in the wet season (**Figure 10-24**). While total rainfall was reduced (90 percent of average) in WY2012 (46.5 inches) and WY2013 (46.6 inches) it increased in WY2014 (54.7 inches) to 106 percent of average. A slightly greater percentage of the total rainfall occurred in the wet season of WY2014 (82.0 percent) relative to the long term average. Average annual rainfall was generally greatest in the Coastal sub-watershed (55.1 inches) and least in the S-4 sub-watershed (40.2 inches; **Figure 10-25**). Rainfall in WY2014was higher in the Tidal Caloosahatchee and West Caloosahatchee sub-watersheds and lower in East Caloosahatchee and S-4 sub-watersheds compared to the long-term averages. The Coastal and West sub-watersheds had substantially higher rainfall in WY2014 than in previous water years.

Inflow

Freshwater discharge at S-79 represents the combined contribution of rainfall driven runoff from the East and West Caloosahatchee sub-watersheds as well as releases from Lake Okeechobee (**Figure 10-26**). During the wet season, water may be released from the lake to regulate water level. In the dry season, water is released to the CRE when available in order to mitigate saltwater intrusion.

The months that the mean monthly flow threshold (2800 cfs at S-79) was exceeded were 0 in WY2012, 2 in WY2013 and 5 in WY2014 (**Figure 10-26**). The long-term average total inflow (WY1997–WY2014) was 1.8 x 10^6 ac-ft (**Figure 10-27**, panel a). The relative contributions from Lake Okeechobee, the Caloosahatchee sub-watersheds, and the Tidal Basin averaged 31.6, 47.6, and 20.8 percent, respectively. While total inflow was lowest in WY2012 (1.0 x 10^6 ac-ft), it increased greatly to 3.0 x 10^6 ac-ft in WY2014, which is three times greater than in WY2012 and almost two times the long term average. The relative contribution from Lake Okeechobee varied greatly, accounting for only 6.9 percent of the inflows in WY2012 but increased to 29.0 percent in WY2013 (29.0 percent) and 37.9 percent in WY2014, due to an increasing need for regulatory releases during the wet season. In WY2014, the relative contribution of the Tidal Basin was reduced (16.5 percent) while the contributions from the Caloosahatchee Watershed (45.5 percent) and Lake Okeechobee (37.9 percent) were lower and higher than the long-term averages, respectively (**Figure 10-27**, panel a).

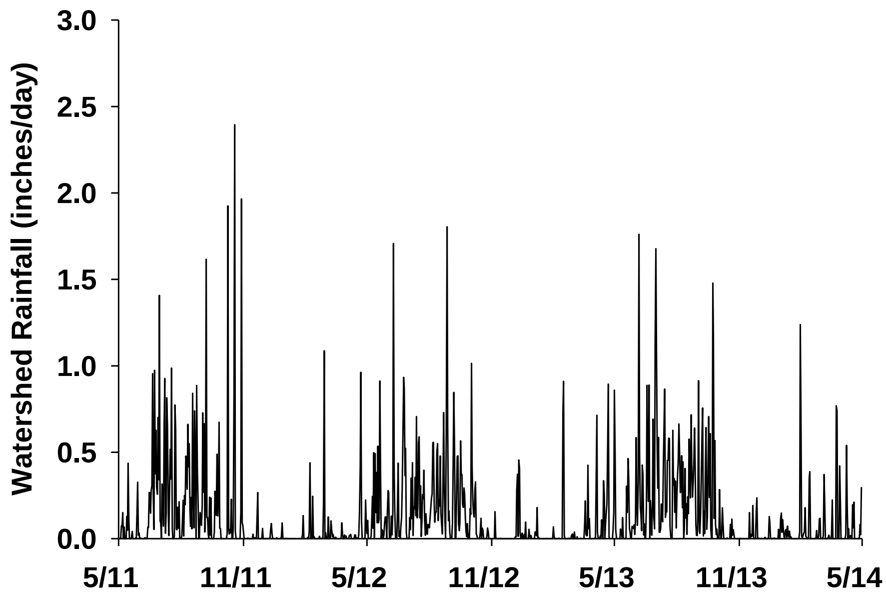

Figure 10-23. Time series of total daily rainfall to the CRE watershed and estuary WY2012-WY2014.

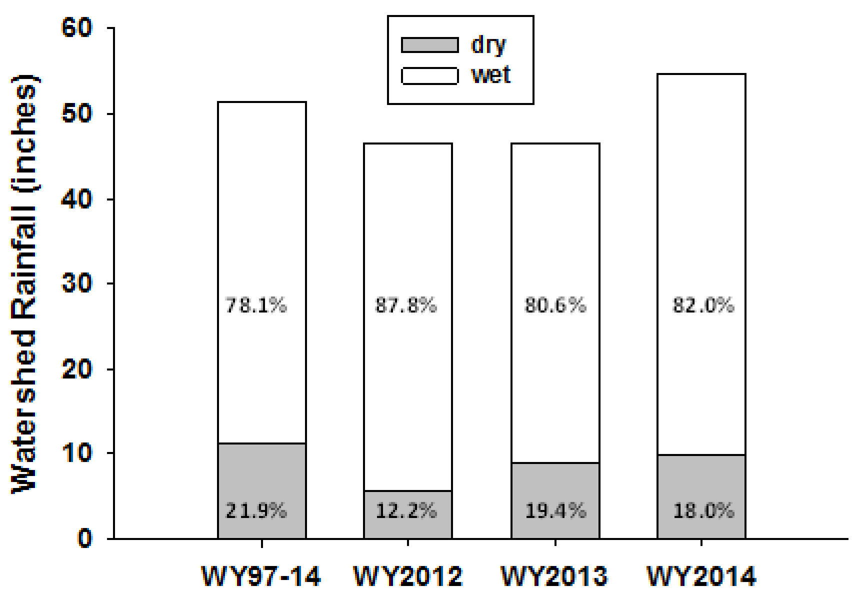

Figure 10-24. Total rainfall to the Caloosahatchee Watershed by water year and season, including the long-term average from WY1997–WY2014, WY2012, WY2013, and WY2014.

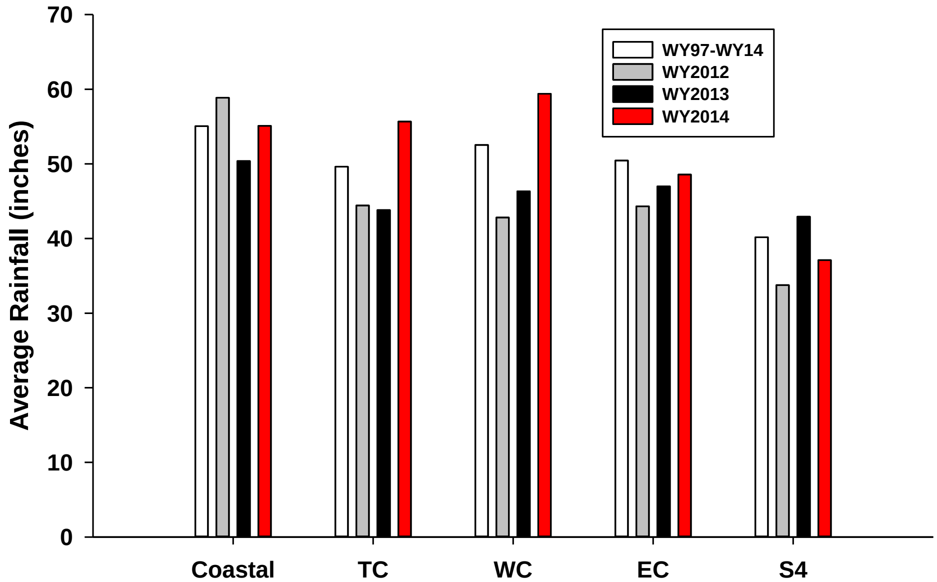

Figure 10-25. Average annual rainfall to the Caloosahatchee sub-watersheds, including the long-term average from WY1997–WY2014, WY2012, WY2013, and WY2014. Sub-basins are Coastal, Tidal Caloosahatchee (TC), West Caloosahatchee (WC), East Caloosahatchee (EC), and S-4 (S4).

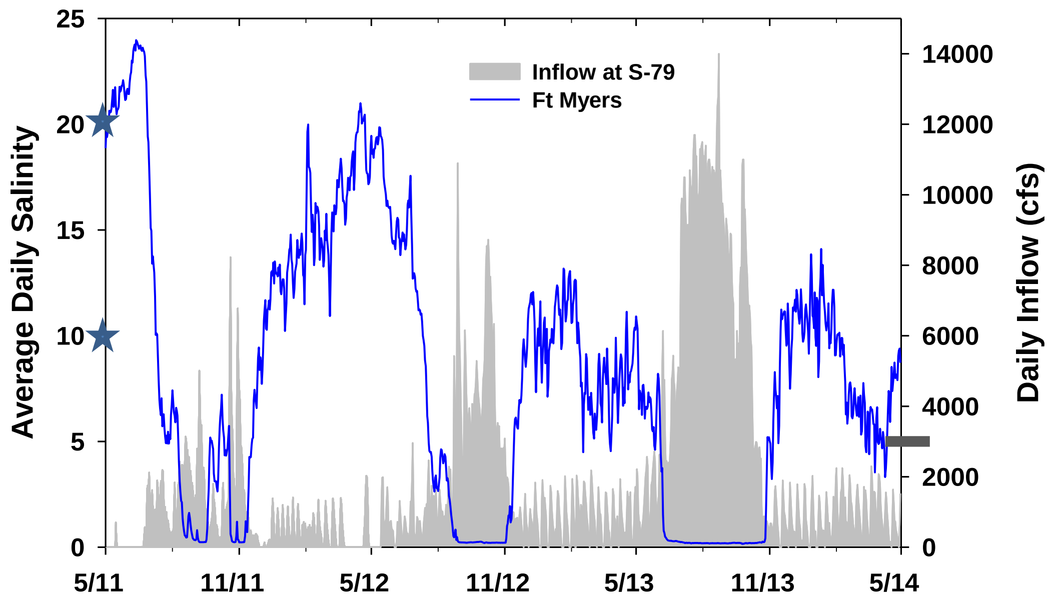

Figure 10-26. Time series of total freshwater inflow (cfs) at S-79 to and average water column salinity (Fort Myers) in the CRE WY2012-WY2014. Freshwater inflow at S-79 is the combination of the Caloosahatchee sub-watersheds and releases from Lake Okeechobee. Blue stars on the left y-axis denote target salinities of 10 and 20 (see **Table 10-10**). The grey bar on the right y-axis denotes the freshwater inflow mean monthly flow threshold (2,800 cfs at S-79). The relationship between freshwater inflow and salinity is non-linear and inverse.

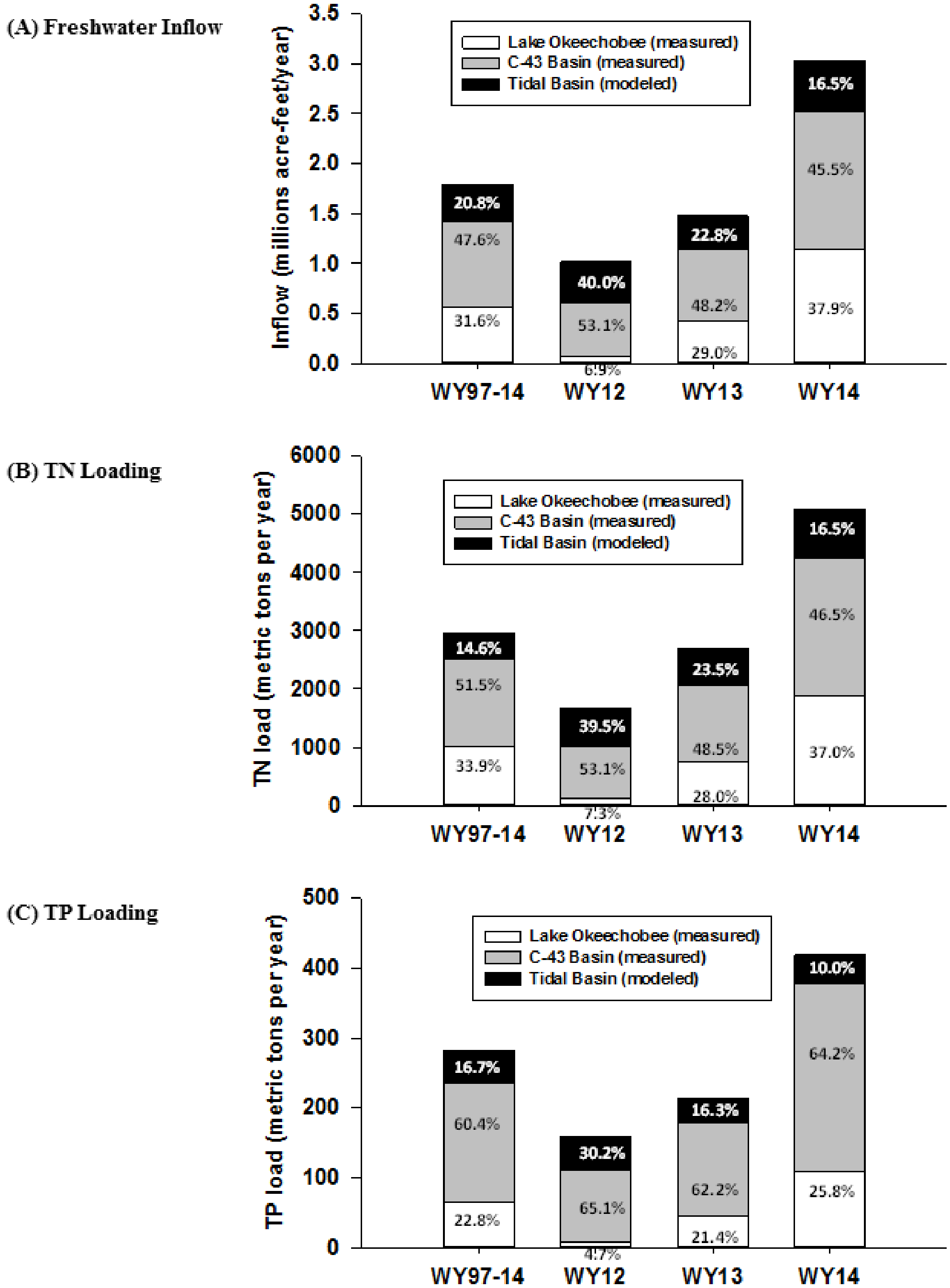

Figure 10-27. Stacked bar chart for the (a) total freshwater inflow (millions of ac-ft/yr), (b) TN loading (mt/yr), and (c) TP loading (mt/yr) attributable to Lake Okeechobee (white), the Caloosahatchee Basin (grey), and the Tidal Basin (black); includes the long-term average from WY1997–WY2014, WY2012, WY2013, and WY2014. The Tidal Basin inflow was estimated using a linear reservoir approach (Wan et al., 2006).

Salinity

Salinity at Fort Myers from WY2012–WY2014 ranged from 20 in May-June of 2012 to near 0 in September-November 2012 and July–October 2013, exhibiting a seasonal pattern inverse to that of freshwater inflow (**Figure 10-26**). Average daily salinity oscillated around 10 from January–May 2013 and from December 2013–February 2014. Salinity values were near zero during high freshwater inflow from July to mid-November 2013 and also in September to mid-November 2012. The long-term (WY1993–WY2014) percentage of days with salinity greater than 20 (7.6 percent) and percentage of days with a moving average salinity greater than 10 (30.6 percent) at Fort Myers were much different than the percentages from WY2012 (17.2 and 54.4 percent), WY2013 (0.0 and 25.2 percent), and WY2014 (0.0 and 0.0 percent; **Table 10-10**). These observations resulted from greatly reduced freshwater inflow in WY2012, a slight increase in freshwater inflow throughout WY2013, and much higher inflow in the wet season of WY2014. Similarly, the long-term average percentage of days where the 30-day moving average salinity was greater than 5 at the I-75 bridge (38.7 percent) increased to 64.7 percent in the WY2012 before declining as freshwater inflow increased in WY2013 (21.4 percent) and WY2014 (0.0 percent). The critical salinity criteria were not exceeded in 2014.

Table 10-10. Exceedances of critical salinity criteria at Fort Myers for WY2012–WY2014. At the Fort Myers station, the daily average salinity goal is to not exceed 20 and the 30-day moving average goal is to not exceed 10. At the Val I75 site, the 30-day moving average is to not exceed 5. The POR for the long-term average for the Fort Myers station is WY1994–WY2014 and Val I75 station is WY2007–WY2014.

POR	Fort Myers		Val I75
	Days with Salinity > 20	Days with 30-day Moving Average Salinity > 10	Days with 30-day Moving Average Salinity > 5
Average	7.6%	30.6%	38.7%
WY2012	17.2%	54.4%	64.7%
WY2013	0.0%	25.2%	21.4%
WY2014	0.0%	0.0%	0.0%

Nutrient Loads and Inflow Concentrations

Total nutrient loading to the CRE is a combination of water and nutrients from Lake Okeechobee, the East and West Caloosahatchee sub-watersheds, and the Tidal Basin. The loading of TP and TN to the CRE followed total freshwater inflow from WY1997–WY2014 (**Figures 10-27** and **10-28**). Overall, the TN:TP ratio of loading was approximately 10:1. Nutrient loading exhibited an increase with freshwater inflow from WY2012–WY2014 (**Figure 10-27**). Annual TN loads at S-79 (excluding the Tidal Basin) ranged from minimum values in WY1997 (~1,000 mt), WY2001 (~1,000 mt), WY2008 (near 0.0 mt), and WY2012 (~1,000 mt), and a maximum value in WY2006 following hurricane-induced discharge late in 2005 (~6,500 mt; **Figure 10-28**). TP loads followed a similar temporal pattern with values near 100 mt (WY1997, WY2001, WY2012), near zero mt in 2008 and ~600 mt (WY2006; **Figure 10-28**). The long-term averages (WY1997–WY2014) for total annual TN and TP loading were 2952.4 and 282.1 mt, respectively (**Figure 10-27**, panels b and c). Over the long term, the C-43 Basin contributed most of the TN load (51.5 percent) and most of the TP load (60.4 percent), followed by Lake Okeechobee which contributed 33.9 and 22.8 percent of the TN and TP loads, respectively. Model estimates suggest that the Tidal Basin contributes the least (14.6 percent of the TN load and 16.7 percent of the TP load). This same relative ranking of the three sources obtained in WY2013 and WY2014 (**Figure 10-27**, panels b and c). Because there was virtually no discharge from Lake Okeechobee in WY2012, it contributed very little to TN and TP loads during this year and the Tidal Basin input became relatively more important.

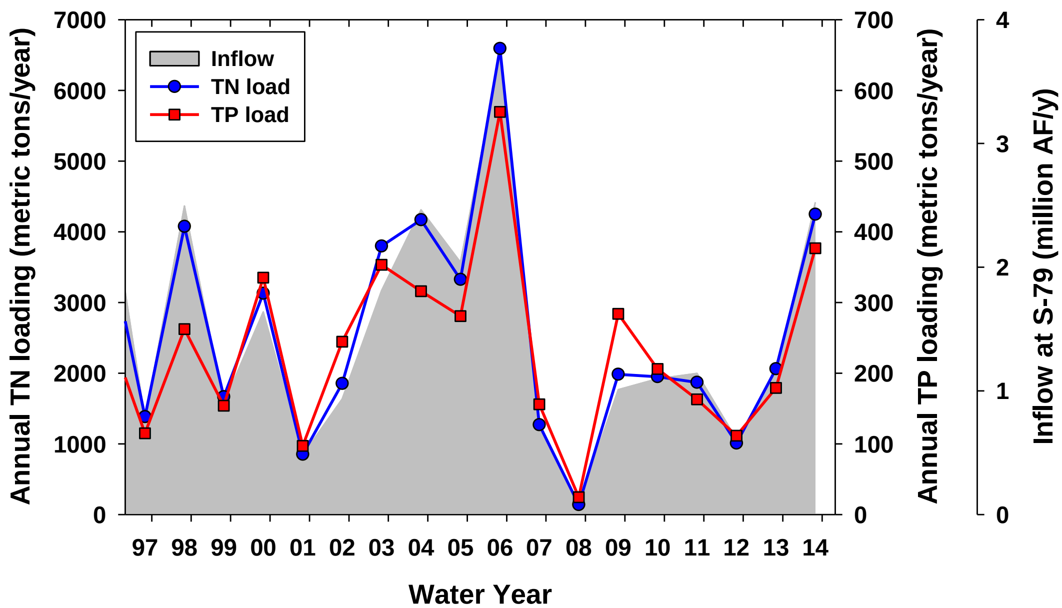

Figure 10-28. Time series of average annual freshwater inflow (shaded area), TN (blue), and TP (red) loading from S-79 to the CRE from WY1997-WY2014.

The annual average flow-weighted TN concentrations in discharges from Lake Okeechobee and the East and West Caloosahatchee sub-watersheds varied from ~0.5 mg/L to ~2.0 mg/L throughout the period of record, except for an extreme value of 3.25 mg/L in WY2001 (**Figure 10-29**, panel a). Generally, the TN concentrations from all three inflow sources remained between approximately 1.4 to 1.75 mg/L. While the sub-watershed with the highest and lowest annual TN concentration varied among the water years, generally the C-43 East Sub-watershed had higher concentrations (14 out of 18 years). Flow-weighted TN concentrations from Lake Okeechobee and the sub-watersheds fell within this general range in WY2014. The lowest concentration of TN from Lake Okeechobee over the entire period of record occurred in WY2014. The annual average flow-weighted TP concentrations varied from 0.05 mg/L to 0.3 mg/L among the three inflow sources (**Figure 10-29** panel b). In general, Lake Okeechobee had the lowest annual flow-weighted TP concentrations as was the case in WY2014.

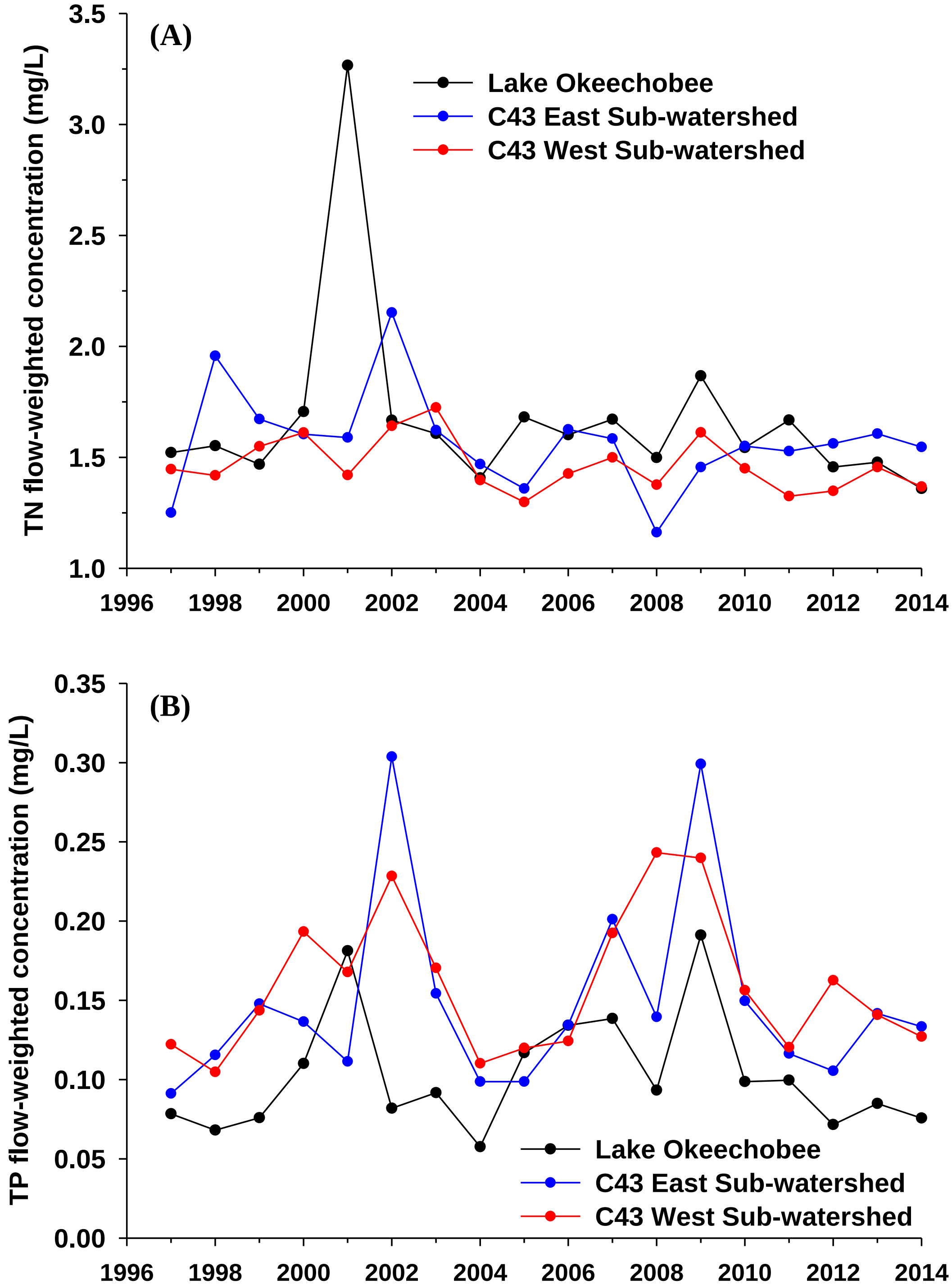

Figure 10-29. Time series of flow-weighted average concentrations of TN (a) and TP (b) from Lake Okeechobee (solid black) and the Caloosahatchee East (blue) and West (red) sub-watersheds (WY1997–WY2014).

Relative Contributions of Caloosahatchee Sub-Watersheds

This section is focused on Caloosahatchee Watershed and examines the general proportionality of the watershed contributing areas and yield of freshwater flows and loads from each of the primary Sub-watersheds that drain to the Caloosahatchee Estuary – East Caloosahatchee/S-4, West Caloosahatchee, and Tidal Caloosahatchee. (Note: It does not include inputs from Lake Okeechobee). Flows and loads are not always proportional to the contributing area. This information provides a relative comparison between the size (acres), flows (ac-ft) and loads (mt/yr) from contribution areas. It can be used to define areas for further analysis, to help focus restoration efforts and to identify areas of opportunity for water storage and/or water quality projects.

It is important to note that the flows and loads from the Tidal Caloosahatchee are modeled (see methods section). The size of the pie pieces in the pie charts below (**Figure 10-30**) are an indicator of relative proportionality of flows and loads to the size of the contributing areas. The pie charts show the size of the contributing areas (panel a), flows and TN and TP loads for the long-term period of record (panels b, d and e), and then the same information for WY2014 (panels c, e, and g).

Long-Term Period of Record (Water Years 1997–2014)

Flow: The relative percent contributions of flows from the East Caloosahatchee, West Caloosahatchee and Tidal Caloosahatchee sub-watersheds are generally proportional to their size. While some water from the East Caloosahatchee Sub-watershed over the long term POR flows east into Lake Okeechobee, it is a very small volume (approximately 22,000 ac-ft on an average annual basis) compared to the flow from this sub-watershed to the Caloosahatchee Estuary (approximately 280,000 ac-ft).

TN and TP Load: TN and TP loads from the three sub-watersheds followed generally consistent patterns. The relative contribution of TN loads (26.9 percent) and TP loads (24.1 percent) to the Caloosahatchee Estuary from the East Caloosahatchee Sub-watershed are generally proportional to the percent of areal coverage (28.6 percent) and flow (22.5 percent). The relative contributions of TN load (21.9 percent) and TP load (23.6 percent) from the Tidal Caloosahatchee Sub-watershed are proportionally low compared to the flow (31 percent) and areal coverage (30.7 percent) of this sub-watershed, indicating that this Basin likely has lower TN concentrations. Relative contributions of TN load (51.3 percent) and TP load (52.4 percent) from the West Caloosahatchee Sub-watershed is proportionally high compared to its contributing area (40.7 percent), which is likely due to a combination of flow (46.5 percent) and TN concentrations.

Water Year 2014 Comparison to the Long-Term Period of Record

The relative contributions of the Sub-watersheds in WY2014 were similar to that of the long term period of record, with two notable differences. The West Caloosahatchee contributed a greater percentage of the flows and TP loads, while the TP load from the Tidal Caloosahatchee was notably less.

In-Estuary Water Quality

Similar to the SLE and other sub-tropical estuaries the relationships between Chl*a* values freshwater inflow are difficult to discern (Buzzelli, 2011). However, in the Caloosahatchee highest concentrations of Chl*a* occur in the upper estuary during periods of low freshwater inflow and decrease as inflow from S-79 increases (Doering and Chamberlain 1998, Doering and Chamberlain 1999; Doering et al 2006). Increased inflow at S-79 pushes the location of maximum Chl*a* concentration downstream (Doering et al., 2006; Buzzelli et al 2013). Preliminary data analysis indicates that water temperature greater than 27°C is conducive for proliferation of phytoplankton in the upper CRE. While the long-term average concentration of Chl*a* was similar at the upper estuarine stations CES01 and CES04 (10.3 µg/L) and higher than at CES06 (8.9 µg/L) located further downstream (**Table 10-11)**. There was also considerable intra- and inter-annual variation at all three stations over the WY2000-WY2014 period of record (**Figure 10-31**, panels A-C**).** Concentrations exceeded 30 µg/L frequently at all stations with large blooms greater than 70 µg/L also occurring, particularly at CES01 (**Figure 10-31**, panels A-C).

Table 10-11. Summary of water column concentrations of Chl-*a* (µg/L), TN (mg/L), and TP (mg/L) at three stations (CES01, CES04, CES06) in the Caloosahatchee River Estuary; includes dry season, wet season, and total averages and standard deviations (avg±SD) from WY2000–WY2014 and average values for WY2012, WY2013, and WY2014.

CES01	Chl-*a*			TN			TP		
	Dry	Wet	Total	Dry	Wet	Total	Dry	Wet	Total
Avg+SD	6.3±2.7	14.2±10.3	10.3±8.4	1.33±0.19	1.45±0.17	1.39±0.19	0.11±0.04	0.16±0.04	0.13±0.05
WY2012	8.5	39.2	23.8	1.35	1.61	1.48	0.10	0.19	0.14
WY2013	6.2	17.3	11.7	1.35	1.37	1.36	0.08	0.14	0.11
WY2014	**6.4**	**8.1**	**7.2**	**1.20**	**1.33**	**1.27**	**0.08**	**0.12**	**0.10**

CES04	Chl-*a*			TN			TP		
	Dry	Wet	Total	Dry	Wet	Total	Dry	Wet	Total
Avg+SD	9.8±5.2	10.8±9.7	10.3±7.7	1.14±0.25	1.25±0.14	1.20±0.20	0.11±0.03	0.15±0.05	0.13±0.05
WY2012	5.3	9.7	7.5	0.98	1.13	1.06	0.09	0.17	0.13
WY2013	22.1	10.5	16.3	1.32	1.22	1.27	0.10	0.14	0.12
WY2014	**10.7**	**7.4**	**9.1**	**1.18**	**1.30**	**1.24**	**0.12**	**0.12**	**0.12**

CES06	Chl-*a*			TN			TP		
	Dry	Wet	Total	Dry	Wet	Total	Dry	Wet	Total
Avg+SD	6.9±4.8	10.9±7.6	8.9±6.6	0.77±0.18	1.08±0.16	0.93±0.23	0.08±0.02	0.12±0.03	0.10±0.03
WY2012	3.3	6.4	4.9	0.71	0.86	0.78	0.06	0.13	0.10
WY2013	4.9	5.1	5.0	0.91	0.98	0.94	0.07	0.11	0.09
WY2014	**6.1**	**7.9**	**7.0**	**0.82**	**1.16**	**0.99**	**0.08**	**0.11**	**0.09**

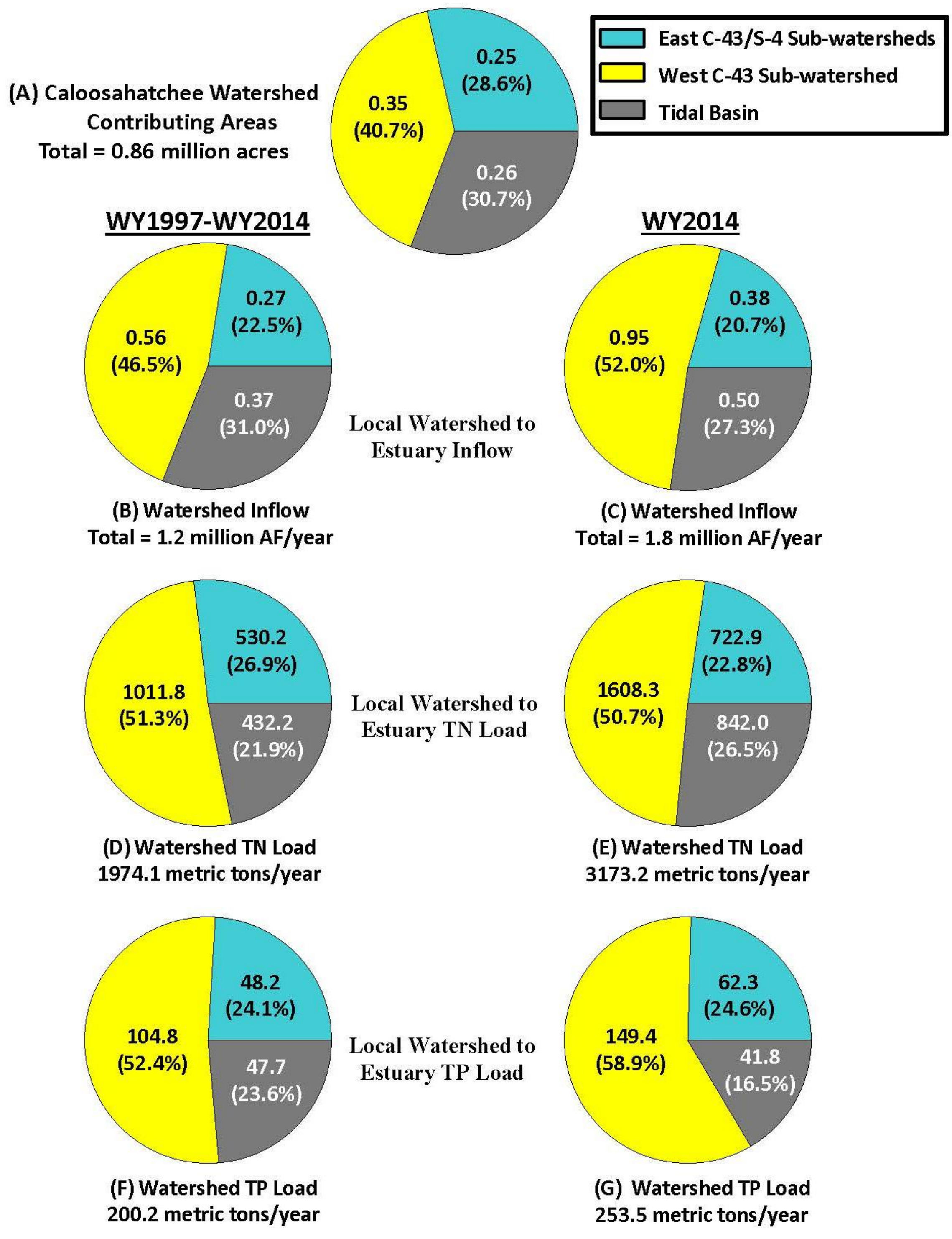

Figure 10-30. Pie charts depicting the percent contributions of East Caloosahatchee (white), the West Caloosahatchee Sub-watershed (grey), and the Tidal Caloosahatchee (black) to (a) average total freshwater inflow, (b) TN loading (mt/yr), and (c) TP loading (mt/yr) from WY1997–WY2014.

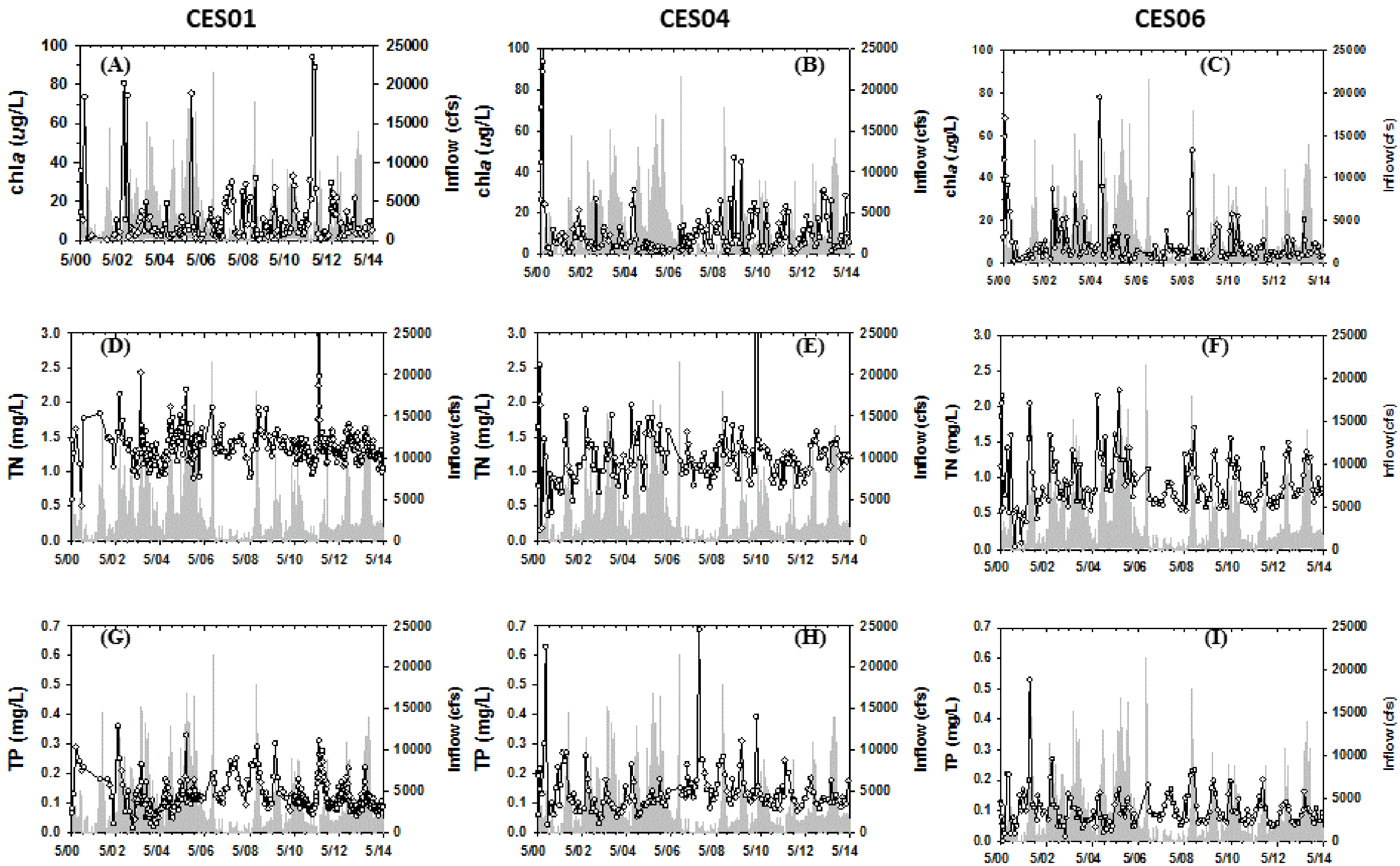

Figure 10-31. Time series of Chl-*a*, TN, and TP at stations CES01, CES04, and CES06 in the CRE from WY2000-WY2014.

Freshwater inflow was far below the long-term average in WY2012. The highest annual average Chl*a* concentration (23.8µg/L) occurred at CES01 in WY2012 (**Table 10-11**). This was due to a particularly high wet season average (39.2µg/L). Annual average concentration decreased as discharge increased in subsequent water years. Inter-annual fluctuations at CES04 did not seem related directly to flow with WY2013, an intermediate flow year, having the highest concentration of the three water years. Seasonally, Chla at CES04 peaked in the dry season when flows were relatively low. At CES06 annual average Chl*a* increased from WY2012 to WY2014 but the change was not large (4.9-7.0 µg/L). At CES01 and CES06 wet season concentrations of Chl*a* were greater than in the dry season (**Table 10-11**), perhaps due to higher temperature and an enhanced supply of nutrients. The dry (9.8 µg/L) and wet (10.8 µg/L) season averages were more similar at CES04. Overall, Chl*a* concentrations were variable at all 3 locations as the standard deviations were 74-80 percent as large as the annual averages.

The overall TN concentration of the CRE is proportional to intra- and inter-annual variations in freshwater inflow and external TN loading (Buzzelli et al., 2013d). Like many other estuaries, the concentrations of TN in the freshwater entering the CRE are higher than those in the ocean water with which it mixes. This mixing generally results in higher nutrient concentrations near major freshwater inputs (S-79) and lower nutrient concentrations near the ocean. Higher concentrations are also expected in the wet season when increased rainfall and runoff increase the amount of freshwater entering the system and rates of internal recycling are higher (Buzzelli et al., 2013b).

The concentration of TN in the Caloosahatchee varied spatially as expected being highest at CES01 nearest S-79 and lowest at CES06, the station located furthest downstream. This pattern was evident in long-term, annual and seasonal averages (**Table 10-11**) and in the long-term time series (**Figure 10-31**, panel b). Wet season concentrations were higher than dry season concentrations at all stations except during WY2013 at CES04. Annual averages during WY2012, WY2013, and WY2014 fluctuated around long-term means at all stations (**Table 10-11**). The standard deviations were 14-17 percent of the annual average TN concentrations at CES01 and CES04 but increased to ~25 percent at CES06. Physical (transport out of the estuary) and biological (internal recycling and phytoplankton removal) mechanisms serve to modulate water column concentrations in the CRE (Buzzelli et al., 2013b; 2013d).

Spatial and temporal patterns of water column TP concentrations are much less variable in the CRE relative to the SLE (Buzzelli et al., 2013d). Additionally, biogeochemical cycling and metabolism in the CRE are relatively insensitive to intra-annual variations in external phosphorus loading. The spatial gradient in TP concentrations between S-79 and the downstream estuary is not as strong as that for TN. Phosphorus cycling in the estuary is much less complicated because phytoplankton production does not respond to external P-inputs (Buzzelli et al., 2013d). In general, long-term, annual and seasonal average concentrations were slightly higher at the upper estuarine stations, CES01 and CES04, than further downstream at CES06 (**Table 10-11**). Generally, concentrations oscillated between about 0.05 and 0.2-0.25 mg/L at all stations (**Figure 10-31**, panels g and h). A longer term oscillation is apparent at CES01 and CES04 with concentrations increasing during the drought years of 2007 and 2008 (**Figure 10-31**, panels g and h). Over the past three water years annual averages for the driest water year, WY2012 were greater than in the wetter WY2013 and WY2014 (**Table 10-11)**. Within a water year however, TP concentrations were almost always higher during the wet season, the exception being CES04 during WY2014 when average concentrations did not vary seasonally. The TP concentration at CES01 averaged 0.13 mg/L while oscillating from 0.05 mg/L to 0.25 mg/L from WY2000–WY2014 (**Figure 10-31**, panel g; **Table 10-11**). The standard deviations were 30 to 38 percent of the annual average TP concentrations at all three locations in the CRE.

Ecological Indicators Results

The distribution and abundance of different SAV populations are influenced by the availability of submarine light and nutrients, seasonal shifts in water temperature and plant physiology, grazing by macro- and mega-fauna, and salinity (Duarte et al., 2007; Lee et al., 2007; Lirman et al., 2008; Buzzelli et al., 2012). While there were some observable patterns for the SAV community coincidental with freshwater inflow from WY2009-WY2014 (**Figure 10-32**), other factors appeared to be influencing SAV species occurrence**.** For example, at site 4, widgeon grass (*Ruppia maritama*) appeared to occur more frequently during periods of higher salinity and decline during periods of lower salinity. A similar trend was apparent at site 5 with shoal grass, where the effects of high discharges in WY2014 were most evident.. The species composition varied greatly between sites 2 and 4 compared to sites 5 and 7. Widgeon grass was the dominant species at sites 2 and 4, with some tape grass at site 2. Both of these species prefer lower salinity, with tape grass being a freshwater SAV. The more halophilic species, shoal grass and turtle grass, were present at downstream sites 5 and 7. In general larger numbers species were found at the more freshwater and marine stations, and few species were found at the stations in between.

The distribution, density, and status of oyster habitat in the CRE varies greatly in time and space depending upon salinity, substrate availability, predation, and disease (Barnes et al., 2007; Volety et al., 2009 Buzzelli et al., 2013c; Parker et al., 2013). There were intra- and inter-annual variations for the indicators of oyster habitat at Bird Island in the lower CRE (**Figure 10-33**). Oyster densities ranged from ~500 oysters/m^2 in WY2008 to ~3000 oysters/m^2 in WY2010, WY2011, and WY2014 (**Figure 10-33**, panel a). The average and standard deviation of oyster density over the period of record at Bird Island was 1793±936 oysters/m^2. There were no obvious relationships between oyster density and the average salinity of the lower CRE at the Bird Island site. However, further upstream at the Iona Cove site oysters were virtually eliminated during the wet season of WY2014 (Figure 10-34).

Larval abundance generally ranged from less than 5 to 50 spat/shell/month (**Figure 10-33**, panel b). Overall, the larval settlement rate was greater in the wet season including a peak value of 135 spat/shell/month in June 2010. There was great variability as the rate of larval settlement averaged 10.5±22.7 spat/shell/month at Bird Island. While it is possible for extreme freshwater inflows to push oyster larvae out of the lower CRE (Barnes et al., 2007), the relationships between salinity and larval settlement were difficult to discern. Spat abundance was reduced in WY2008 when salinity remained high throughout the wet season. The percentage of oysters infected with Dermo (e.g., prevalence) ranged from ~10 to 100 percent throughout the period of record (WY2007–WY2014; **Figure 33**, panel c). Prevalence was reduced to 25 to 50 percent in 2006, 2007, and 2010. Overall, prevalence averaged 78.1±20.2 percent at Bird Island from WY2007–WY2014. Although a large percentage of the oysters were infected with Dermo, the level or intensity of the infection averaged 1.8±0.7 and was generally low ranging from 1-2 (**Figure 33**, panel d). Infection intensity was minimal in 2006, 2007, 2009–2010, and 2013–2014. The intensity of oyster infection was greater than 3.0 in 2007, 2011, and 2012. The inverse relationship between the percentage of oysters with Dermo and the relative intensity of the infection is expected given that Dermo is a marine parasite and that times of increased temperature coincide with low salinity in the CRE (LaPeyre et al., 2003).

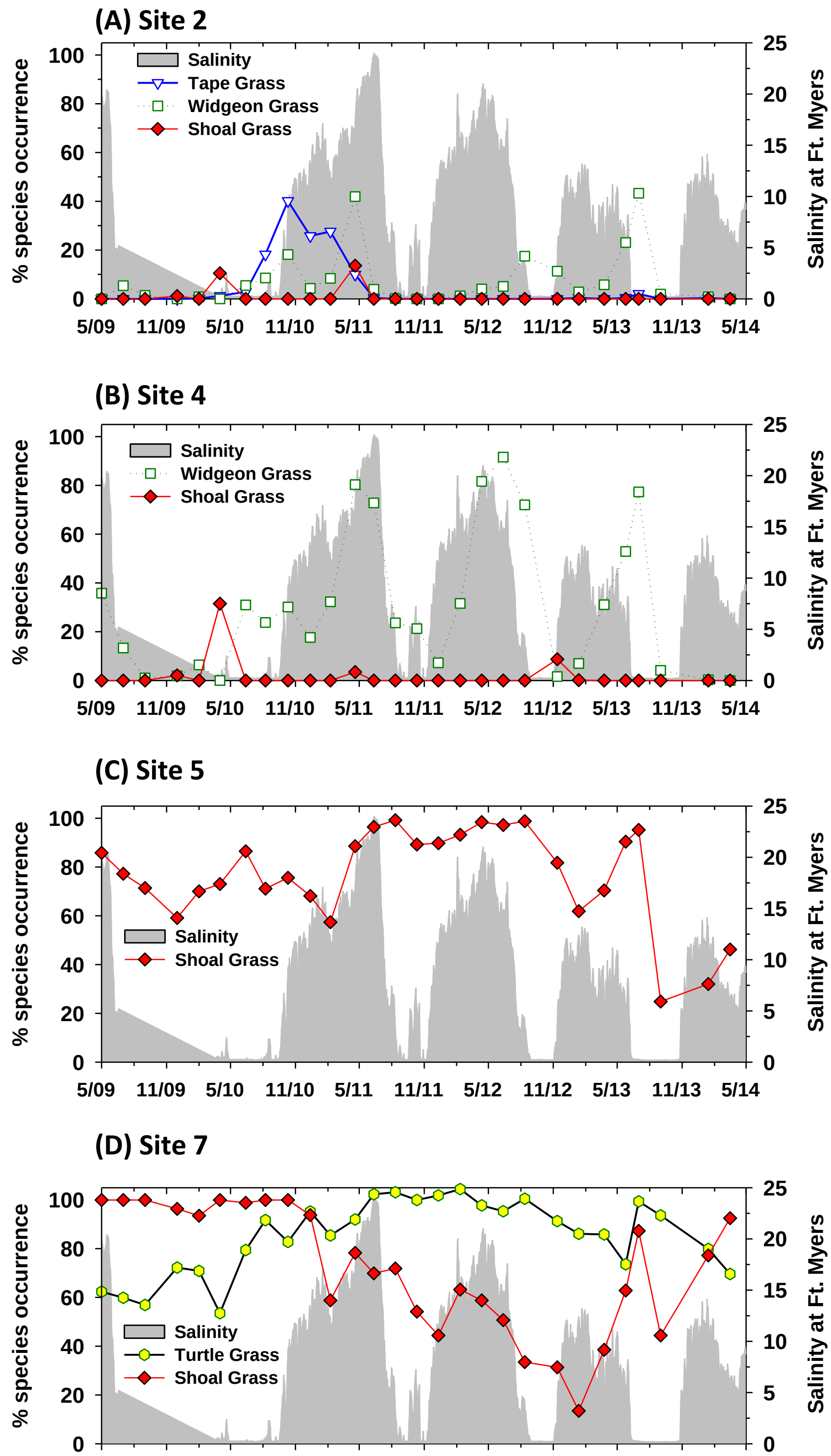

Figure 10-32. Time series of percent species occurrence (% occurrence) for the SAV community at (a) Site 2; (b) Site 4; (c) Site 5; (d) Site 7 in the CRE from WY2010-WY2014; includes the average daily salinity at the Fort Myers (grey area).

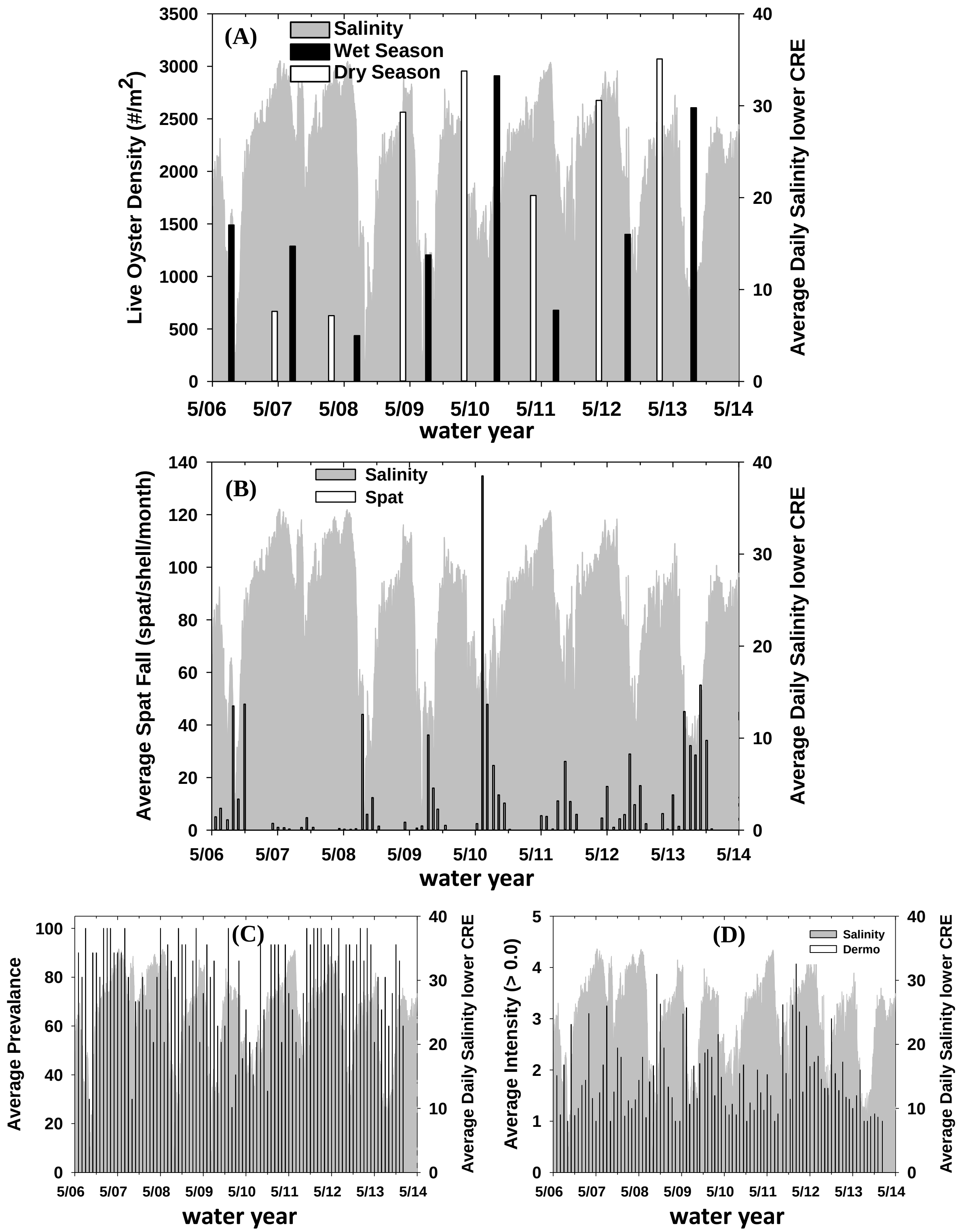

Figure 10-33. Time series for average live oyster density (a), larval abundance (b), and the prevalence (c), and intensity (d) of the oyster-specific pathogen, Dermo, from WY2007-WY2014 at Bird Island. The average salinity in the lower CRE is included in each time series.

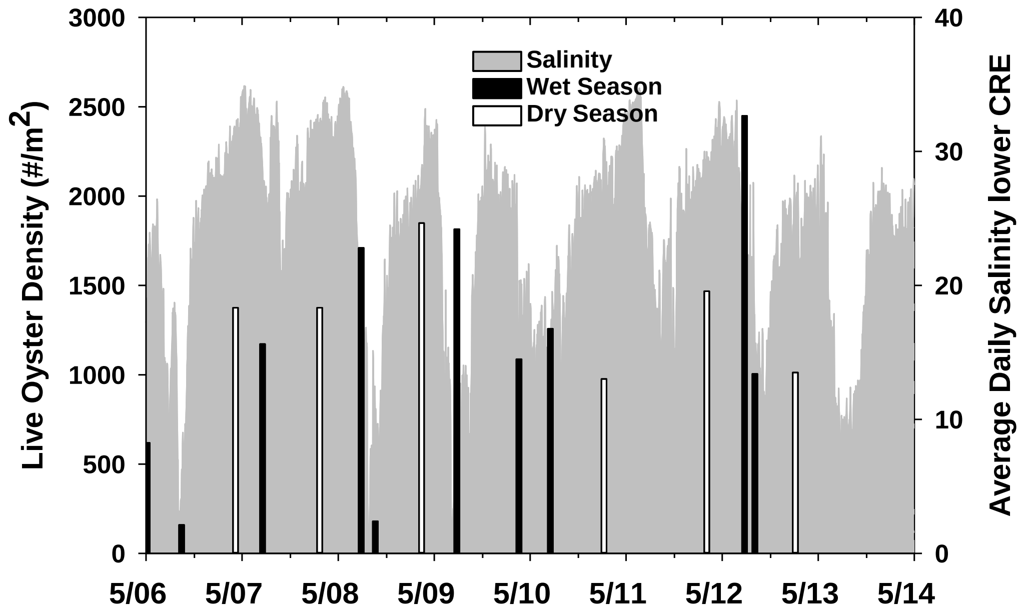

Figure 10-34. Time series for average live oyster density from WY2007-WY2014 zt Iona Cove. The average salinity in the lower CRE is included in the time series.

Significant Findings

- In WY2014, for example, the total annual rainfall in the Caloosahatchee Watershed exceeded the long-term (WY1997–WY2014) average (51.5 inches) due to greater precipitation in both the dry and wet seasons. While total rainfall was reduced in WY2012 and WY2013, it increased in WY2014. The wet season percentage in WY2014 (82.0 percent) was slightly greater than the long-term average (78.1 percent).
- Total freshwater inflows to the Caloosahatchee River Estuary (CRE) greatly exceeded the long-term average (by approximately 1.3 million ac-ft) and the previous two water years (WY2012 and WY2013). 62 percent of inflow in WY1014 was from the Caloosahatchee Watershed and 38 percent from the Lake Okeechobee.
- While inflow was greatly reduced in WY2012 (1.0 x 10^6 ac-ft), the value increased to 3.0 x 10^6 ac-ft in WY2014. The contribution of Lake Okeechobee was elevated in WY2014 relative to the long-term average (37.9 versus 31.6 percent), the C-43 Basin approached the long-term average (45.5 versus 47.6 percent), and the Tidal Basin input was reduced (16.5 versus 20.8 percent).
- Salinity is inversely related to freshwater inflow in the estuaries. Salinity was particularly low during wet season when rainfall and inflows were high. The long-term percentage of days with salinity greater than 20 (7.6 percent) was much different than the percentages in WY2012 (17.2 percent), WY2013 (0.0 percent), and WY2014 (0.0 percent). These observations resulted from greatly reduced freshwater inflow in WY2012, a slight increase in freshwater inflow throughout WY2013, and much higher inflow in the wet season of WY2014.
- Inter-annual fluctuations in TN and TP loading follow fluctuations in freshwater inflow.

  The long-term averages (WY1997–WY2014) for total annual TN and TP loading were 2,952.4 and 282.1 mt, respectively, with 33.9 percent of the TN and 22.8 percent of the TP derived from Lake Okeechobee, 51.5 percent (TN) and 60.4 percent (TP) derived from the C-43 Basin, and 14.6 percent (TN) and 16.7 percent (TP) from the Tidal Basin. The percent contributions from Lake Okeechobee, the C-43 Basin, and the Tidal Basin were similar to the long-term average in WY2014.
- Chl-*a* concentrations in the CRE did not correspond well to freshwater inflow. However, concentrations at CES04 in the upper estuary were highest during the dry season when flows are lowest. The highest concentrations were observed at the most upstream site (CES01) during the drought of WY2012. Average Chl-*a* values were reduced compared to the long-term averages throughout the CRE in the wet seasons of WY2013 and WY2014.
- The concentration of TN in the CRE varied spatially, with the highest concentrations at CES01 nearest S-79 and lowest at the more downstream CES06. TN concentrations in WY2014 were slightly lower at CES01 but slightly higher at CES04 and CE06 relative to the long-term average values. Wet season concentrations were higher than in the dry season due to a combination of increased inflow and TN loading and increased water temperature and rates of internal cycling.
- Spatial and temporal patterns of water column TP concentrations were much less variable in the CRE relative to the SLE. In general, long-term, annual, and seasonal average concentrations were slightly higher at the upper estuarine stations. TP concentrations were slightly higher during the wet season.
- While there were some observable patterns for the SAV community coincidental with freshwater inflow from WY2009-WY2014 (**Figure 10-33**), other factors appeared to be

influencing SAV species occurrence. In general larger numbers species were found at the more freshwater and marine stations and few species were found at the stations in between.

- There were intra- and inter-annual variations for the indicators of oyster habitat at Bird Island in the lower CRE. There were no obvious relationships between oyster density and the average salinity of the lower CRE at the Bird Island site. Further upstream at the Iona Cove site, oysters were virtually eliminated during the wet season of WY2014. Overall, the larval settlement rate was greater in the wet season. Although a large percentage of the oysters were infected with Dermo, the level or intensity of the infection was generally low. The inverse relationship between the percentage of oysters with Dermo and the relative intensity of the infection is expected given that Dermo is a marine parasite and that times of increased temperature coincide with low salinity in the CRE.

STRATEGIES MOVING FORWARD

The 2015 SLRWPP and CRWPP updates represent the second three-year evaluation to the original 2009 plan (SFWMD et al., 2009a; 2009b). These evaluations include strategic projects and activities for water quality and quantity improvements to benefit both watersheds. The following section will focus on projects and initiatives that the coordinating agencies as well as local stakeholders are planning and implementing primarily over the next several years and in some cases beyond (e.g., BMAP activities).

KEY ACTIVITIES MOVING FORWARD

Basin Management Action Plans

A BMAP is the blueprint for restoring impaired waters by reducing pollutant loadings to meet a Total Maximum Daily Load. A TMDL is the maximum amount of a pollutant that a water body or segment can assimilate from all sources without exceeding water quality standards. A BMAP represents a comprehensive set of strategies—permit limits on wastewater facilities, urban and agricultural BMPs, conservation programs, financial assistance and revenue generating activities, etc.—designed to implement the pollutant reductions established by the TMDL. A description of the BMAP development process is available at www.dep.state.fl.us/water/watersheds/bmap.htm. As described in Section 403.067(7), F.S., BMAPs address some or all of the watershed and basins tributary to the water body and equitably allocate pollutant reductions to individual basins, as a whole to all basins, or to each identified point source or category of nonpoint sources, as appropriate. BMAPs provide an iterative approach to achieving the TMDL through an implementation plan that is adopted by FDEP secretarial order pursuant to Chapter 120, F.S., and therefore are enforceable. FDEP's BMAPs serve as the overarching water quality restoration plans in the Northern Everglades, and the Watershed Protection Plans serve as the basis for the BMAPs. The BMAPs are the forums to track water quality restoration projects and initiatives that stakeholders agree to implement during a specific phase of the BMAP.

The FDEP along with its stakeholders successfully adopted BMAPs for TN for the Caloosahatchee Estuary (FDEP 2012) and for TP and TN for the St. Lucie River and Estuary (FDEP 2013) since the RWPP 2012 Updates. Both BMAPs are in the first five year phase during which projects will be implemented but planning and other activities (e.g., new modeling) will also be taking place in order to set the stage for the second phase of the BMAP. The second phase of the Caloosahatchee Estuary BMAP is currently planned to begin in 2017, while the St. Lucie River and Estuary's BMAP second phase is expected to begin in 2018.

In the St. Lucie River and Estuary Basin, FDEP estimates that the first five-year iteration is expected to reach 30 percent of the required reductions for TP and TN by 2018 based on projects submitted by stakeholders (17 entities). In the Caloosahatchee estuary BMAP, FDEP estimated stakeholders (8 entities) submitted projects that reduced total nitrogen in the tidal watershed by approximately 40 percent of the original TMDL over the first five years. In both watersheds, examples of nutrient reduction projects and initiatives include, but are not limited to, urban first generation baffle boxes, agricultural BMPs, and local fertilizer ordinances. Through these efforts, the FDEP expects the following outcomes after the first five years in both the St. Lucie Watershed and the Tidal Caloosahatchee (FDEP, 2012; 2013):

- Modest improvements in water quality trends in the watershed tributaries as well as each estuary (St. Lucie and Caloosahatchee);
- Decreased loading of the applicable target pollutants (TP, TN, and BOD);
- Increased coordination between state and local governments and within divisions of local governments in problem solving for surface water quality restoration;
- Determination of effective projects through the stakeholder decision-making and priority-setting processes;
- Enhanced public awareness of pollutant sources, pollutant impacts on water quality, and corresponding corrective actions;
- Enhanced understanding of basin hydrology, water quality, and pollutant sources.

FDEP held the first annual update meeting on the Caloosahatchee Estuary BMAP in February 2014 and released its report (http://www.dep.state.fl.us/water/watersheds/docs/bmap/caloosa-estuary-bmap-apr2013.pdf), which details each stakeholders' highlights towards meeting the agreed upon BMAP projects and initiatives. Over the next three years, the FDEP plans to continue these updates as well as work with stakeholders to begin planning for the second phase after the revised TMDL and new TMDLs in the basin are completed.

The first annual update meeting for the St. Lucie BMAP was held by the FDEP in August 2014 and a draft report has also been released highlighting stakeholders' highlights (http://www.dep.state.fl.us/water/watersheds/bmap.htm). Over the next three years, the FDEP plans to work with stakeholders on a new model for the second phase of the BMAP. In addition, the FDEP will continue to work with local stakeholders to identify on new projects and initiatives to reach the second phase's eventual load reduction goals for TN and TP.

Continued Implementation of Pollutant Source Control Programs

The Pollutant Source Control Program is a multifaceted approach, including the coordinated implementation of regulations and BMPs and development and implementation of improved BMPs by agencies and stakeholders. As previously noted, the SFWMD, FDEP, and FDACS are defined as the coordinating agencies for implementing the Pollutant Source Control Program in the Northern Everglades watersheds, as defined by the NEEPP. Details of the programs are discussed earlier in the *Pollutant Source Control Program Update* section of this chapter. Key upcoming activities and strategies associated with continued implementation of these programs and the specific rule amendments are discussed below.

Upcoming Rule Amendments

District's Regulatory Source Control Program. Chapter 40E-61, F.A.C., the Lake Okeechobee Works of the District Rule adopted in 1989, is the District's regulatory nutrient source control program for controlling phosphorus in stormwater runoff within the Lake Okeechobee Watershed. The objective of the District's program is to ensure that the uses of

District works by landowners within the watershed are compatible with the District's ability to implement Chapter 373, F.S. The existing rule requires BMP plans for phosphorus control to be approved by permit and establishes water quality monitoring requirements. NEEPP directs the District to initiate rule development amending the existing program under Chapter 40E-61, F.A.C., to expand to the St. Lucie River and Caloosahatchee River watersheds. It is a District priority to initiate the rule development process to amend Chapter 40E-61, F.A.C., consistent with water quality improvement strategies in the Northern Everglades, including the BMAP. It is anticipated that rulemaking workshops will be initiated in 2015 to solicit public input on draft rule text so that an amended rule may be adopted and implemented. The District's regulatory plan submitted to OFARR includes amendments to Chapter 40E-61, F.A.C. It is expected that future proposed rule amendments will include incentives to participate in nutrient reduction demonstration and research projects to provide the data necessary for optimizing BMP performance.

Monitoring

Key upcoming activities associated with the District's Chapter 40E-61 F.A.C. Program include optimization of the monitoring networks at the basin level monitoring sites and the upstream sites within the River Watersheds. These efforts are necessary to support future proposed Chapter 40E-61, F.A.C., amendments.

Florida Department of Agricultural and Consumer Services' Agricultural Best Management Practices Program

The FDACS agricultural BMP program includes implementation of owner-implemented and cost-shared BMPs. Practices under the owner-implemented category generally are non-structural, and include nutrient and irrigation management, maintenance of vegetative buffers to protect water features from sediment- and nutrient-laden runoff, and location of livestock feeding/mineral stations away from water features.

Cost-shared BMPs generally are structural, and typically include surface water control structures, detention/retention structures, alternative watering facilities for livestock, and tail-water recovery ponds. These practices may require significant investment by the landowner, and require long-term planning and cost-share assistance for installation and maintenance. The FDACS estimates that approximately $70 million is needed to complete implementation of cost-shared BMPs in the Lake Okeechobee Watershed.

In recent years, the FDACS has requested $5 million annually of Everglades Forever Act funding in their legislative budget request to continue implementing cost-shared BMPs. The Florida Legislature typically has appropriated $3 million annually for this purpose, to be used within the NEEPP area. In 2014, the legislature appropriated $10 million in funding to expedite planning and implementing these projects. FDACS anticipates making legislative requests of $10 million in subsequent years to continue funding these types of projects.

For both the St. Lucie and Caloosahatchee rivers watersheds, the FDACS will continue to enroll agricultural lands, conduct BMP implementation assurance activities, and adopt or update BMP manuals as needed. As funding is available, the FDACS will continue working with landowners to identify opportunities to implement cost-shared BMPs. FDACS has dedicated a position to work in the Caloosahatchee watershed to assist producers with BMP implementation. They are in process of hiring additional staff for the same purpose in the St. Lucie Watershed. In addition, the FDACS will continue to work with the UF/IFAS to evaluate BMP effectiveness.

Coordinating Agencies' Regional Projects

Several regional projects listed in **Table 10-2** are scheduled to meet important milestones over the next reporting period for the RWPPs and beyond. Key highlights are provided below, with more specific project details in **Table 10-2**.

- **CERP Indian River Lagoon South – C-44 Reservoir/STA (St. Lucie Watershed).** On July 10, 2014, the District's Governing Board approved amending the Project Partnership Agreement with the USACE), which allows the SFWMD to begin work toward constructing the 6,300-acre STA (see **Figure 10-9b**) by 2017, and the Project Partnership Agreement amendment has been finalized. This STA is estimated to remove up to 26 mt/yr of TP and 82 mt/yr for TN. Importantly, the state has provided $60 million over the last two years to ensure a successful start to this important feature of the overall C-44 project. In August 2014, the District's Governing Board continued the process by awarding a contract for construction of a spillway that will serve as the single point of water movement out of the entire C-44 project.

  While the SFWMD's and STA work is under way, it is expected the USACE will continue its efforts on the reservoir portion of the project (see **Figure 10-9b**) for important water storage benefits (estimated up to 50,600 ac-ft of storage). On July 31, 2014, the USACE announced that they had successfully completed the first construction contract of the project. This is considered an important foundation toward which the implementation of all phases can move forward, with an expected overall project completion date currently planned in 2020.
- **Ten Mile Creek (St. Lucie Watershed).** In August 2014, the SFWMD submitted a letter to the USACE requesting that the Ten Mile Creek Project be formally returned to the District. Currently, the SFWMD and the USACE remain committed to dialogue on how to best move forward for a project at this location.
- **CERP Caloosahatchee River (C-43) West Basin Storage Reservoir Project (Caloosahatchee Watershed).** On June 10 2014, the federal Water Resources Reform and Development Act (WRRDA) was signed into law, authorizing the USACE to undertake water resources projects under their jurisdiction. Importantly, WRRDA 2014 includes authorization for 34 projects nationwide including the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, which has a design capacity of 170,000 ac-ft. This represents a major milestone in moving forward for this important regional project. Currently, federal appropriations are still needed to start construction of the project. In the interim, the site was used for short-term water storage during the extremely high rainfall events of 2013 and 2014. Results from these initial projects provide important steps toward the full implementation of the overall project. In 2014, the State of Florida appropriated $18 million to design and construct a C-43 Early Start Project, which would have provided interim water storage on-site until the full reservoir could be completed. The state is now planning to move forward to complete Phase I of the full C-43 Reservoir Project by 2019. Finally, an important Water Reservation rulemaking for the larger CERP project became effective in July 2014 and is a critical step moving forward (also, see Volume II, Chapter 3).
- **C-43 Water Quality Treatment and Testing Facility Project (Caloosahatchee Watershed).** Following completion of the conceptual design in 2013, two components of this important partnership project between the SFWMD and Lee County moved forward in FY2015. The District is currently conducting a one-year bioassay study to learn information for use in larger-scale mesocosm studies. Pending confirmation of additional funding sources, the design, construction, and operation of

mesocosms are planned to take place through FY2018. The results from these important scientific investigations results will likely be available for consideration in the second phase of the Caloosahatchee BMAP. It is also expected that the overall results will have applications throughout Florida's many watersheds undergoing water quality restoration.

- **Lake Hicpochee Hydrologic Enhancement Project North (Caloosahatchee Watershed).** In 2014, the SFWMD acquired approximately 715 acres of land for a shallow storage feature north of the lake bed, which will work in conjunction with a spreader canal to store and deliver water to the lake bed. The District also procured a contract for final design documents which are anticipated to be finished in 2015. Construction is also anticipated to begin in 2015.

Dispersed Water Management

The DWM Program is one of the ways the District and its partners are addressing the legislative intent of NEEPP, which encourages and supports the development of partnerships to facilitate or further the restoration of surface water resources in the Northern Everglades. The DWM Program is relatively new and the storage, retention, and detention created by projects within the DWM Program since 2005 will be approximately 93,202 acre-feet (ac-ft). [Note: See the Dispersed Water Management projects in the *Watershed Efforts* sections for more information on the DWM components and specific projects.]. The DWM Program is still evolving, new possibilities are being explored (e.g., WF-PES), and many questions still need to be answered. Key activities to help answer key questions, guide the future direction of the program, and assist with policy decisions planned in the few years are provided in **Table 10-12**. Further information on the agency's DWM Program is available at www.sfwmd.gov/storage.

Table 10-12. Key future activities of the Dispersed Water Management (DWM) Program.

Task	Description
Suitability Analysis	This task will identify the primary criteria needed to successfully implement DWM projects and limitations of DWM, which will in turn be used to determine where in the Northern Everglades DWM components would be most feasible and necessary. Development of suitability criteria will consider key cost and feasibility drivers such as hydrology, engineering constraints, and land use.
Water Storage Model(s) Investigation	The DWM Specific Water Storage Modeling Team will investigate and determine the most appropriate model(s)/analysis to estimate water retention for all types of DWM projects.
Water Retention Analysis of Publicly Owned Lands	The District plans to investigate the suitability of using-District owned lands for water retention including pre-project land parcels, lands with permanent easements, and lands leased for cattle. This will build upon an evaluation was performed 2011 to identify publicly-owned parcels that could be used to retain stormwater with minimal alternation (Hesperides Group, 2011).
Cost Effectiveness Analysis	Evaluating cost effectiveness greatly assists decision makers in many ways including assessing efficiency and success as it relates the cost of the program or project to its key benefit, in this case water storage. For the purposes of this analysis, it is anticipated that projects will be categorized two ways. The first category will be by project type (private lands, public lands, Northern Everglades Payment for Environmental Services (NE-PES) projects and WF-PES) and developing metrics that compare across project types will be necessary. The second categorization is by large-scale versus small-scale DWM projects. These comparisons will include an analysis of implementation costs to the District based on project size and type.
Funding Opportunities	As with any program, evaluating funding options and opportunities is key. The District will explore innovative and alternative approaches to funding the DWM Program.
DWM Database	The purpose is to improve the DWM monitoring database to store all project related information including permitting, monitoring, reports, etc. This will improve the efficiency of the program overall and will specifically help in the areas of permit and contract compliance, monitoring data management, processing data requests, performing data analysis and substantiating documented services. The database will also be used to track Clean Water Act Section 319 grant obligations, benefit estimation, water quality data, and volumes diverted.

Local Projects

Local projects provide benefits on a local and sub-regional scale and collectively provide water quality and quantity benefits on a regional scale. The SFWMD and FDEP have worked with numerous local governments throughout the St. Lucie and Caloosahatchee Watersheds to improve water quality enhance flood protection and enhance wastewater infrastructure to meet the needs of future generations. For example, the FDEP has provided grant funding (Clean Water Act Section 319 and TMDL) toward over 30 non-point source projects in the Northern Everglades (SFWMD et. al. 2014). The total costs (inclusive of match by the local governments) of these projects were in excess of $38 million. Building on successes such as the State of Florida’s Water Projects funding and TMDL grant funding, the SFWMD contributed nearly $15 million toward 36 stormwater and wastewater infrastructure partnership projects with local governments throughout the Lake Okeechobee Watershed (SFWMD et al., 2014). The coordinating agencies will continue to identify local project and funding sources. One mechanism for accomplishing this is through the FDEP's BMAP, as discussed in detail above, and others are discussed below.

In many cases, including projects in a protection plan or a BMAP increases the probability of receiving project funding (e.g., TMDL or Clean Water Act Section 319 grant). As part of these RWPP updates, local construction projects which will benefit the estuaries were incorporated (see **Table 10-4)**. The idea with this table is to increase local entities chances of securing funding by being able to say their project supports the goals of the protection plans. Also, to assist stakeholders further, a list of potential funding sources is provided in Appendix 10-1 of this volume. These lists may also be useful during development of the second phases of both the Caloosahatchee Estuary BMAP and the St. Lucie River and Estuary BMAP.

In the Caloosahatchee Watershed, the Caloosahatchee Community Forums are bringing interested stakeholders to develop shared prioritization and support for specific projects that will benefit the Caloosahatchee River and Estuary. An effective prioritization process can yield many meaningful benefits such as improving current and future coordination among the various state and local agencies, engaging stakeholders, generating a prioritized and politically supportable list of short and mid-term actions, and galvanizing stakeholder support for resources. The first community forum was held on August 8, 2014, where representatives of state and local governments, agriculture, environmental and conservation non-governmental organizations, academic institutions, and concerned citizens reviewed the state of ecological indicators in the estuary and projects designed to improve river and estuary health. A follow-up community forum is anticipated by the end of 2014 to discuss prioritization and implementation of projects.

On the East coast, the St. Lucie Issues Team's recommended projects have received $63 million from the Florida legislature, more than $65 million from local partners and $2 million from the federal government from 1998 into early 2013 (http://www.tcpalm.com/news/8-projects-to-help-indian-river-lagoon-in-martin). To date, the projects have restored more than 4,671 acres of habitat, 4,358 acres of wetlands, and 25,940 feet of shoreline throughout the lagoon and its watershed. Continued collaboration with the St. Lucie Issues Team will benefit the efforts to implement the St. Lucie Watershed wish list projects.

Throughout the Northern Everglades, local entities will have the opportunity participate in the District's new Cooperative Funding Program, which expands and builds upon previous funding partnerships in support of local stormwater management, alternative water supply, and water conservation projects (www.sfwmd.gov/coopfunding). Through this program, the SFWMD, as a regional agency, is committed to ensure that local perspectives are incorporated into its activities. Each fiscal year, the District's Governing Board will determine the amount of funding to allocate to the Cooperative Funding Program, project priorities for that year, and cost share to be allocated. Program funding will be subject to approval by the Florida legislature and governor each year. The SFWMD is currently evaluating proposals for Fiscal Year 2016.

Exploring Innovative Treatment Technologies

The NEEPP supports the investigation and implementation of innovative treatment technologies. NEEPP states that the river watersheds pollutant control program is designed to be a multifaceted approach to reducing pollutant loads through "…utilization of alternative technologies for pollutant reduction, such as cost-effective biologically based, hybrid wetland/chemical and other innovative nutrient control technologies…" (Sections 373.4595(4)(a)2, and 373.4595(4)(b)2, F.S). The coordinating agencies have been evaluating alternative water quality treatment technologies in both the STAs and the Northern Everglades for almost two decades, and are often approached by individuals and firms with proposals for improving regional water quality, prompting the need for a structured process to learn about and evaluate these technologies. An example of the efforts to explore innovative treatment technologies was the District's New Alternative Treatment Assessment effort which was completed in 2014. Through this effort and Requests for Proposals, the District provided opportunities for individuals and firms to demonstrate their potential technologies for reducing TP or TN loading in both waters and sediments discharged from the Everglades watershed. The completed the evaluation of several products/technologies and documented results are provided in SFWMD (2013). The coordinating agencies will continue to explore innovative treatment technologies through other opportunities. A new technology being implemented at two sites in the Northern Everglades is Floating Aquatic Vegetative Tilling, which uses floating aquatic vegetation, water level management, and recycling of the plant material in the soils to remove nutrients from the water column. One of the two sites is located in the East Caloosahatchee Sub-watershed. Another technology that is proving effective in removing TP and TN is Hybrid Wetland Treatment Technology (HWTT). There is one active HWTT site (Ideal 2 Grove) in the St. Lucie Watershed and another is under development (Bessey Creek). The FDACS is the lead coordinating agency on these technologies. An additional five HWTTs exist in the Lake Okeechobee Watershed (Nubbin Slough, Mosquito Creek, Lemkin Creek, Grassy Island, and Wolff Ditch). Further information on these technologies is presented in **Table 10-2**.

WORKING COLLABORATIVELY TO IDENTIFY FUNDING OPPORTUNITIES

One of the biggest challenges to implementing large, watershed-scale restoration efforts is identifying funding for projects that will improve the quality, quantity, timing, and delivery of water. In 2014, approximately $232 million were appropriated by the State of Florida for projects that will improve the health of the Northern Everglades estuaries. Several of the projects that received funding are in the river watersheds. For example, the CERP IRL-S C-44 Reservoir and STA received $40 million and the C-43 Basin Storage Reservoir Early Start Project received $18 million. It also includes projects outside the river watersheds that will help minimize damaging discharges from Lake Okeechobee such as the Kissimmee River Restoration which received $5 million and project to remove impediments to moving water through the such as the C-111 South Dade Project, which also received $5 million.

Perhaps one of the primary drivers in the 2014 legislative funding was the Indian River Lagoon Lake Okeechobee (IRLLOB) Select Committee. As previously noted, the start of the 2014 wet season was the wettest on season since 1968 and the wettest April through July since 1932. These rainfalls led to relatively high lake stages and saturation of most areas in the region early in the wet season, leaving few options for moving water early in the hurricane season. The volume and seasonal timing of this rainfall led to large inputs of fresh water to the estuaries from local runoff and Lake Okeechobee. The ecological impacts to the St. Lucie and Caloosahatchee estuaries—including higher nutrient loading, undesirably low salinity, algal blooms, and seagrass and oyster mortality—were significant and of notable public interest to seek action to resolve the situation. As a result, the IRLLOB Select Committee was established with the goal of investigating the policies, funding, and other governmental activities affecting water management in the Lake Okeechobee Basin. The committee held two intensive, public meetings with presentations, panels, and testimony. The Final IRLLOB Report is available online at http://www.flsenate.gov/usercontent/topics/irllob/finalreport.pdf. As a result, $232 million was appropriated to implement projects identified in the report, exceeding the initial recommendation of $220 million (http://www.flsenate.gov/Media/PressReleases/Show/1785).

During this effort, the District and FDEP recommended both short- and longer-term actions to help improve the quantity, timing, and delivery of water throughout the system. The hydrologic connections and complexities of the entire system, discussed in the *Everglades Past and Present* section of this chapter, were considered in the recommendations. Short-term solutions included efforts such as storing water on public and private lands in the watershed and operational approaches to moving water through the system more quickly. The suggested longer-term solutions were focused on completing projects that are already under way or planned in order to assist with storing water, improving water deliveries south, and minimizing damaging discharges to the Northern Estuaries. It is anticipated that the District and FDEP will continue to seek funding in the future to complete restoration projects, allowing the benefits from those projects to be realized, and for strategic new projects that will further restoration of the Everglades.

SYSTEM-WIDE EFFORTS

Below are projects that are not located in the river watersheds, but benefits gained from completing them are expected to improve the quantity, timing, and delivery of water throughout the system, which will ultimately benefit the Northern Estuaries. [Refer to the *Everglades Past and Present* section in this chapter for interrelationships and hydrologic connectivity of the system.] For example, projects that provide additional storage above Lake Okeechobee may contribute to more optimal timing and volume of hydrological inputs to the lake. Projects south of Lake Okeechobee may be important from a system-wide perspective, as they contribute (at their unique project scale) to the overall effort to move additional water south. Several of the projects listed below were included in state's and District's recommendations to the IRLLOB Select Committee. The hydrologic connections and complexities of the entire system, as previously discussed, were considered in the recommendations. More details on several of these projects and their benefits to the river watersheds are available on the District's website at www.sfwmd.gov/everglades.

- **Kissimmee River Restoration Project.** When restoration construction is completed, 40 square miles of Kissimmee River and floodplain ecosystem will be affected, including almost 25,000 acres of wetlands and 40 miles of historical river channel (www.sfwmd.gov/kissimmee). Three phases are complete and ecological monitoring has documented initial restoration success. Additional work ongoing includes backfilling another 9 miles of canal and restoring flow to 16.4 additional miles of the river. Continuing construction and land acquisition requirements for Kissimmee River Restoration headwaters will also lead to the completed project having the storage capacity of up to approximately 100,000 ac-ft of water utilizing the Upper Kissimmee Basin. The first three construction phases of restoration were completed between 2001 and 2009. The last major phases of construction are scheduled to begin in 2015 and are scheduled for completion in 2017.

- **Restoration Strategies Program.** In June 2012, the State of Florida and the U.S. Environmental Protection Agency (USEPA) reached a consensus on new strategies for improving water quality in the Everglades. The Restoration Strategies Program will expand water quality improvement projects to achieve the total phosphorus water quality standard established for the Everglades. Under these strategies, the SFWMD is implementing a technical plan to complete several projects that will create more than 6,500 acres of new Everglades STAs and 116,000 ac-ft of additional water storage through construction of Flow Equalization Basins. Design and construction of the treatment and storage projects in the Restoration Strategies Regional Water Quality Plan will take place in three phases over a 12-year timeframe, with completion of all projects set for 2025. Work is under way on several components for the plan's first two phases, which are scheduled to be finished by 2016 and 2018, respectively. The technical plan is part of a revised National Pollutant Discharge Elimination System permit issued by the FDEP and approved by the USEPA for operation of the District's network of Everglades STAs south of Lake Okeechobee.

Additional information on the Restoration Strategies Program, Everglades STAs and associated Science Plan is presented in Chapters 5A, 5B, and 5C of this volume, respectively (also, see www.sfwmd.gov/restorationstrategies).

- **Central Everglades Planning Project.** The CEPP will identify and plan for projects on land already in public ownership to allow more water to be directed south to the central Everglades, Everglades National Park, and Florida Bay while improving the health of coastal estuaries. As such, this USACE partnership project with the SFWMD is an important part of the long-term solution for moving water south away from the northern coastal estuaries and into the heart of the Everglades and ENP. When completed, approximately 210,000 ac-ft of Lake Okeechobee water on an average annual basis is planned to be directed south where it can provide ecological benefits. On August 8, 2014, the USACE released the revised final report for CEPP for public, state and agency review. After a 30-day public comment period, the USACE will work toward a final Chief of Engineers' Report to be submitted to the U.S. Congress.
- **Modified Water Deliveries to Everglades National Park, C-111 South Dade Project, and C-111 Spreader Canal Western Project.** These three projects represent major initiatives to improve hydrological flows in the southern end of the regional system. Both Modified Water Deliveries (MWD) and the C-111 South Dade Projects were included in the 1989 Everglades National Park Protection and Expansion Act and are aimed at restoring conditions in ENP and adjacent Everglades while maintaining flood control requirements east of the ENP. The (MWD) project's purpose is to construct modifications to the C&SF Project to improve water deliveries to the ENP and restore more natural hydrological conditions in Northeast Shark River Slough. One of the major components is the modifications to Tamiami Trail (US Highway 41) to increase water conveyance to the ENP and a one mile bridge that was completed in March 2013 (http://www.evergladesplan.org/docs/fs_tt_mod_waters_jan_2014.pdf). The State of Florida is supporting future construction of an additional 2.6 mile bridge with $90 million as recommended by the Governor and the Florida Senate Indian River Lagoon and Lake Okeechobee (IRLLOB) Select Committee. The C-111 South Dade Project enhances freshwater wetlands and improves freshwater flows in the Southern Glades in southern Miami-Dade County. Along with MWD and Kissimmee River Restoration, it is one of the three pre-CERP foundation projects for South Florida ecosystem restoration. The C-111 South Dade Project was also in the Florida Senate IRLLOB Select Committee recommendations and received $5 million from the State of Florida in 2014 to assist with its completion. Also located in southern Miami-Dade County, the CERP C-111 Spreader Canal Western Project is providing ecosystem restoration of freshwater wetlands, tidal wetlands, and near-shore habitat as well as recreation opportunities. SFWMD completed construction of major features in 2012 and dedicated it in early 2013, the project restores the quantity, timing, and distribution of water delivered to Florida Bay through Taylor Slough located in ENP. Additionally, it is expected to optimize hydroperiods wetlands in the Southern Glades and Model Lands.
- **Herbert Hoover Dike Rehabilitation**. The USACE continues to rehabilitate the Herbert Hoover Dike (HHD), the 143-mile structure surrounding Lake Okeechobee. From 2007 until early 2013, the USACE invested over $300 million in projects designed to reduce the risk of catastrophic failure of aging structure (http://www.saj.usace.army.mil/Portals/44/docs/FactSheets/HHD_FS_Rehab_Spring

2013_508.pdf). Some of the work includes installing a cutoff wall and conducting various studies and technical reviews to help ensure the safety of local residents. Additionally, the USACE plans to replace or remove 32 culverts within the HHD system, many which date back to the 1930s in their origin. Beyond the critical human safety factor of this project, a rehabilitated HHD should provide more flexibility in the lake's water management for both in-lake and regional purposes.

The District is also actively engaged with federal, tribal, state, and local partners to identify other water storage and operational opportunities. For example, the District, in cooperation with FDEP and in coordination with the Florida Fish and Wildlife Conservation Commission, repaired pump station G-200A, which will allow STA-treated water to be conveyed into the Holey Land Wildlife Management Area (Holey Land). As drier-than-desirable conditions within Holey Land sometimes coincide with regulatory releases from Lake Okeechobee and damaging discharges to the estuaries, the repair of G-200A will enable the District to direct excess water to the Holey Land.

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