Chapter 10: Coastal Priorities

Edited by Richard Alleman

SUMMARY

During Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011), the South Florida Water Management District (SFWMD or District) worked on several key restoration projects to benefit estuarine systems. These construction projects are aimed at reducing pollutant loads, or improving salinity patterns through freshwater inflow management, which are issues that affect all the estuaries to some degree. In the Northern Estuaries (St. Lucie River Estuary, Southern Indian River Lagoon, and Caloosahatchee River Estuary), nutrient load reduction and storage projects (see Appendices 10-1 and 10-2 of this volume) and water inflows from Lake Okeechobee were targeted. In the Loxahatchee River Estuary, a pilot project to add fresh water during the dry season was deployed. In Lake Worth Lagoon, a sediment trapping project was implemented. In lower Biscayne Bay, portions of a flow redistribution project began operation. Water control improvements were made on the southwest coast to benefit the Fakahatchee Estuary and Naples Bay. Projects associated with Florida Bay (e.g. C-111 Spreader) are provided in Volume I, Chapter 6 since restoration projects to improve Florida Bay occur upstream within the Everglades. Results of freshwater inflows, salinity, and other parameters are given in relation to the restoration projects and Minimum Flows and Levels (MFL) rules. In general, conditions were dry during WY2011. In addition, the agency progressed with the following monitoring, applied research, and modeling efforts:

- Initiated a project to develop the capability of capturing data about the productive low salinity zone within riverine estuaries under differing inflow regimes;
- Continued monitoring submerged aquatic vegetation in the Southern Indian River Lagoon and the Caloosahatchee River Estuary, with an emphasis on tape grass (*Vallisneria americana*) in the upper estuary;
- Completed a science plan for the Loxahatchee River in collaboration with multiple public organizations;
- Began development of a hydrodynamic model for Naples Bay; and
- Successfully applied a Caloosahatchee River hydrodynamic model on a weekly basis to predict salinity in the estuary to make operational decisions regarding supplemental flows from Lake Okeechobee.

INTRODUCTION

This chapter of the *2012 South Florida Environmental Report* (SFER) – *Volume I* highlights select coastal ecosystem areas where the South Florida Water Management District (SFWMD or District) has focused its efforts during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) (**Figure 10-1**). Most of the projects related to these areas are described in detail in the SFER Consolidated Project Report Database, available on the District's website at www.sfwmd.gov/SFER under SFER Reports. Key findings are presented where appropriate and, in most cases, reflect District or District-sponsored research and monitoring efforts. However, the District works closely with other local, state, and federal organizations involved in studying these systems, and findings from these sources are included and duly recognized as well. District strategies aimed at protecting or restoring estuaries include regulations and restoration projects. Three-year updates of the St. Lucie River Watershed and Estuary and Caloosahatchee River Watershed and Estuary Protection Plans are presented in Appendices 10-1 and 10-2 of this volume, respectively, along with highlights in this chapter.

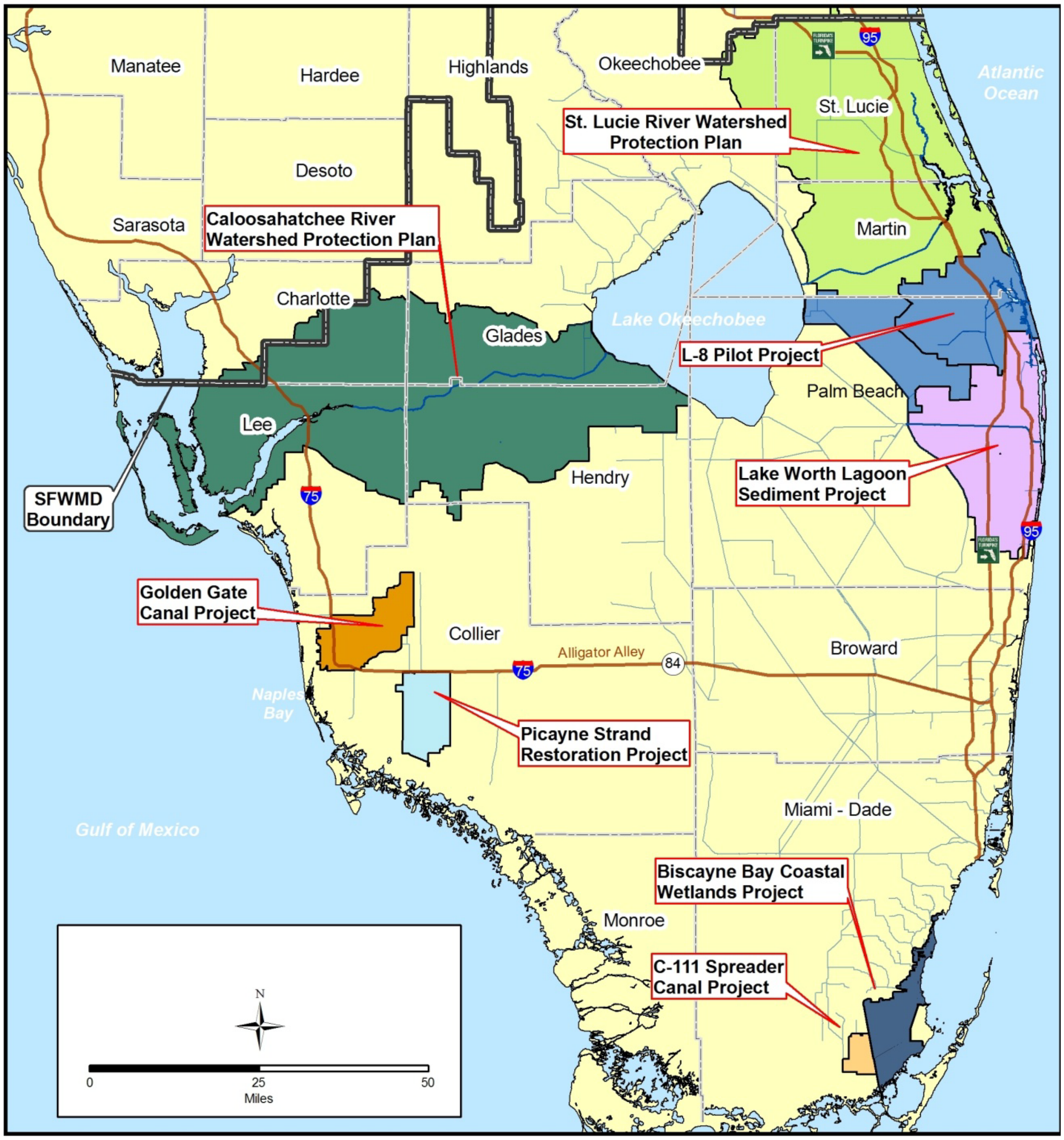

Figure 10-1. 2012 coastal project areas within the District boundaries.

NORTHERN ESTUARIES

Richard Alleman and Pinar Balci

INTRODUCTION

As defined by the Northern Everglades and Estuaries Protection Program (NEEPP) legislation (Section 373.4595, Florida Statutes [F.S.]), the Northern Estuaries consists of the St. Lucie River Estuary, Southern Indian River Lagoon, Caloosahatchee River Estuary, and Southern Charlotte Harbor (**Figure 10-1**). The St. Lucie Estuary is a brackish water body on the east-central coast of Florida in Martin and St. Lucie counties, and a primary tributary to the Southern Indian River Lagoon. The Caloosahatchee River (C-43 canal) is the major source of fresh water to the Caloosahatchee River Estuary, which extends about 43 miles from Lake Okeechobee at Moore Haven (S-77) to the Franklin Lock and Dam (S-79) at Olga. The lock and dam marks the head of the estuary, which empties into San Carlos Bay in the southern portion of the Charlotte Harbor system.

Freshwater flow into these estuaries is a primary concern, particularly when water from Lake Okeechobee is discharged via the St. Lucie and Caloosahatchee rivers to the estuaries to maintain Lake Okeechobee’s regulation schedule. As a result, estuarine salinity often falls below healthy levels. By contrast, freshwater inflows can be so low at times during the dry season that salinity exceeds the levels needed to sustain key estuarine organisms such as tape grass (*Vallisneria americana*). In addition, nutrient enrichment in these estuaries is believed to cause phytoplankton blooms, which may periodically impact submerged aquatic vegetation (SAV) by attenuating down-dwelling light. Mortality of large numbers of phytoplankton may also depress dissolved oxygen (DO) concentrations (SFWMD et al., 2009a, 2009b).

In 2010, the District adopted specific protocols (Adaptive Protocols) that work within the flexibility of the 2008 Lake Okeechobee Regulation Schedule (see Volume I, Chapter 8) to provide guidance on releasing water into the Northern Estuaries based on water levels in Lake Okeechobee and other criteria (SFWMD, 2010). As local sponsor for the Central and Southern Florida Flood Control Project (C&SF Project), the District interacts with the United States Army Corps of Engineers (USACE) on Lake Okeechobee operations within the confines of the federally adopted Lake Okeechobee Regulation Schedule. Each week, conditions within the estuaries are examined and compared to specific criteria within the Adaptive Protocols to make operational recommendations.

NORTHERN ESTUARIES HIGHLIGHTS

The NEEPP legislation (Section 373.4595, F.S.) requires the initial development and three-year updates of watershed protection plans for the three Northern Everglades watersheds: Lake Okeechobee Watershed, Caloosahatchee River Watershed, and St. Lucie River Watershed (**Figure 10-2**). The coordinating agencies — the District, Florida Department of Environmental Protection, and Florida Department of Agriculture and Consumer Services — initially developed the plans with stakeholder input and submitted the plans to the Florida legislature in January 2009. In this volume, Appendices 10-1 and 10-2 include the three-year updates to the St. Lucie and Caloosahatchee River Watershed Protection Plans, respectively. These appendices provide detailed information on related climate, freshwater inflow, water quality, and valued ecosystem component status. A summary of both updates is provided below.

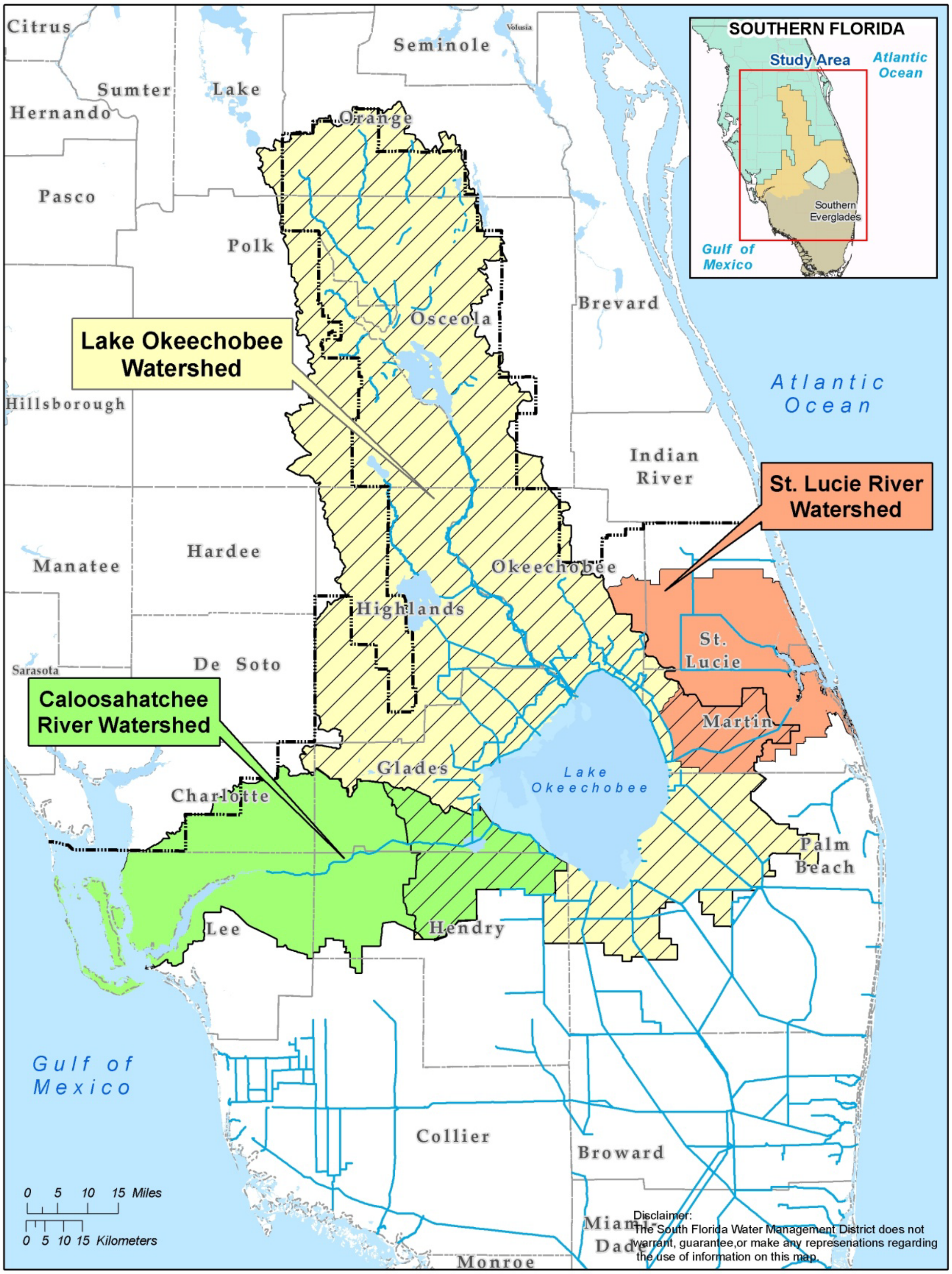

Figure 10-2. Northern Everglades and Estuaries Protection Program (NEEPP) basins as defined by the Florida legislature.

The three main program elements of the watershed protection plans are the (1) Watershed Construction Project that identifies water quality and storage projects to improve hydrology, water quality, and aquatic habitats within the watershed; (2) Watershed Pollutant Control Program with a multifaceted approach to reducing pollutant loads by improving management of pollutant sources within the watershed; and (3) Watershed Research and Water Quality Monitoring Program to fill knowledge gaps and provide results about the progress of the programs and the health of the estuaries. The watershed protection plans build upon existing and planned programs and projects, and consolidate previous restoration efforts into a broader approach focused on restoring the entire Northern Everglades system.

St. Lucie River Estuary and Southern Indian River Lagoon

In WY2011, freshwater inflows from canals [313,000 acre-feet (38,608 hectare meters)] were less than inflows during WY2010 [402,000 acre-feet (49,586 hectare meters)]. About 70 percent of the freshwater inflow from canals discharging into the estuary was from Lake Okeechobee. During the dry season, however, supplemental flows from the lake were not necessary to maintain salinity within acceptable ranges. Salinity at the U.S. Highway 1 Bridge, a key station, was above 25 practical salinity units (psu) from November through April, but the 30-day average remained below 30 psu. The Minimum Flows and Levels (MFL) criteria for the North Fork of the St. Lucie Estuary were met throughout the year. Total nitrogen (TN) and total phosphorus (TP) loads were lower than last water year. Seagrass acreage was about the same as last water year, and has been stable since May 2008.

Caloosahatchee River Estuary and Southern Charlotte Harbor

Freshwater inflows to the Caloosahatchee River Estuary through S-79 were about the same in WY2011 [1.1 million acre-feet (135,683 hectare meters)] and WY2010, but a greater percentage was derived from Lake Okeechobee (45 percent). Supplemental water was delivered through S-79 during the dry season in accordance with the Adaptive Protocols criteria (SFWMD, 2010). The District recommended 11 water releases between November 5 and February 25 to maintain lower salinity. In addition, the USACE conducted two more releases in March. Once the water level in Lake Okeechobee fell below the Water Shortage Management Band, all supplemental flows ceased. Daily surface salinity averaged about 8–9 psu at the Fort Myers Yacht Basin during WY2011; however, salinity exceeded the MFL criterion 215 days during the water year. TN and TP loads were lower than last water year. Tape grass abundance was greatest in the fall, and declined throughout the rest of the water year as salinity increased.

LOXAHATCHEE RIVER AND ESTUARY

Marion Hedgepeth, Rebecca Robbins and Christopher Buzzelli

DESCRIPTION AND ISSUES RELATED TO DISTRICT PRIORITIES

The Loxahatchee River Watershed and Estuary are located within northern Palm Beach County and southern Martin County (**Figure 10-3**). The Loxahatchee River Watershed currently drains an area of about 240 square miles (622 square kilometers). Historically, the watershed extended from just east of Lake Okeechobee to Jupiter Inlet. Freshwater runoff originally flowed from wetlands in the Loxahatchee and Hungryland Sloughs (SFWMD, 2006). However, in the last century, a combination of flow diversion, channelization, wetland drainage, deforestation, and urban and agricultural development have greatly decreased the watershed area. Now, the Loxahatchee River originates in Grassy Waters Preserve, and flows into the Northwest Fork of the Loxahatchee River from the C-18 canal through the G-92 structure in northern Palm Beach

County (**Figure 10-3**). As a result of reduced inflows, salinity has increased in the upper river segments. The Loxahatchee Estuary system extends inland from Jupiter Inlet for several miles up the three forks of the Loxahatchee River and the Atlantic Intracoastal Waterway (i.e., the southern end of Indian River Lagoon and the northern end of Lake Worth Creek). The opening of the Jupiter Inlet also allows larger tidal amplitude and promotes saltwater intrusion into the lower estuary and river system.

Key issues in WY2011 for the Loxahatchee River include flows and salinity related to the MFL criterion, an experiment to provide additional water in the dry season, and completion of a science plan. In 2003, the District adopted a MFL rule (Chapter 40E-8, Florida Administrative Code [F.A.C.]) for the Northwest Fork of the Loxahatchee River. A MFL exceedance occurs when flow over the Lainhart Dam declines below 35 cubic feet per second [cfs; 0.99 cubic meters per second (m^3s^{-1})] for more than 20 days or the average salinity at River Mile 9.1, expressed as a 20-day rolling average, exceeds 2 parts per thousand (ppt; measured in the field as psu). The District also conducted an experiment to deliver supplemental water to the river from a reservoir in western Palm Beach County, and collaborated on the completion of a science plan for the Loxahatchee River Watershed and Estuary.

RESTORATION STATUS AND EFFECTS

Freshwater Inflows and Water Quality

The parameters of salinity and freshwater flow are examined each year to better understand current dry and wet season hydrologic flow patterns and how water management can be used to ecologically benefit the freshwater portions of the river and the tidal estuary. The Restoration Plan for the Northwest Fork of the Loxahatchee River (SFWMD, 2006) provided a preferred restoration scenario that established a variable dry season flow between 50 and 110 cfs (1.4–3.1 m^3s^{-1}) (light blue line in **Figure 10-4**), with a mean of 69 cfs (1.9 m^3s^{-1}) over Lainhart Dam, providing an additional 30 cfs (0.8 m^3s^{-1}) of flow from the downstream tributaries. Data from the five tide and salinity stations that have been deployed since 2002 for compliance with the MFL rule were examined, along with flow data from Lainhart Dam. During WY2011, flow over Lainhart Dam was mostly maintained above the MFL criterion of 35 cfs, except for the periods of November 27, 2010 to March 3, 2011 (66 days), and April 20 to May 1, 2010 (12 days) (**Figure 10-4**). The 20-day rolling average salinity at River Mile 9.1 did not exceed 2 psu during WY2011.

The District experimented with operational options during the WY2011 drought in an effort to get more water into the Loxahatchee River. Water from the L-8 Reservoir was routed through a series of canals using pumps northward through the City of West Palm Beach's Grassy Waters Preserve from March 1 through April 19. A portion of the water stored within Grassy Waters Preserve was then released north through the G-161, G-160, and G-92 structures to the Northwest Fork of the Loxahatchee River. This was a collaborative effort between the District, City of West Palm Beach, Palm Beach County, and Loxahatchee River District to develop an operational plan for delivering water to the Northwest Fork of the Loxahatchee River to meet MFL criteria. An estimated 10,872 acre-feet (1,341 hectare meters) of water was delivered, and the MFL criterion for the Loxahatchee River was met for 48 days during the 2011 drought. A full report on this project is in preparation.

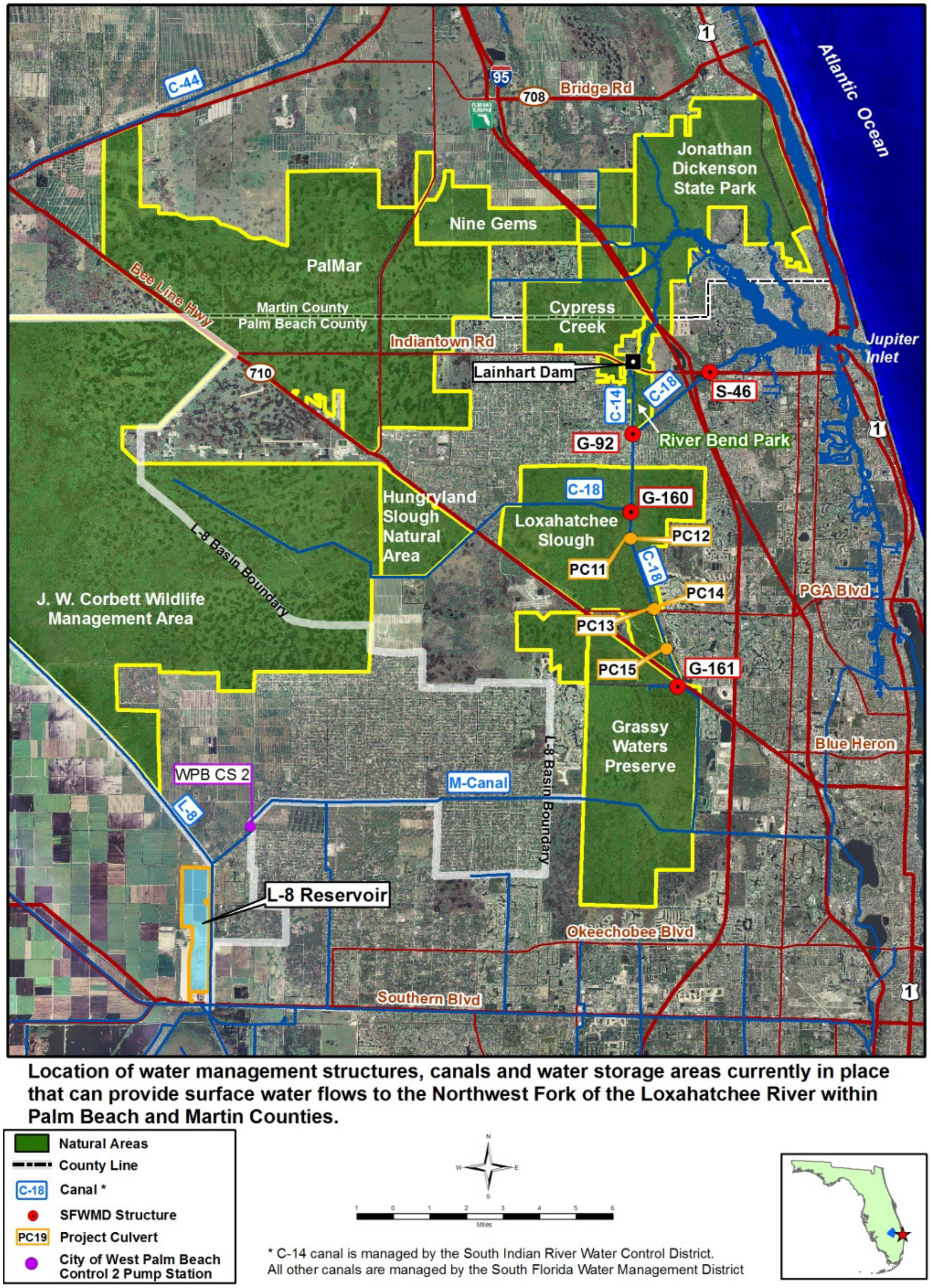

Figure 10-3. Loxahatchee River Watershed.

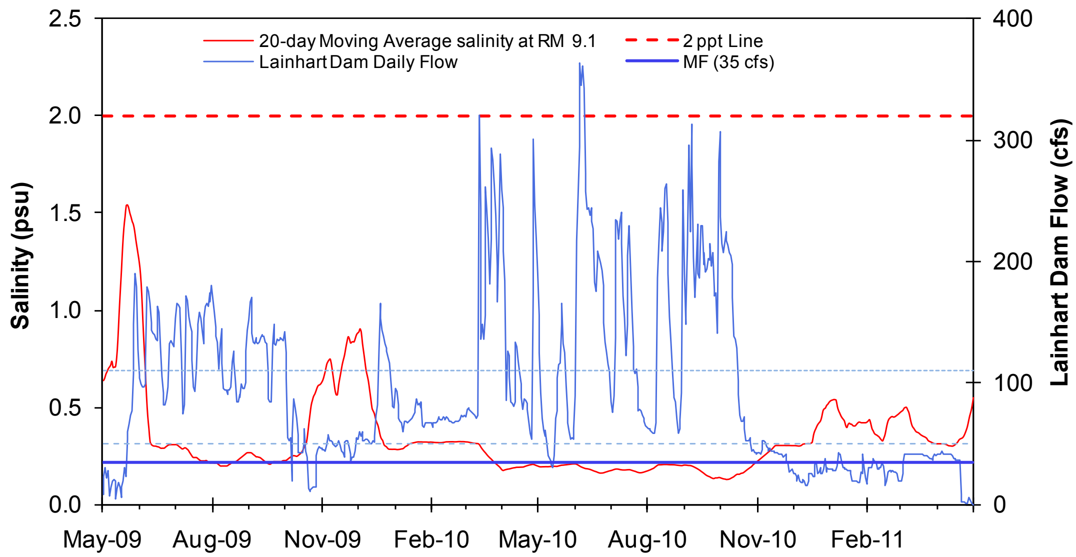

Figure 10-4. Flow rate and salinity related to the MFL criterion at Lainhart Dam in the Loxahatchee River during WY2010–WY2011.

Overall, nutrient concentrations observed in the Loxahatchee River during WY2011 were similar to those in WY2010 (see *Eastern Estuaries* section, 2011 SFER – Volume I, Chapter 12). The response of water quality to freshwater flow and associated nutrient loads are addressed in the Draft Addendum to the Restoration Plan for the Northwest Fork of the Loxahatchee River (SFWMD et al., 2011). The objectives of this analysis were to (1) quantify freshwater flows and nutrient loads; (2) determine the source of the flows and nutrient loads; and (3) examine the response of water quality in the Northwest Fork to freshwater and nutrients loads. Nutrient loads to the Northwest Fork mimicked the temporal variations of freshwater inflows with clear interannual and seasonal signals.

Valued Ecosystem Components Highlights

In 2010, the Loxahatchee River District completed their third species-specific seagrass map of the Loxahatchee River Estuary. Bimonthly monitoring of seagrass at four locations along the salinity gradient and one background location have also continued (see *Eastern Estuaries* section, 2011 SFER – Volume I, Chapter 12; Figure 12-35). Methods and results for these efforts are being detailed in the Draft 2011 Addendum to the Restoration Plan for the Northwest Fork of the Loxahatchee River (SFWMD et al., 2011). In general, post-hurricane seagrass recovery has been documented at most of the monitoring locations. However, manatee grass (*Syringodium filiforme*) has not recovered at the Sand Bar site. Comparison of water quality with seagrass data shows only shoal grass (*Halodule wrightii*) and Johnson's seagrass (*Halophila johnsonii*) are successful in the darker water areas with greatest salinity variation (SFWMD et al., 2011). These two species continue to be the dominant species in the estuary, while other species are typically present downstream in more stable and higher salinity (SFWMD et al., 2011).

The Fish and Wildlife Research Institute, a division of the Florida Fish and Wildlife Conservation Commission, conducted eastern oyster (*Crassostrea virginica*) monitoring for the District on the Northwest and Southwest Forks of the Loxahatchee River from 2005 to 2011. Monitoring included four aspects of oyster ecology and health: (1) spatial and size distribution patterns of adult oysters, (2) reproduction and recruitment, (3) juvenile oyster growth, and

(4) distribution and frequency patterns of the oyster diseases *Perkinsus marinus* (dermo) and *Haplosporidium nelsoni* (MSX). After reaching minimum levels early in 2008, live oysters began to rebound throughout 2009 and 2010 (Parker and Geiger, 2010). In spring and fall 2010, live oyster density remained about the same at the Northwest Fork stations. In contrast, in the Southwest Fork, live oyster densities increased slightly in fall 2010.

The District conducted surveys of hydrology and vegetation at ten Loxahatchee River floodplain transects from Calendar Year (CY) 2003 to CY2010 (SFWMD et al., 2011). A total of 30 species of vascular nonnative trees, shrubs, ground cover, and vines have been identified.

Ground cover stem counts provided an insight into new recruitment on the floor of the floodplain for each survey period. Several observations were significant. Bald cypress (*Taxodium distichum*) showed an increase in seed production with the increased 2010 freshwater flow levels. Cypress seedlings went up from a low of two in CY2003 to 18 in CY2007 and 295 in CY2010 (**Figure 10-5**, left panel). It was encouraging that, for the first time in any survey, bald cypress seedlings were observed in the lower tidal reach at River Mile 6.5 during the CY2010 survey period. White mangrove (*Laguncularia racemosa*) showed a positive reaction to the 2007 drought conditions and a negative reaction to the increased freshwater flows of CY2010 with 251 seedlings in CY2003, 2,976 in CY2007, and 336 in CY2010 (**Figure 10-5**, right panel). Also noteworthy, the first red mangrove (*Rhizophora mangle*) seedlings were observed on the upper North Fork of the Loxahatchee River in CY2010.

Loxahatchee River Science Plan

As recommended in the Restoration Plan for the Northwest Fork of the Loxahatchee River (SFWMD, 2006), a Loxahatchee Interagency Science Team was established to collaboratively develop a science plan for the Loxahatchee River to address prioritization of monitoring efforts that support adaptive management of the system, and fill in gaps of critical knowledge regarding ecosystem restoration success. The science plan was completed in 2010 (SFWMD et al., 2010). Management and research objectives are described and linked to watersheds, riverine, and estuarine resources. Several ongoing projects were identified along with new projects to address informational gaps. Results are expected to be used to evaluate the status of the system, and to develop predictive tools and improved performance measures for assessing biological and hydrological effects of water management practices on the ecosystem.

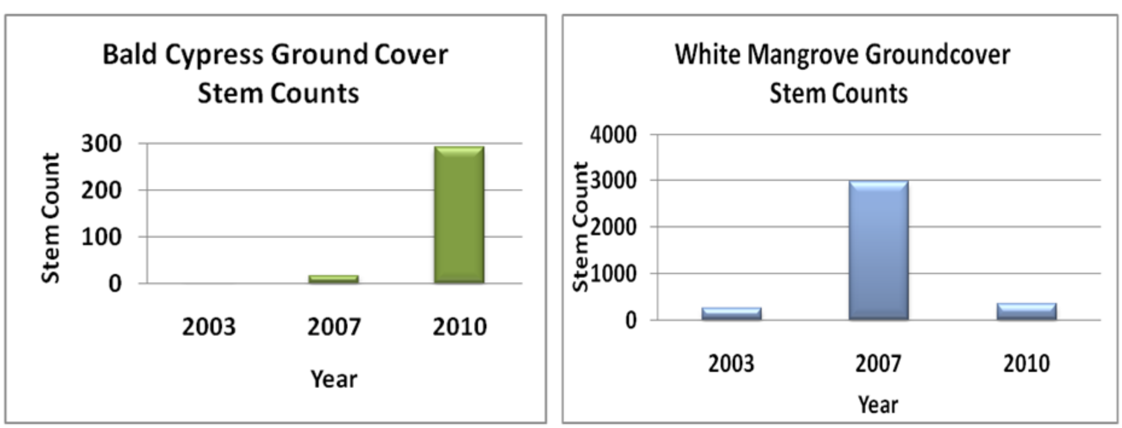

Figure 10-5. Ground cover stem counts for bald cypress and white mangrove seedlings by survey calendar year.

LAKE WORTH LAGOON

Marion Hedgepeth, Rebecca Robbins and Christopher Buzzelli

DESCRIPTION AND ISSUES RELATED TO DISTRICT PRIORITIES

The District has an interest in both the quantity and quality of stormwater runoff entering and conveyed, particularly by the C-51 canal system, to Lake Worth Lagoon (**Figure 10-6**). Stormwater runoff discharges through the S-155 control structure to the lagoon. Pollutants contained in the stormwater are believed to be a major contributing source of organically enriched muck in the lagoon (PBERM, 2008). Muck originates in areas where soil retention practices are inefficient, and where excess nutrients and organic materials are used on land. Muck often builds up at the mouth of the canal and remains there until a heavy rainfall flushes it into the lagoon. In addition to muck sediment accumulation, the District is concerned with shoaling, which has been documented to occur within the C-51 canal. Shoaling reduces conveyance capacity resulting in upstream flood events.

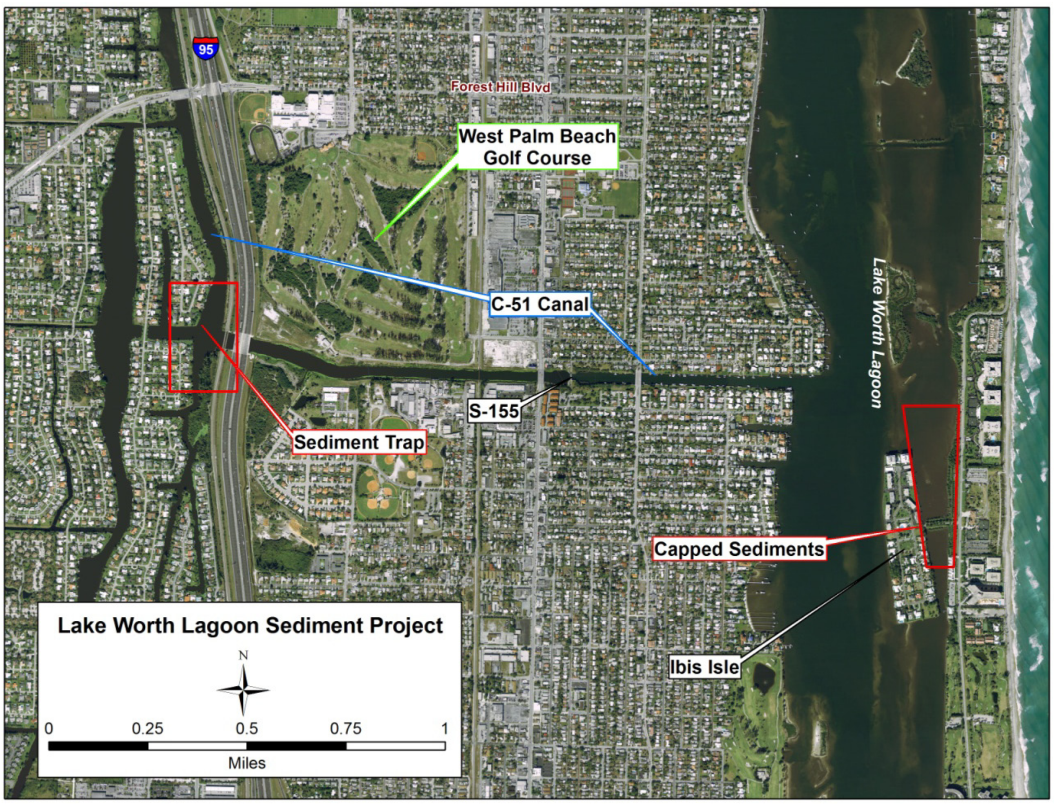

Figure 10-6. Location of the C-51 canal outfall and Ibis Isle in Lake Worth Lagoon.

In partnerships with the District and the City of West Palm Beach, Palm Beach County Department of Environmental Resources Management conducted annual hydrographic surveys of the C-51 canal system following the C-51 Canal Sediment Management Project completed in 2006. About 101,500 cubic yards [77,602 cubic meters (m^3)] of muck from a 3,500 linear foot (1,067 meter) section of the canal was removed during the project. Annual hydrographic surveys were conducted between 2007 and 2010 to determine the effectiveness of a newly created sediment trap, and to examine volumetric changes (i.e., erosion or accretion) over the project area. The purpose of this analysis was to (1) determine if there was a correlation between annual discharge volumes at the S-155 structure and sediment accretion within the C-51 canal, (2) estimate the annual rate of accretion within the sediment trap, (3) propose maintenance dredging requirements for the canal system, and (4) evaluate any remaining muck deposits that might exist outside of the dredged area. There was a net accretion of material [about 11,394 cubic yards (8,711 m^3)] throughout the limits of the project area between 2007 and 2009. The majority of the accretion occurred between 2008 and 2009. The majority of sediment accumulated within the sediment trap. During the final year of the study period (2009–2010), there was a substantial loss of material throughout all reaches of the canal. This was attributed to an increase in rate and volume of water discharged through the S-155 structure.

A second sediment management project was conducted in 2009 and completed in 2010 near Ibis Isle, a mangrove fringed island located about 2.5 miles south of the confluence of the C-51 canal system and the lagoon. In this sediment study, 41,000 cubic yards (31, 347 m^3) of sand were brought into the project area to cap the muck and raise the wetland shelf elevation to appropriate intertidal levels for the planting of mangroves and cord grass (*Spartina alterniflora*). In addition, lime rock was deposited to create one acre (0.4 hectare) of new oyster habitat. Both of these sediment projects were a part of the Comprehensive Everglades Restoration Plan (CERP) North Palm Beach County - Part 1 Project (USACE and SFWMD, 2005). Short-term muck compression, 25 millimeters on average, occurred in the days immediately following the placement of the sand cap. Results in October 2010, about nine months after the last area was capped, showed very little long-term muck compression or accretion (on average +/- 25 millimeters). By 2011, 0.3 hectare of oyster habitat, 1.3 hectare of mangrove habitat, and 1.5 hectares of cordgrass habitat had been restored.

BISCAYNE BAY

Richard Alleman

DESCRIPTION AND ISSUES RELATED TO DISTRICT PRIORITIES

Biscayne Bay is a shallow, subtropical estuary located along Florida's southeastern coast (**Figure 10-7**). In general, issues with Biscayne Bay include altered salinity patterns, water quality and reduced fisheries compared to historical conditions (see *Southern Estuaries* section, 2011 SFER – Volume I, Chapter 12). The District's primary focus for Biscayne Bay at this point is restoration of the south-central area by redistributing freshwater inflows. The Biscayne Bay Coastal Wetlands (BBCW) Project will restore some overland freshwater flow to coastal wetlands in southern Biscayne Bay (see SFER Consolidated Project Report Database) (USACE and SFWMD, 2010), and will likely result in some incidental reduction of nutrient loads to the bay.

The District has completed two components of the BBCW Project. Four culverts were installed in a north-south levee near the coast (L-31E) to facilitate movement of fresh water from the borrow canal along the western side into wetlands to the east. The water is then free to flow through the wetlands and into Biscayne Bay rather than being discharged directly into the bay via a canal outfall. The culverts became operational July 2010. A second component consists of a pump station and outfall that moves water from the C-100 canal (Cutler Drain) back into a historical slough and creek (Cutler Creek) that passes through the Deering Estate Preserve. The pump station is expected to become operational in January 2012. The District monitors water flow, water quality, and vegetation as required by the permits (see Volume III, Appendix 2-3).

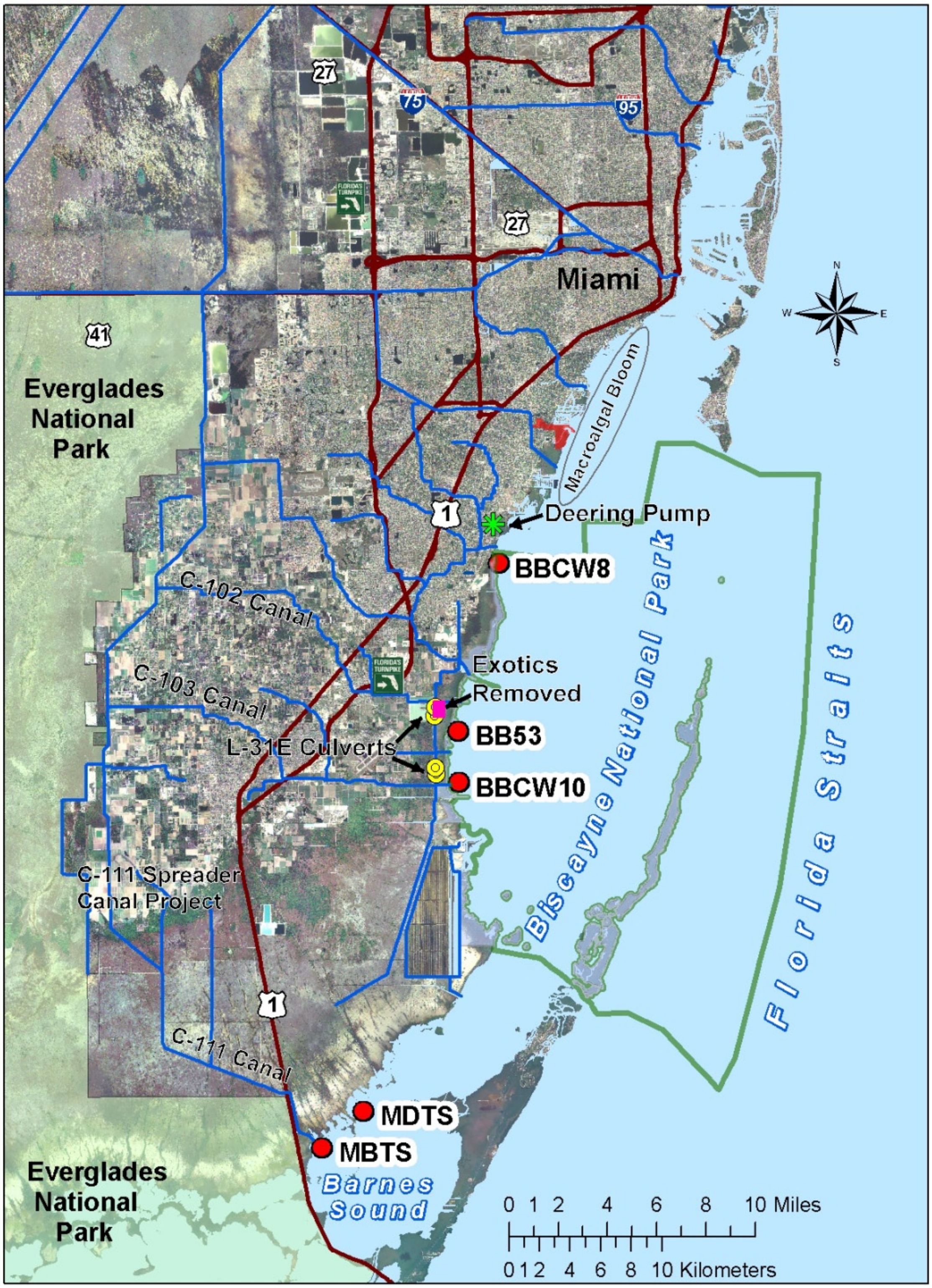

Figure 10-7. Biscayne Bay and selected monitoring stations.

The District tracks salinity results in the nearshore area of south-central Biscayne Bay to monitor how the system responds to inflows from the C-102, C-103, and Military canals. Salinity in this area tends to become hypersaline (i.e., > 35 psu) during the dry season (see *Southern Estuaries* section, 2011 SFER – Volume I, Chapter 12). This condition is considered to be unhealthy for many of the estuarine species (Montagna et al., 2008). It is unlikely the current BBCW Project features will alleviate this condition, but the District is currently investigating the feasibility of operational changes to alleviate or mitigate elevated salinity in this area. A second phase of the BBCW Project is to include water detention features to improve the situation, but planning has not yet begun.

Another CERP restoration project, the C-111 Spreader Canal Western Project, which is designed to restore some freshwater flows to northeast Florida Bay, also has the potential to affect Manatee Bay and Barnes Sound in southern Biscayne Bay (see Chapter 6 of this volume). According to simulations, features being constructed under an expedited schedule may actually reduce freshwater inputs to Manatee Bay, at least until more of the project is implemented (USACE and SFWMD, 2011). The expedited components became operational in August 2011.

A macroalgal bloom has been observed in the north-central area of Biscayne Bay. The green alga *Anadyomene stellata* has proliferated in a zone just offshore of the western shoreline. While *A. stellata* is normally present as part of the Biscayne Bay macroalgal community, the abundance in this area is out of proportion. The increased abundance was first observed by Miami-Dade Department of Environmental Resources Management in about 2005. No obvious cause, such as a change in water quality, has been detected.

RESTORATION STATUS AND EFFECTS

Salinity and Freshwater Inflows

A primary concern has been both seasonal excursions of hypersalinity and annual variability of salinity near the western shore of south-central Biscayne Bay and within Manatee Bay. Hypersalinity in Biscayne Bay is defined by the District as any value greater than 35 psu. The current target is not more than five percent of the annual daily mean values over 35 psu measured at certain points. It is felt when salinity exceeds 35 psu more frequently than five percent annually, it creates stress for some of the estuarine organisms such as eastern oysters. It is not unusual for salinity to range from about 15 to 40 psu within a year. Components of the BBCW Project constructed thus far will not likely substantially change the frequency of hypersalinity in the nearshore area because they do not increase water storage or include a strategy to release more fresh water into the bay during the dry season. Operational components of the BBCW Project are expected to modify the salinity patterns geographically, and redistribute water through wetlands rather than directly through canals. The District has however begun to examine whether any opportunities exist to increase dry season flows at critical times through operational changes to the C-102 and C-103 canals. The current C-111 Spreader Canal Project components are also not likely to decrease salinity in Manatee Bay as they are designed to improve the flow of water to northeast Florida Bay. Freshwater inflows to Barnes Sound and Manatee Bay are primarily through direct rainfall and overland runoff, but the C-111 canal is a source of inflow especially during the wet season.

The top right panel of **Figure 10-8** shows that flows in WY2011 were fairly typical except for very low flows in March and April. The bottom panel of **Figure 10-9** displays the historical total annual flow from the C-111 canal since WY1990. C-111 flows in WY2011 were close to average historical flows.

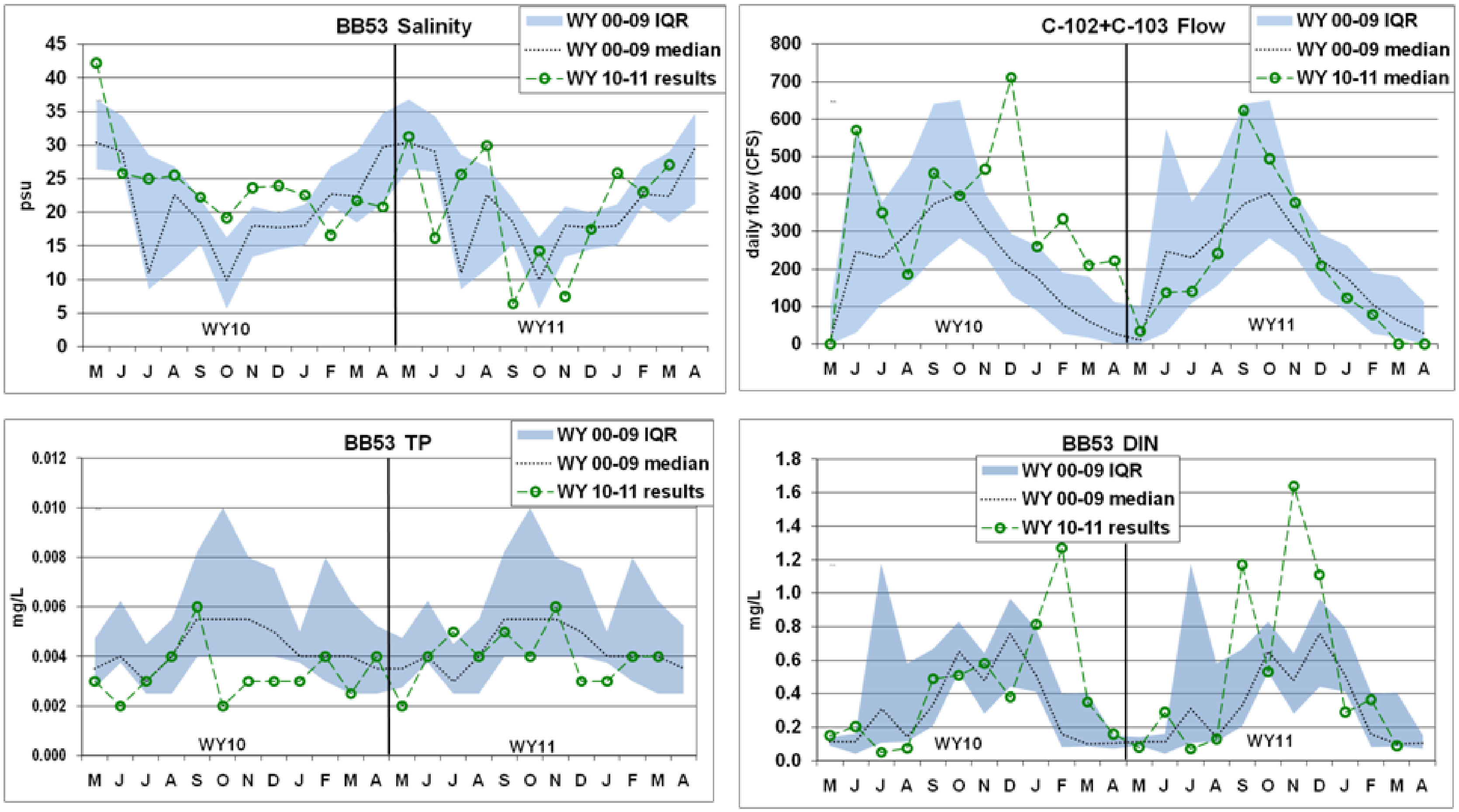

Figure 10-8. Long-term water quality results for WY2010 and WY2011 at station BB53, and freshwater inflows from the C-102 and C-103 canals. (Note: IQR – interquartile range).

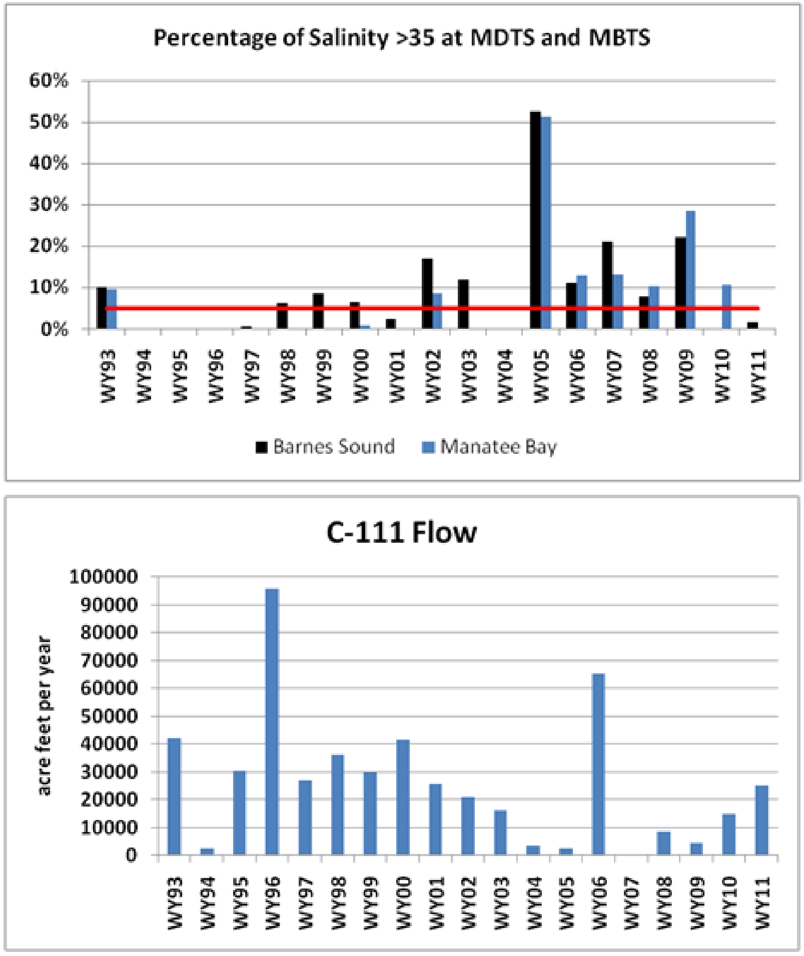

Figure 10-9. The top panel shows the percentage of days salinity was greater than 35 psu at stations MBTS in Manatee Bay (blue columns) and Barnes Sound (black columns) by water year. The red line indicates 5 percent. The bottom panel shows historical annual discharge from the C-111 Canal.

Monthly salinity results in the south-central nearshore area of Biscayne Bay at monitoring station BB53 were slightly more variable than historical salinity, with five of the values falling outside of the interquartile range, but none exceeded 35 psu (**Figure 10-8**, top left panel). Historical salinity in the nearshore near of the Deering Estate is unknown, but Biscayne National Park recently established monitoring stations in that location. The frequency of salinity exceeding 35 psu at stations BBCW8 and BBCW10, which have been operational since WY2010, are given in **Table 10-1**. Salinity exceeded 35 psu more than five percent of the time at these locations during both water years. In Manatee Bay and Barnes Sound, the period of record is much longer. The top panel of **Figure 10-9** shows the historical results. In WY2011, mean daily salinity did not exceed 35 psu at MBTS and salinity exceeded 35 psu less than two percent of the time at MDTS.

Freshwater inflow from the C-102 and C-103 canals was about 187,000 acre-feet (23,066 hectare meters) in WY2011. Monthly flows are typically less than 100 cfs (2.8 m^3s^{-1}) during the dry season months (**Figure 10-8**, top right panel). Monthly median flows in WY2011 were within the interquartile range of historical results most of the year except in March and April when the median flow dropped to zero. The culverts in the L-31E levee divert small amounts of water that would normally flow out of the canals; however, they can only flow during the wet season because water levels are generally held below the soil surface elevation during the dry season for agricultural benefits. The total quantity of water estimated to be discharged through the BBCW culverts in WY2011 was about 736 acre-feet (91 hectare meters). An additional roughly 200 acre-feet (25 hectare meters) was estimated to be discharged from a pre-existing culvert that benefits wetlands. Estimates of the water diverted by the pump at the Deering Estate will be included in WY2012 results.

Table 10-1. Mean daily salinity greater than 35 psu at BBCW8 and BBCW10.

Period of Record	Station	Number Days Salinity > 35 psu	Percent Days Salinity > 35 psu
WY2010	BBCW8	36	10
	BBCW10	35	10
WY2011	BBCW8	32	9
	BBCW10	55	15

Nutrients

The BBCW Project may reduce inorganic nutrient load to the bay (see *Southern Estuaries* section, 2011 SFER – Volume I, Chapter 12); however, given the variability of results, this reduction may not be easy to detect. No Biscayne Bay historical nutrient data are available adjacent to the Deering Estate. WY2011 TP [in milligrams per liter (mg/L)] results at station BB53 nearshore and downstream of the L-31E culverts were within or below the historical interquartile range (**Figure 10-8**, bottom left panel). Dissolved inorganic nitrogen (DIN) concentrations exceeded the historical interquartile range in WY2011 during the months of September, November, and December (**Figure 10-8**, bottom right panel). The cause is not clear, but the peaks in nitrogen concentration appear to be associated with lower salinity events that occurred during September and November.

Valued Ecosystem Components Highlights

Fishes have been surveyed visually along the western and eastern shorelines in lower Biscayne Bay since 1998 (Serafy and Johnson 2010). Densities of common species such as mojarras (*Eucinostomus* spp.), yellowfin mojarras (*Gerres cinereus*), and barracuda (*Sphyraena barracuda*) were significantly lower in 2010 compared to historical. Unusually, low water temperatures in January 2010 may have played a role.

The western nearshore zone (up to one kilometer offshore) of central Biscayne Bay is surveyed annually for SAV and macroalgae (Lirman and Serafy, 2010). Results from 2010 suggested that turtle grass (*Thalassia testudinum*), the most abundant seagrass, increased somewhat from previous years. Macroalgae was more abundant than seagrasses. On average, only about one percent of the bottom in this area is devoid of seagrasses or macroalgae. Results from tissue analyses indicated that the seagrasses are exposed to nitrogen concentrations that exceed their growth needs, and were limited by phosphorus availability. *Chara hornemanii* was consistently found in lower and variable salinity areas nearshore, and may be a good bioindicator of potential changes of salinity patterns

One of the objectives of the BBCW Project is to restore native wetland plant communities where invasive, exotic plants have crowded out the native flora. Twenty-five acres (10 hectares) of coastal wetlands downstream of two BBCW culverts east of the L-31E levee were cleared of nonnative invasive plants in April 2011 (**Figure 10-7**). The dominant exotic species removed were shoebutton (*Ardisia elliptica*), Australian pine (*Casuarina equisetifolia*), small-leaf climbing fern (*Lygodium microphyllum*), and Brazilian pepper (*Schinus terebinthifolius*).

FAKAHATCHEE ESTUARY

Patricia Goodman[1] and Richard Alleman

DESCRIPTION AND ISSUES RELATED TO DISTRICT PRIORITIES

The Big Cypress and Everglades Watersheds are the exclusive drainage basins entering the Ten Thousand Islands. The Big Cypress Watershed drains the majority of Collier County, supplying fresh water to the estuaries of the Ten Thousand Islands through a series of tributaries. Prior to anthropogenic impacts, flat topography, marly soils, and seasonal rainfall cycle were principal influences on the hydrology of the Picayune Strand area, which is surrounded by preserves and wildlife areas (**Figure 10-10**). The natural sheetflow system absorbed floodwater, promoted groundwater recharge, sustained wetland vegetation, rejuvenated freshwater aquifers, assimilated nutrients, and removed suspended materials. Fresh water reached the Ten Thousand Islands estuaries and associated acreages of salt marsh and mangrove swamp through a combination of overland sheetflow and groundwater seepage (USACE and SFWMD, 2004). The quantity and timing of freshwater inflows determined many characteristics of estuarine habitat by establishing salinity, other aspects of water chemistry, and dynamics of currents and water exchange. This slow year-round influx of fresh water maintained salinity in the natural range that estuarine species require (SFWMD, 2008).

The CERP Picayune Strand Restoration Project involves rehydrating the former Southern Golden Gate Estates subdivision [about 94 square miles, (243 square kilometers)] by removing the associated infrastructure of roads and canals and restoring the area's pre-drainage hydrology. These components will be linked to and enhanced by the restored conditions within the project area, creating a combined natural area that will function as a single connected regional ecosystem of estuaries, freshwater wetlands, and uplands. Within the project area, four large drainage canals flow from north to south: Miller, Faka Union, Merritt, and Prairie. These canals have drained the area resulting in (1) reduction of aquifer recharge, (2) increased freshwater point source discharges to Faka Union Bay, (3) decreased freshwater overland flow and seepage into the remaining receiving estuaries, (4) invasion by nuisance vegetation, (5) loss of ecological connectivity and associated habitat, and (6) increased frequency of forest fires. Expected improvements resulting from the project include the following:

- Reversal to historic plant and animal communities
- Reestablishment of sheetflow through Picayune Strand toward coastal estuaries
- Reduction of harmful surge flows via Faka Union Canal into Faka Union Bay
- Improved freshwater overland flow and seepage into other bays of the Ten Thousand Islands region
- Improved aquifer recharge and increased spatial extent of wetlands
- Decreased frequency and intensity of forest fires
- Improved habitat for fish/wildlife including threatened and endangered species
- Reductions in invasive native and exotic species

[1] Contributed as SFWMD staff during the draft SFER production cycle.

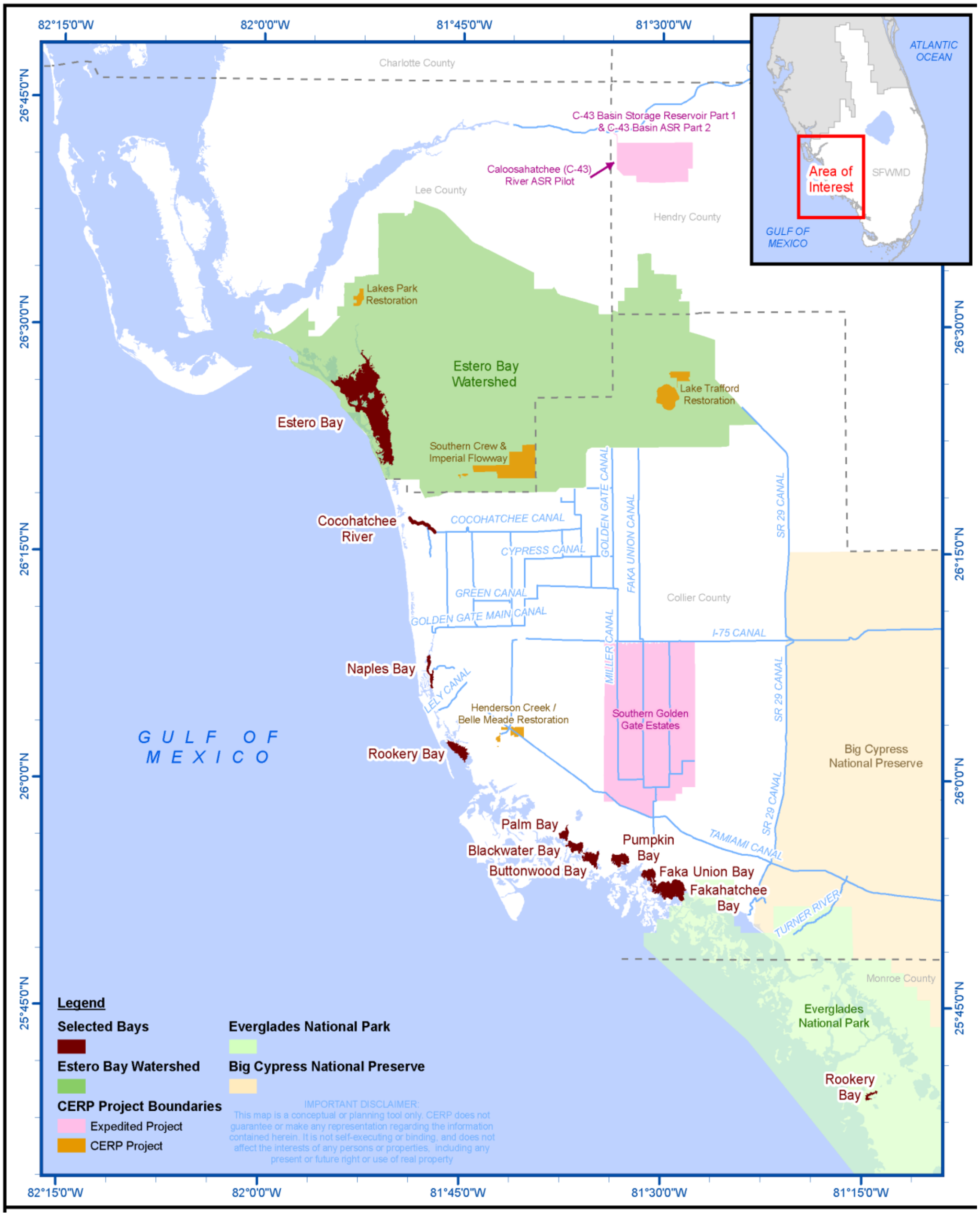

Figure 10-10. Watersheds and estuaries along the southwest coast.

A contract was awarded November 24, 2010 to construct a pump station, continue plugging the Faka Union Canal, and remove 100 miles of roadway. Construction began in early 2011 and will take about three years to complete. A similar contract was awarded in October 2009 for the Merritt Canal phase of the project. The roads in the Merritt phase have all been leveled except for those associated with the pump station construction, which began in March 2009. It will be at least a year before the north-south portion of the Merritt Canal can be filled. More information on the Picayune Strand Restoration Project is available in Volume III, Appendix 2-1, and the SFER Consolidated Project Report Database.

RESTORATION STATUS AND EFFECTS

Salinity and Freshwater Inflows

Monthly salinity measured at the TTI69 station varies seasonally (**Figure 10-11**) ranging from greater than 40 psu during the dry months to less than 20 psu during the wet season. Salinity during WY2011 appears to have been similar to historical results except in May, which is likely due to an unusually wet dry season (**Figure 10-12**).

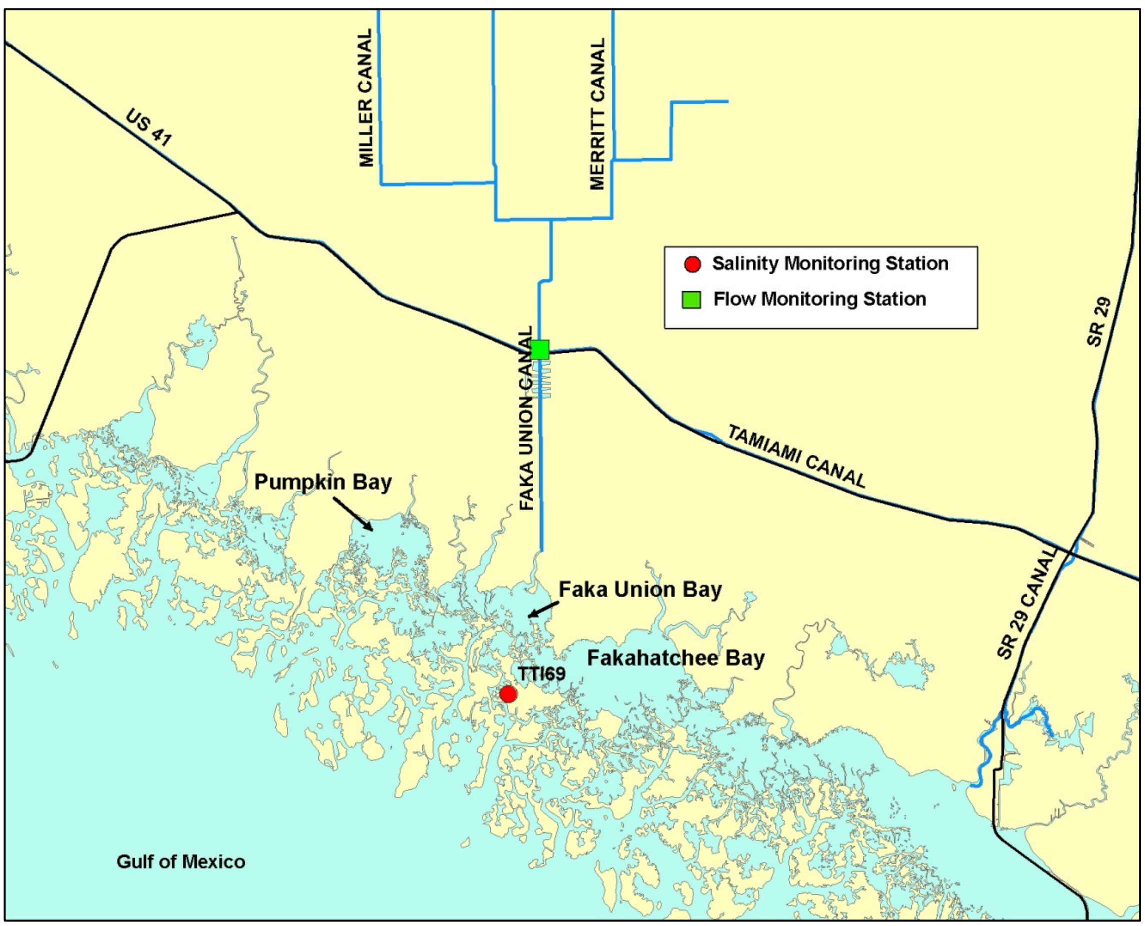

Figure 10-11. Fakahatchee Estuary and monitoring sites.

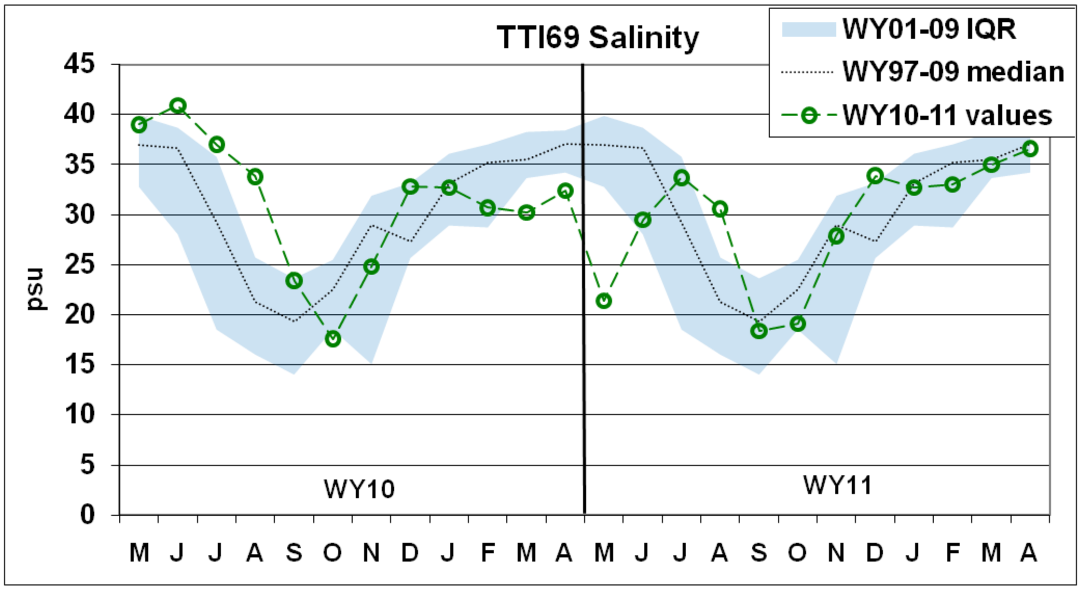

Figure 10-12. Monthly salinity at Station TTI69 in the Fakahatchee Estuary.

A water reservation was established for the protection of fish and wildlife for the Picayune Strand and Fakahatchee Estuary ecosystems and the rule pertaining to this reservation was adopted by the District Governing Board in February 2009. Flows from the Faka Union Canal should be between 50 and 500 cfs (1.4-14.2 m^3s^{-1}) (SFWMD, 2008). Ideally, flows should be within this range about 92 percent of the time over a three-year period to produce salinity conditions for estuarine species such as oysters. Flow values for Faka Union Canal are available beginning in August 2009. For the period of record through WY2011, mean daily flows were within the desired range about 39 percent of the time. During WY2011, mean daily flows were within the desired range about 71 percent of the time.

Eastern Oyster Abundance and Distribution

Oyster resources within the Ten Thousand Islands region associated with Picayune Strand restoration were the subject of a study conducted between July 1999 and May 2001 (Volety and Savarese, 2001). This is the most recent information collected. It is expected that oyster health in general and densities within Pumpkin and Faka Union bays will improve with implementation of the CERP Picayune Strand Restoration Project. This is to be confirmed through salinity and oyster monitoring that will commence in 2012.

NAPLES BAY

Patricia Goodman[1] and Richard Alleman

DESCRIPTION AND ISSUES RELATED TO DISTRICT PRIORITIES

Naples Bay is a long, narrow estuary located within a flat, low elevation region on the coast of Collier County (**Figure 10-13**). The bay is a shallow, north-south oriented water body formed by the confluence of the Gordon River and other small tributaries that empty through Gordon Pass into the Gulf of Mexico. The Naples Bay Basin lies within the Big Cypress Basin. The bay once received drainage from about 10 square miles (26 square kilometers) but with the construction of the Golden Gate Canal system, the basin expanded to about 120 square miles (311 square kilometers) (SFWMD, 2007). Naples Bay Basin is bound by the Gulf of Mexico to the west, terminating within the northwestern corner of Rookery Bay Reserve, and shares borders with Corkscrew-Cocohatchee Basin to the north, Faka Union Canal Basin to the east, and Henderson Creek and District VI Basins along the southeast.

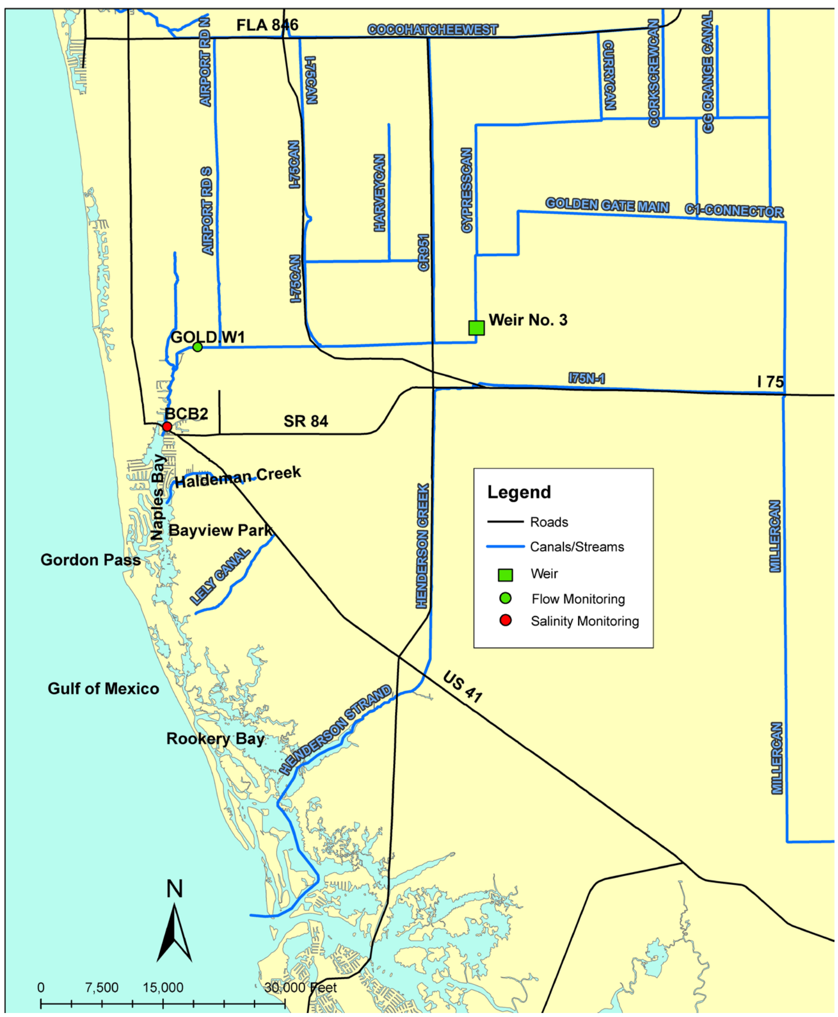

Figure 10-13. Naples Bay and monitoring locations.

Tidal exchange occurs through Gordon Pass at the southern end of the bay. Average daily tide range at Gordon Pass is 2.1 feet (0.64 meters). The highest tides occur every two weeks during the spring tides at full and new moons. Spring tide average is 2.8 feet (0.85 meters) at Gordon Pass. Tidal ranges increase slightly, moving north from Gordon Pass to the U.S. 41 Highway Bridge in downtown Naples due to amplification caused by the elongated shape of Naples Bay. Tidal ranges decrease in the Gordon River north of the bridge where tidal flow is limited by the constricted shape of Naples Bay near the bridge.

Salinity and Freshwater Inflows

During the wet season, the deeper portions of northern Naples Bay become stratified and form layers of different salinity water. Low salinity water flowing out of the Golden Gate Canal and other tributaries moves over denser, higher salinity bay waters, resulting in a series of horizontal layers that increase in salinity from the surface to the bottom. In the northern bay, these layers often do not mix. This lack of mixing between the upper layers, where oxygen is produced, and lower layers results in low bottom oxygen concentrations.

Stratification problems are believed to have increased due to increased freshwater flow and the construction of deep, dead-end canals. Stratification is less of a problem in the lower bay where horizontal mixing from tidal currents is greater (Simpson et al., 1979). Golden Gate Weir 3 improvements, currently under construction, will divert a portion of Golden Gate Main Canal flows into Henderson Creek to help reduce freshwater discharges that affect water quality in Naples Bay.

The District executed a contract with the United States Geological Survey (USGS) to collect salinity and water level data at three stations in Naples Bay. Data collection at Gordon Pass Inlet and City Dock (also referred to as downstream of US-41) monitoring stations started from May 19 and 27, 2011, respectively (**Figure 10-14**). Real-time data for Gordon Pass and City Dock stations are now available on the USGS National Water Information System web pages (http://waterdata.usgs.gov/nwis). Construction and instrumentation is progressing at the third station, Rowing Club Point (also referred as upstream of US-41). The measurements to be collected include tidal water levels, salinity, and temperature at two depths at 15-minute intervals. Also, flow rate is being collected at Gordon Pass Inlet in 15-minute intervals (**Figure 10-15**).

The District is developing a three-dimensional hydrodynamic and salinity model for Naples Bay and the Rookery Bay Estuarine System. The model will be able to simulate different water management and restoration scenarios so that the effects of strategies can be evaluated. It includes creating, calibrating, and validating a model that simulates mixing, circulation, and distribution of salinity in Naples and Rookery bays using the Curvilinear Hydrodynamic 3 Dimensional (CH3D) modeling platform. The computation efficiency of the model allows for both short-term (1 to 2 years) and long-term (36 or 41 years) simulations to be conducted on District computer platforms. In 2011, available model input and calibration data will be compiled, processed, and evaluated including tide (water level), bathymetry, salinity, current velocity (flow rate), freshwater inflows, wind, rainfall, and evaporation.

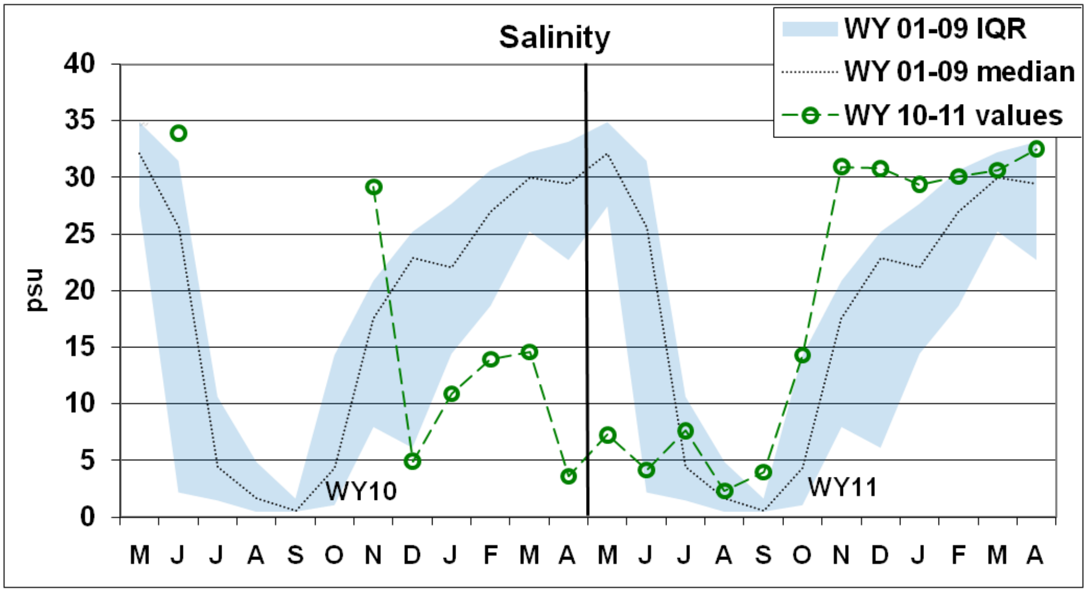

Figure 10-14. Surface salinity results in Naples Bay at station BC2 for WY2010 and WY2011 compared to the long-term results.

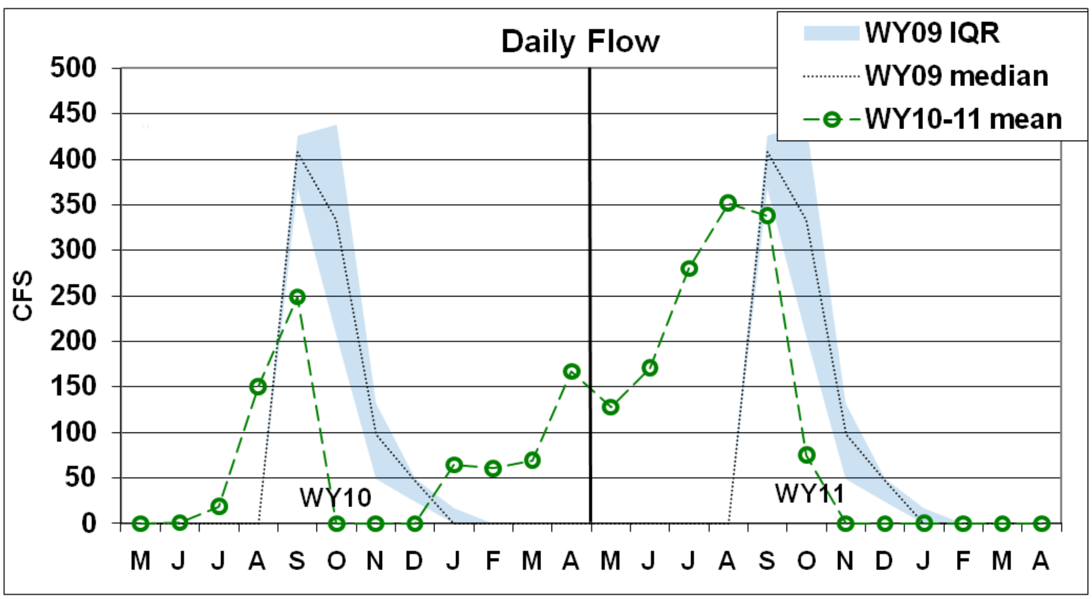

Figure 10-15. Daily flow results at station GG1 in the Golden Gate Canal.

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