Appendix 10-1: St. Lucie River Watershed Protection Plan Update

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INTRODUCTION

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BACKGROUND

The St. Lucie River, its estuary, and its watershed are located in southeast Florida, in Martin and St. Lucie counties, and a portion of Okeechobee County (**Figure 1**). The estuary is a major tributary to the Southern Indian River Lagoon (SIRL) and is geographically divided into four distinct regions: the North Fork, South Fork, Middle Estuary, and Lower Estuary. The St. Lucie Estuary (SLE) provides tremendous opportunities for population and economic growth, luring both year-round and seasonal residents along with agricultural, recreational and business interests. It serves as a nursery for many commercial and recreational fish species and is also home (seasonally or annually) to several threatened and endangered aquatic and avian species. For these reasons, it is essential to maintain the health of the estuary for both the local economy and the environment.

Changes to watershed drainage, flood control releases from Lake Okeechobee, population growth, and urban and agricultural development have led to ecological consequences for the estuary. Three major watershed influences are affecting the estuary's ecological health: (1) excessive nutrients, mainly from urban runoff, fertilizers, agricultural operations, and septic systems; (2) freshwater discharges from the St. Lucie River Watershed and Lake Okeechobee resulting in undesirable low salinity conditions in the SLE; and (3) undesirable low flows to the estuary resulting in high salinity conditions. These influences have resulted in detrimental changes to water quality in the estuary including changes in salinity, decreased dissolved oxygen (DO) content, and increased turbidity. They have also changed the abundance and distribution of valued ecosystem components (VECs), such as submerged aquatic vegetation (SAV) and oysters, and caused algal blooms.

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. 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., 2009), completed in 2009, aims to minimize the undesirable flows and improve the quality of water delivered to the estuary through implementation of the three major elements specified by NEEPP legislation: Construction Project, Source Control Program, and Research and Water Quality Monitoring

Program (RWQMP). The SLRWPP was developed by 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, with extensive stakeholder input. It must be updated every three years.

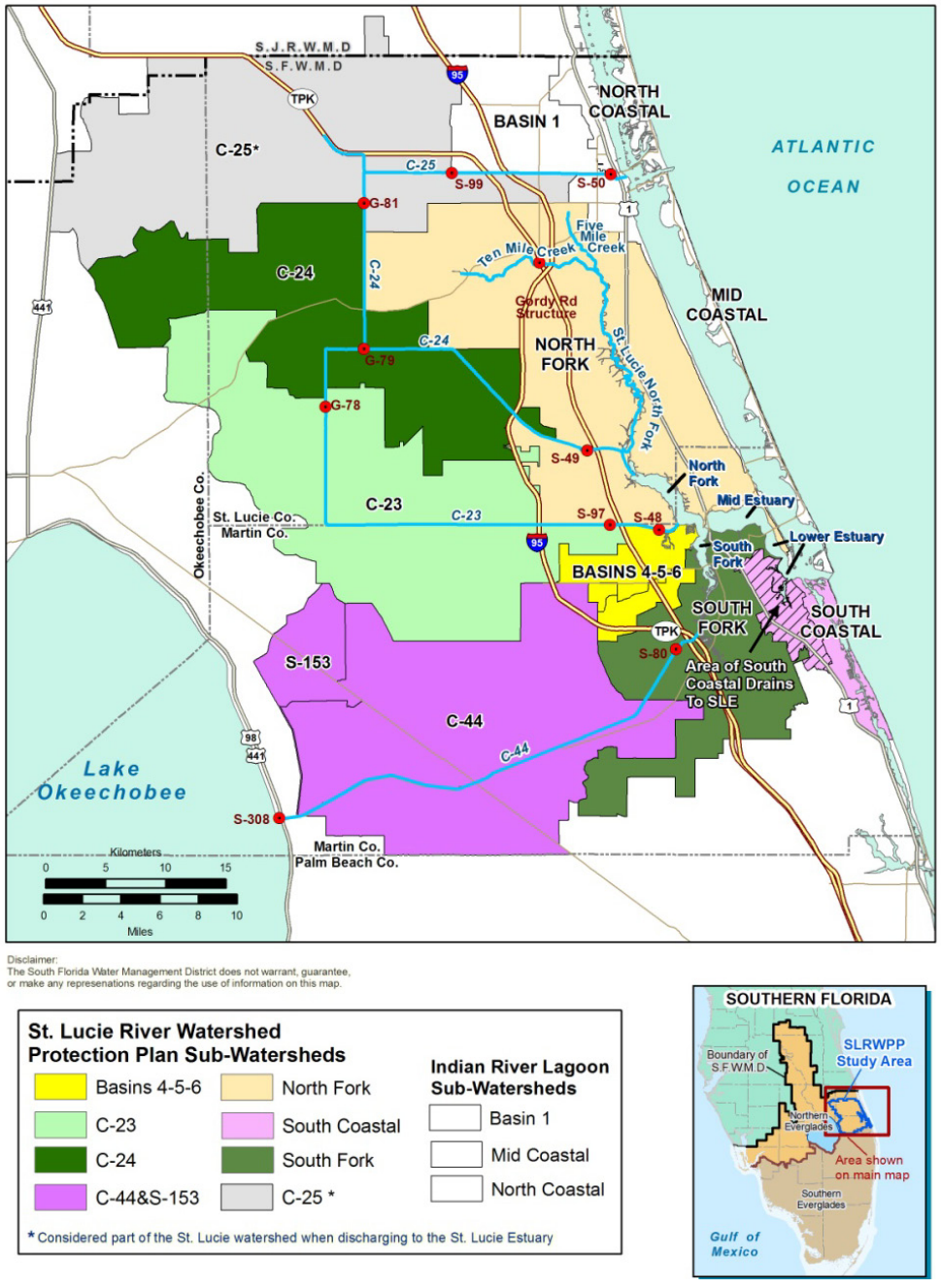


Figure 1. Sub-watersheds of the St. Lucie River Watershed Protection Plan (SLRWPP) area and four regions of the St. Lucie Estuary (SLE): North Fork, South Fork, Middle Estuary, and Lower Estuary.

This update fulfills the legislative requirement for the three-year update to the SLRWPP and focuses on the coordinating agencies' progress since 2009 toward meeting the plan's goals. It also defines current and proposed nutrient reduction and storage projects that will require funding for implementation and identifies the lead agencies for implementing each activity or project. As supporting information for this update, the SLRWPP new project/activity sheets are included in **Attachment A**, and revised nutrient loading rates and reduction factors associated with Best Management Practices (BMPs) and technologies are provided in **Attachment B**. Assumptions for BMP implementation rates are provided in **Attachment C**. An overview of the St. Lucie River Watershed and Estuary monitoring efforts is provided in **Attachment D**.

Coordinating Agencies Roles and Areas of Responsibilities

The coordinating agencies are tasked with implementing NEEPP, each with specific areas of responsibility (**Figure 2**). The District, in cooperation with the FDEP and FDACS, is the lead agency for annual status reports and three-year updates of the SLRWPP; however, each agency is responsible for implementing its respective programs. In addition, local stakeholders play a key role in implementing NEEPP. Local governments, special districts, and other stakeholders are essential in helping achieve water quality and storage targets through development and implementation of local projects and by providing local information and knowledge that help focus and guide coordinating agencies' decisions.

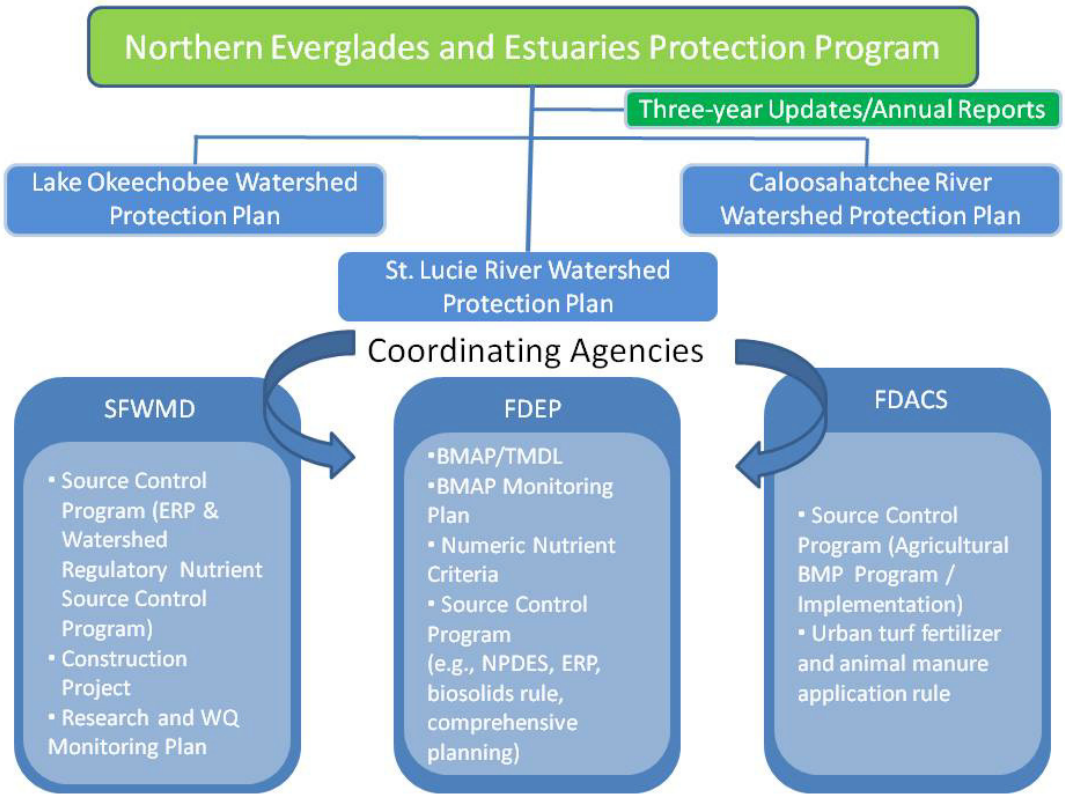


Figure 2. Responsibilities of the coordinating agencies associated with the Northern Everglades and Estuaries Protection Program (NEEPP). [Note: BMAP = Best Management Action Plan; BMP = Best Management Practice; ERP = Environmental Resource Permitting; NPDES = National Pollution Discharge Elimination System; TMDL = Total Maximum Daily Load; WQ = water quality]

Total Maximum Daily Loads

In accordance with NEEPP, the SLRWPP must include an implementation schedule for pollutant load reductions consistent with any adopted Total Maximum Daily Loads (TMDLs) and in compliance with applicable state water quality standards. The FDEP developed a TMDL for the St. Lucie River Watershed while the SLRWPP (SFWMD et al., 2009) was being formulated. The TMDL technical document was finalized (FDEP, 2008) and the rule was adopted [Rule 62-304.705, Florida Administrative Code (F.A.C.)] in 2009. The TMDL focused on nine water body identification areas (WBIDs) (**Figure 3**), which were determined to be impaired for nutrients, DO, or biochemical oxygen demand (BOD) (FDEP, 2008).

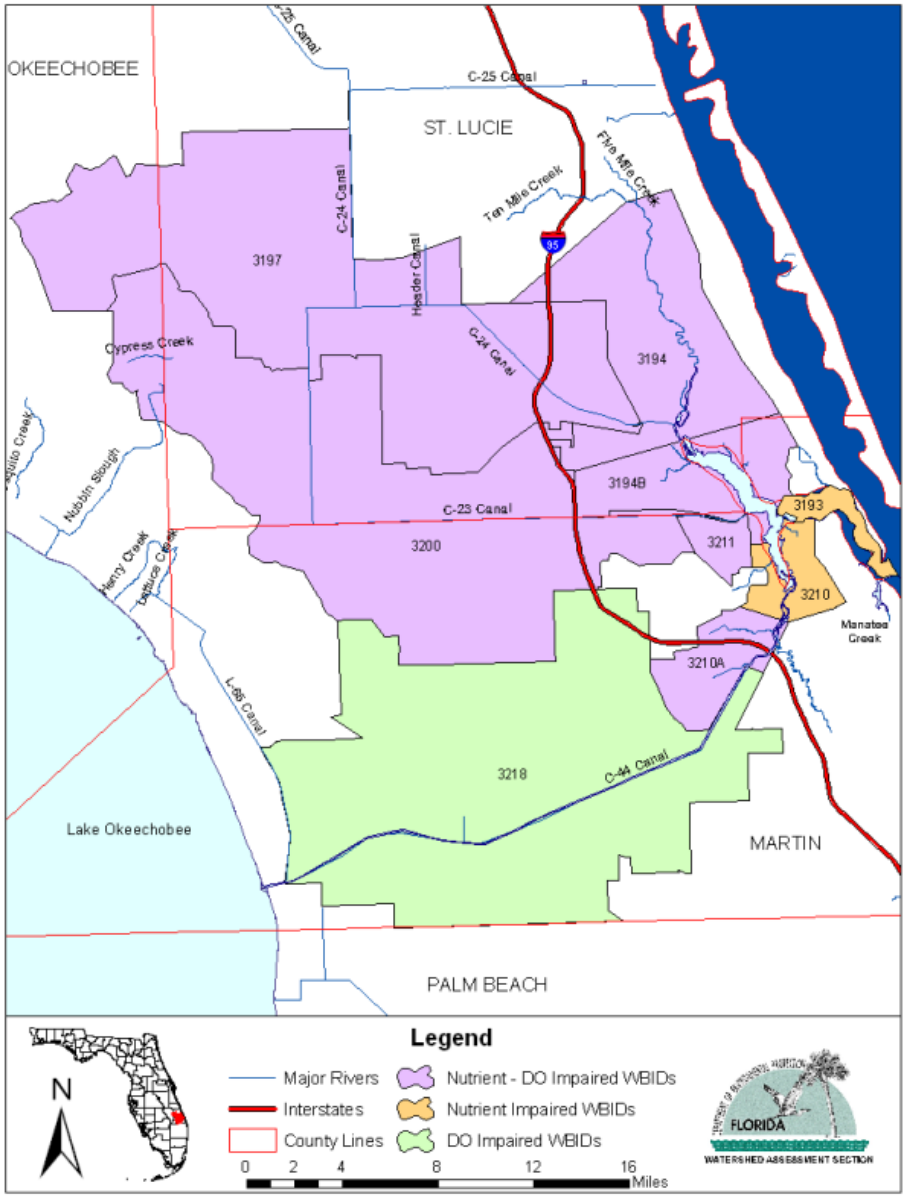


Figure 3. Verified impaired water body identification areas (WBIDs) for nutrients and dissolved oxygen (DO) for the St. Lucie River Watershed (WBIDs 3193, 3194, 3194B, 3197, 3200, 3210, 3210A, 3211, and 3218).

As reported in the 2009 SLRWPP, "After considering several options, FDEP selected the total phosphorus (TP) and total nitrogen (TN) targets from the Central and Southern Florida Project Indian River Lagoon – South Final Integrated Project Implementation Report and Environmental Impact Statement (IRL-S PIR) (USACE and SFWMD, 2004) as the end point for calculating the TMDLs for the affected WBIDs. These water quality targets [0.081 milligrams per liter (mg/L) TP and 0.72 mg/L TN] applied at the Roosevelt Bridge (at US Highway 1) were also supported by several additional lines of evidence developed through subsequent evaluations by the FDEP and District (see FDEP, 2008)."

A Watershed Hydrology and Water Quality (WaSh) model (URS, 2008) was used to simulate flows into the estuary. Average flows from 1996 through 2005 were combined with the modeled hydrological information and measured water quality data averaged over the same period. This information is used to compute the overall TN and TP loads from the St. Lucie sub-basins (WBIDS). The TMDL for individual WBIDs was then expressed as a percent reduction in concentration to meet the TN and TP concentration targets at Roosevelt Bridge (FDEP, 2008).

Basin Management Action Plan

NEEPP also requires the development of a Basin Management Action Plan (BMAP) once the TMDL is established. The St. Lucie TMDL will be implemented primarily through a BMAP. See http://www.dep.state.fl.us/water/watersheds/bmap.htm for a description of the BMAP development process. In general, a BMAP is the "blueprint" to meeting the TMDL. As described in Subsection 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. **Table 1** details the progress to date of the BMAP development process for the St. Lucie River Watershed. **Figure 4** shows the BMAP planning area which encompasses the St. Lucie River Watershed and the BMAP sub-watershed boundaries which were based on the SLRWPP sub-watershed boundaries. Allocations are being developed for entities responsible for supporting the BMAP [e.g. municipal separate storm sewer system (MS4) permit holders, agricultural producers] based upon these sub-watersheds. At the BMAP meeting on March 29, 2011, draft allocations were presented based on the sub-watersheds and reductions ranged between 39 to 55 percent for TN and 63 to 82 percent for TP.

St. Lucie Basin Management Action Plans and St. Lucie River Watershed Protection Plan Construction Project Alignment

As discussed in the *Basin Management Action Plan* section, the SLE TMDL will be implemented primarily through a BMAP, which is currently under development. The BMAP and the SLRWPP both have the desire of achieving the estuarine TMDL. While this is the main goal of the BMAP, it is only one component of the SLRWPP, which also has salinity envelope targets and water quantity and storage goals, the Pollutant Control Program, and the RWQMP. The BMAP will capture projects set forth in the pollutant control program from the SLRWPP along with individual stakeholder efforts and will also include a water quality monitoring plan to be implemented as part of an adopted BMAP. District and FDEP staff have been coordinating the SLRWPP and the BMAP processes and working to align specific components where possible. This interagency effort focuses on avoiding duplicative efforts by the two agencies while minimizing inconsistencies.

Table 1. Summary of progress to date for the St. Lucie Watershed Basin Management Action Plan (BMAP) development.

Date	Location	Main Topics Covered
July 21, 2009	City of Port St. Lucie Building B Training Room Port St. Lucie, FL	Introduced BMAP process and discussed final Total Maximum Daily Load (TMDL)
March 25, 2010	Blake Library Stuart, FL	Technical meetings are held quarterly; reviewed BMAP boundaries along with individual stakeholders' jurisdictional boundaries, discussed TMDL allocation strategies, and distributed project collection tables
August 18, 2010	City of Port St. Lucie City Hall Port St. Lucie, FL	Continued dialogue on stakeholder jurisdictional boundaries, distributed Best Management Practice (BMP) project credit descriptions, and discussed project spreadsheets and BMAP needs
March 29, 2011	South Florida Water Management District Martin Service Center Stuart, FL	Discussed entity-based detailed allocations using SFWMD sub-watershed boundaries versus water body identification areas (WBIDs), discussed additional 2011 consent decree TMDLs under development (Ten Mile Creek, South Fork of St. Lucie River)
May 24, 2011	Havert L. Fenn Center Room 122 Fort Pierce, FL	Discussed projects collected from stakeholders to date and the alignment of BMAP with St. Lucie River Watershed Protection Plan (SLRWPP) boundaries; draft allocations to be refined and project credit calculations are under way
November 16, 2011	City of Stuart, Commission Chambers	Discussed BMAP/SLRWPP alignment efforts, projects/information collected from stakeholders, agricultural BMP efforts in the SLRW, allocation refinements and implementation, locations of projects in the watershed, and prioritization of projects.

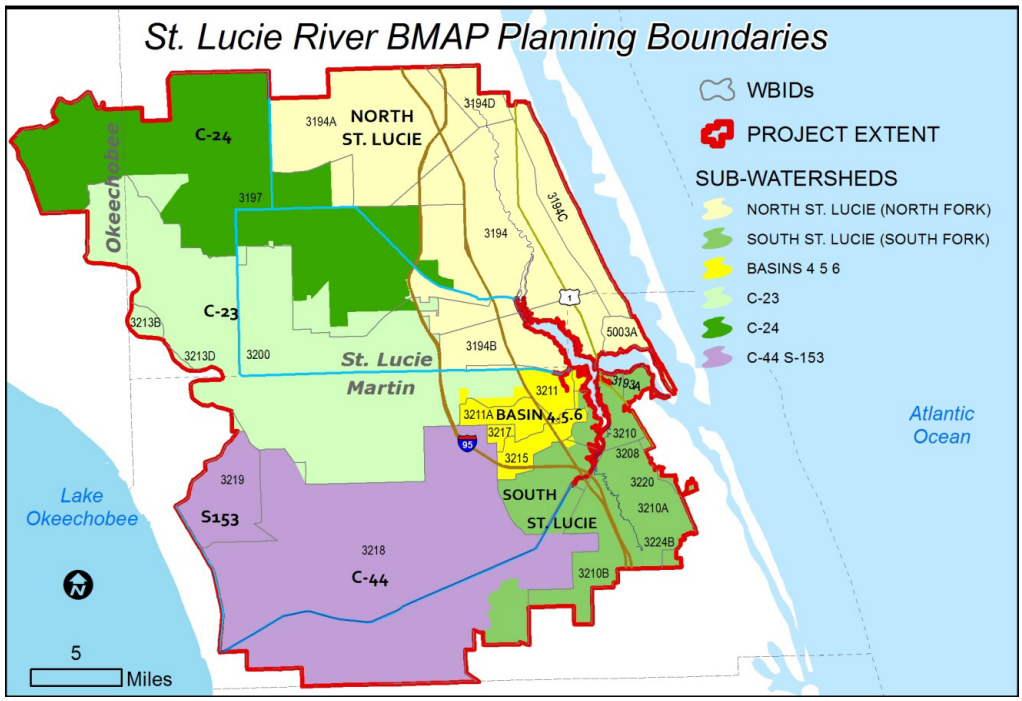


Figure 4. Current Basin Management Action Plan (BMAP) planning boundaries for the St. Lucie River and Estuary.

Both of these processes used spreadsheet models for the St. Lucie River Watershed; however, separate spreadsheet models were needed because they serve different purposes. The BMAP spreadsheet model was developed to determine load allocations for specific entities while the SLRWPP spreadsheet model was used to calculate remaining loads after applying estimated load reductions from projects and for estimating BMP efficiencies. In 2011, the District and FDEP identified specific components of the two spreadsheets that could be aligned and made the following recommendations:

- **Unit Loads.** A unit load is the estimated nutrient run-off in pounds per acre per year expected from a specified land use. The FDEP uses unit loads in their watershed loading estimates and allocations while the District uses them in estimating BMP efficiencies. The FDEP and District collaborated on one set of unit loads for the St. Lucie River Watershed, which will be applied to each of the agencies' spreadsheets.
- **Watershed Boundary.** The FDEP uses WBIDs for TMDL development; however, WBID boundaries in the St. Lucie River Watershed did not encompass the entire watershed. During BMAP development, the FDEP determined a watershed approach for assigning load allocations was more appropriate than using the WBID boundaries. This is also consistent with the SLRWPP approach. Therefore the BMAP will adopt the updated SLRWPP planning boundary (see the *Plan Boundary and Land Use* section) to the greatest extent possible.
- **Period of Record (POR).** The 2009 SLRWPP (SFWMD et al., 2009) used a 1995–2005 POR. The BMAP used a 1996–2005 POR and did not include 1995 because it was an unusually wet year. For consistency with the BMAP POR, this update has adopted the 1996–2005 POR for the water quality evaluation.
- **Land Use.** The SLRWPP used 2004 land use coverage while the BMAP used 1999 land use coverage. The agencies compared these two datasets and only identified insignificant differences; therefore no alignment for land use was necessary.
- **Local Water Quality Projects.** Another component of the alignment process involves local water quality projects and associated load reductions. The FDEP is currently inventorying local water quality projects dating back to 2000 and estimating project-specific load reductions. It is anticipated that FDEP's BMAP list of local water quality projects and their associated load reductions will be adopted in the next SLRWPP update, while pollutant load reduction projects moving forward in the updated SLRWPP will be captured in the future BMAP implementation plans. This update incorporates the 2009 SLRWPP list of local water quality projects and new projects identified since 2008.

Numeric Nutrient Criteria

Both the United States Environmental Protection Agency (USEPA) and FDEP are currently in the process of developing numeric nutrient criteria for Florida. Both are ongoing efforts scheduled to conclude after this SLRWPP update is finalized and will depend on various external factors beyond the scope of this update. Related impacts of the rulemaking process on current TMDL and BMAP activities are presently unknown but will be important to the Northern Everglades watersheds. Additional details on the evolving state and federal processes of numeric nutrient criteria development are available at www.dep.state.fl.us/water/wqssp/nutrients and http://water.epa.gov/lawsregs/rulesregs/florida_index.cfm, respectively. **Table 2** highlights some key chronological events related to the overall development of numeric nutrient criteria (note that dates for future activities are subject to change).

Table 2. Overview of timeline for numeric nutrient criteria development.

Date	Lead Agency/ Organization[1]	Status/Action
1998	USEPA	Develops policy document for a national nutrient strategy
2000/2001	USEPA	Released nutrient criteria technical guidance manuals for lakes, rivers and streams, and estuaries
2000/2001	USEPA	Released ambient water quality recommendations documents for various national eco-regions
2003	FDEP	Kicked-off the Technical Advisory Committee process
2004	USEPA/FDEP	Executed a mutual agreement on Numeric nutrient criteria plan development for Florida
2004–2007	FDEP	Conducted Technical Advisory Committee deliberations on lakes, rivers and streams numeric nutrient criteria
2007	USEPA/FDEP	Executed mutual agreement on revised numeric nutrient criteria plan development for Florida
August 2008	FWF	Florida Wildlife Federation filed suit to compel the United States Environmental Protection Agency (USEPA) to set numeric nutrient criteria
January 2009	USEPA	Declared numeric nutrient criteria necessary via a determination letter
August 2009	USEPA/FWF	Agreed on a Consent Decree that contains implementation dates for numeric nutrient criteria: freshwater flowing waters and lakes proposed rule due January 2010 and final due by October 2010; estuaries and coastal waters proposed rule due by January 2010 and final due by October 2010
Spring 2009	FDEP	Held several Technical Advisory Committee meetings to finalize numeric nutrient criteria
July 2009	FDEP	Released draft numeric nutrient criteria
November 2009	USEPA/FWF	Upheld Consent Decree
January 2010	USEPA	Proposed freshwater flowing waters and lakes rule
February–April 2010	USEPA	Held six public hearings and took public comment on rule
June 2010	USEPA/FWF	Agreed to extend timelines for estuaries, coastal waters, and South Florida canals proposed rule to November 2011 and final to August 2012; announced formation of a scientific advisory board to review these waters
August 2010	USEPA	Released notice of data availability for additional comment on numeric nutrient criteria freshwater rule
December 6, 2010	USEPA	Released final rule for freshwater lakes, flowing waters in most of the state, and springs
March 2011	USEPA	Released “Stoner” memo to give guidance to states on eight key elements for nutrient management
April 2011	FDEP	Petitioned USEPA to rescind determination letter, final freshwater rule, and to halt all current rulemaking; Florida Department of Environmental Protection (FDEP) also lists a schedule for their own rulemaking
June 2011	USEPA	Issued a letter that neither denies nor accepts the Florida Department of Environmental Protection’s petition but states they will observe progress
June–September 2011	FDEP	Initiated rulemaking via public process including three series of meetings and website for public input during the development of nutrient standards
December 2011	FDEP	Will take state’s rule before the Environmental Regulations Commission for adoption if rulemaking is pursued
January–March 2012	FDEP	Will take state’s rule before the Florida legislature for ratification if Environmental Regulation Commission adoption is successful
March 2012	USEPA	Due date for USEPA’s freshwater rule to be in effect
March 2012	USEPA	Due date proposed for estuaries, coastal waters, and South Florida canals numeric nutrient criteria
November 2012	USEPA	Due date for USEPA to release final rule for estuaries, coastal waters, and South Florida canals numeric nutrient criteria

[1]FDEP = Florida Department of Environmental Protection; FWF = Florida Wildlife Federation; USEPA = United States Protection Agency

Plan Components and Their Total Maximum Daily Load/Best Management Action Plan Relationships

The three main SLRWPP components are the Pollutant Control Program, Construction Project, and RWQMP. This section describes these components, their relationships to each other in the SLRWPP, and their relationships to the TMDL and BMAP efforts (**Figure 5**).

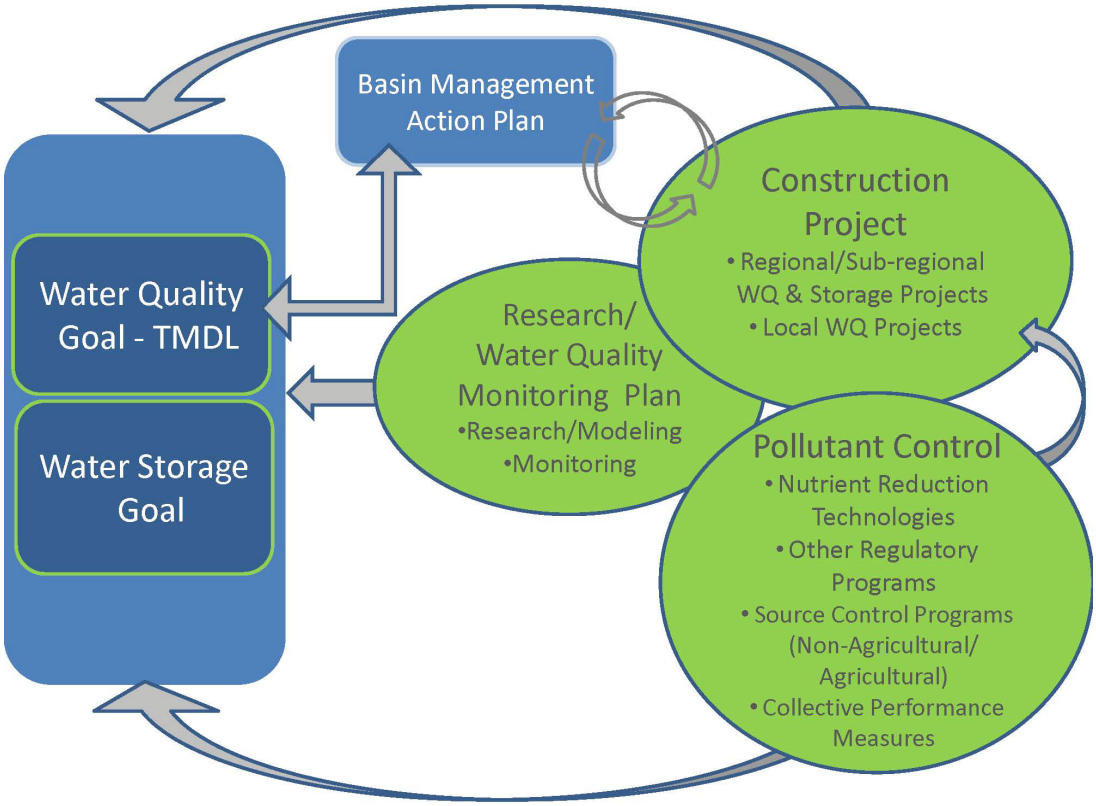


Figure 5. The relationships among the three SLRWPP components, the Total Maximum Daily Load (TMDL), and the BMAP. The green ovals represent the components and building blocks of the SLRWPP. [Note: WQ = water quality]

Brief descriptions of the three main SLRWPP components are as follows:

- **Pollutant Control Program**. This is a multifaceted approach to reducing pollutant loads by improving the management of pollutant sources within the watershed. It comprises source control programs being implemented by the coordinating agencies including BMPs, on-site treatment technologies, stormwater and wastewater infrastructure upgrades and master planning, and regulatory programs focused on water quality and quantity.
- **Construction Project.** This component identifies water quality and storage projects to improve hydrology, water quality, and aquatic habitats within the watershed. They include regional, sub-regional, and local scale water quality and quantity projects [e.g., reservoirs, stormwater treatment areas (STAs), chemical treatment, and local stormwater projects].
- **RWQMP.** This builds upon the District's existing research program and is intended to carry out, comply with, or assess the plans, programs, and other

responsibilities created by the SLRWPP. The program will also conduct an assessment of the water volumes and timing from the Lake Okeechobee and St. Lucie River watersheds and their relative contributions to the estuary. The primary purpose of this component is to track progress towards achieving the water quality and storage targets.

The relationship among the components of the SLRWPP, TMDL, and BMAP is complex (**Figure 5**). The Pollutant Control Program (source control) is the first building block of the water quality treatment train. It includes the development of performance measures to evaluate the effectiveness of the collective source control programs (see the *Pollutant Source Control Program* section). The Construction Project component, including regional, sub-regional, and local water quality and storage projects, builds upon the Pollution Control Program efforts to maximize load reductions and water storage. The RWQMP monitors the health of the estuary and provides research needed to support or refine the water quality and storage goals. It also provides a platform for evaluating plan performance and goals based on measured data and model results. The BMAP has an overlapping goal with the SLRWPP of achieving the SLE TN and TP TMDL. Both the BMAP and the SLRWPP Construction Project include local water quality projects geared towards reducing watershed loading. In accordance with NEEPP, the SLRWPP provided the basis for BMAP development.

PLAN BOUNDARY AND LAND USE

SLRWPP Planning Boundary Updates

The 2009 SLRWPP (SFWMD et al., 2009) included descriptions of all nine sub-watersheds comprising the St. Lucie River Watershed. Of those sub-watersheds (**Figure 1**), 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). The Basin 1, C-25, and the C-25 East sub-watersheds mostly drain to the Indian River Lagoon (IRL) and therefore were not considered in the water quality evaluation. Occasional inter-basin transfer between the C-25 sub-watershed and the C-24 sub-watershed occurs, mostly from the C-25 to the C-24, which is captured in the C-24 flows and loads; however flow can go both ways and for WY2010 a vast majority of flow went from C-24 to C-25. Water quality is not measured at this interchange. The water quality evaluation was performed on the sub-watersheds draining to the SLE with the exception of the South Coastal Sub-watershed because adequate flow and load data from this sub-watershed do not exist and contributions of flows and loads from this sub-watershed are expected to be proportionately less than the other six sub-watersheds (mainly due to its small size).

The boundary of the SLRWPP study area has been modified slightly from the 2009 SLRWPP. These changes were made for consistency with the District's enterprise Arc Hydro Enhanced Database (AHED), which serves as its official database of record for hydrologic feature locations within the District. The AHED is updated periodically to reflect new hydrologic information gained from activities such as permit applications and studies.

The St. Lucie River Watershed boundary map (**Figure 1**) and acreages of the sub-watersheds (**Table 3**) have been updated since 2009. Overall, 0.04 percent (212 acres) more land is included within the watershed now from the addition of two areas: a small parcel (approximately 209 acres) on the eastern boundary of the South Fork Sub-watershed and the addition of the L-65 canal along the western border of the C-44/S-153 Sub-watershed. The main change within the interior of the planning boundary is the reassignment of approximately 500 acres from the C-23 Sub-watershed to the Basin 4-5-6 Sub-watershed since this area drains downstream of the S-48 structure.

Table 3. Comparison of sub-watersheds acreages between the 2009 St. Lucie River Watershed Protection Plan (SLRWPP) and this update.

Sub-Watershed	2012 SLRWPP Update (acres)	2009 SLRWPP (acres)	Difference Between Mapping Years (acres)	Percent Change
Basin 4-5-6	15,581	15,055	526	3.49%
C-23	112,160	112,675	-514	-0.46%
C-24	87,770	87,706	65	0.07%
C-44/S-153	129,856	129,719	137	0.11%
North Fork	119,105	119,168	-63	-0.05%
South Fork	50,121	49,965	157	0.31%
South Coastal	14,600	14,695	-95	-0.65%
Total	**529,194**	**528,982**	**212**	**0.04%**

Land Use

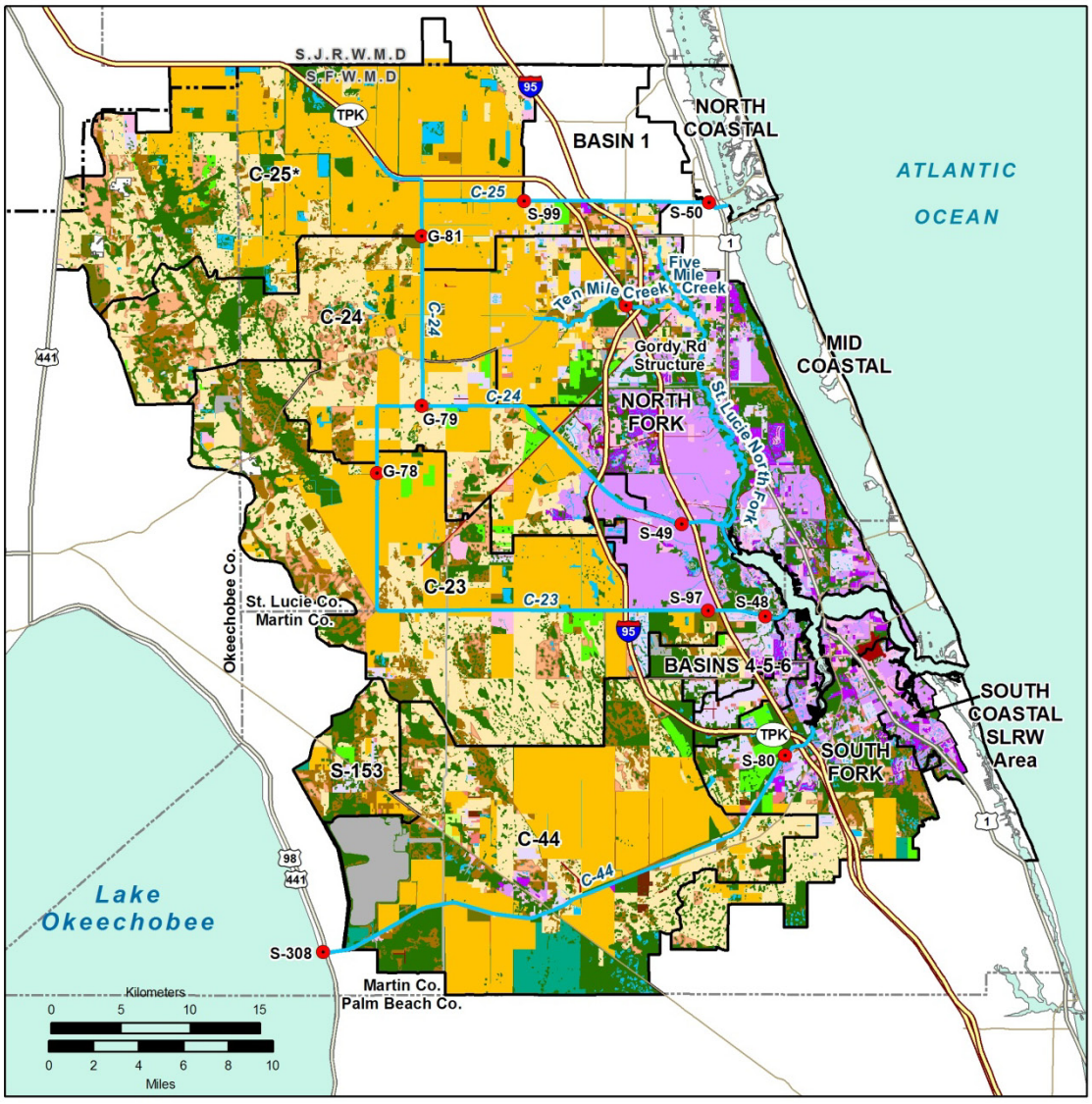
Nutrient levels in surface water runoff are directly related to land use and land management practices within the watershed (Hiscock et al., 2003). Agricultural land uses dominate the St. Lucie River watershed and account for 57 percent (297,601 acres) of the total area including citrus and improved pasture; followed by natural areas (20 percent or 106,996 acres) and urban areas (17 percent or 89,540 acres). Agriculture, improved pastures, and natural areas occur mostly in the more rural sub-watersheds (C-23, C-24, C-44/S-153, and northern reaches of the North Fork), and urban areas occur most in the South Fork and Basin 4-5-6 sub-watersheds, and in southern portions of the North Fork Sub-watershed (**Table 4** and **Figure 6**).

This update utilized the 2004 land use data for water quality evaluations since the District's 2008 land use coverage was not available for incorporation into this update. However, an initial comparison between the preliminary 2008 and the 2004 land uses was performed mostly to address the concerns regarding the change in citrus acreages due to citrus diseases. The analysis indicated that, in general, the total agricultural acreage remained almost unchanged with an approximate one percent decrease, despite a dramatic decrease in citrus acreages (approximately 31 percent), between 2004 and 2008, mostly due to the greater prevalence of citrus diseases. In addition, there was an overall nine percent increase in urban areas, and a five percent decrease in natural areas.

Table 4. Land use acreage by sub-watershed for the SLRWPP as of 2004.

Land Use Category	Basin 4-5-6	C-23	C-24	C-44/S-153	North Fork	South Fork	South Coastal[1]	Total	Percent of Total Watershed
Residential Low Density	4,659	1,566	1,236	1814	9,445	3,330	257	22,307	4%
Residential Medium Density	1,236	304	2,531	315	30,428	3,471	2,725	41,010	8%
Residential High Density	703		295	186	4,784	1,730	939	8,637	2%
Other Urban	1,270	1,266	782	588	8,974	3,025	1,680	17,586	3%
Improved Pastures	1,007	33,635	33,950	23,185	5,000	9,553		106,329	20%
Unimproved Pastures	87	5,062	6,064	2,168	558	1,094		15,034	3%
Woodland Pastures/ Rangeland	769	10,300	7,110	12,841	4,566	3,783	124	39,493	8%
Row Crops	156	1696	1,550	852	1,166	2,460		7,881	2%
Sugar Cane				5,240		322		5,562	1%
Citrus	30	32,467	17,479	42,756	20,690	3,026		116,448	22%
Sod Farms				294				294	0%
Ornamentals	211		25	268	238	504		1,246	0%
Horse Farms	54	54	14	592		71		784	0%
Dairies		419						419	0%
Other Agricultural Areas	166	2,139	958	567	159	121		4,110	1%
Water	402	1,791	1,261	1,932	4,274	1,730	236	11,625	2%
Natural Areas	4,086	20,088	13,891	27,833	25,036	14,651	1,411	106,996	20%
Transportation	305	448	521	611	2,623	1,167	548	6,225	1%
Communications/ Utilities	439	926	102	7,814	1,164	83	14	10,543	2%

[1]This analysis only includes portions of the South Coastal Sub-watershed that drain to the St. Lucie Estuary and does not include the C-25 or C-25 East sub-watersheds.



Disclaimer:
The South Florida Water Management District does not warrant, guarantee, or make any represenations regarding the use of information on this map.

2004 Land Use

Residential Low Density	Unimproved Pastures	Sod Farms	Water
Residential Medium Density	Woodland Pastures/Rangeland	Ornamentals	Natural Areas
Residential High Density	Row Crops	Horse Farms	Communications/Utilities
Other Urban	Sugar Cane	Dairies	Transportation
Improved Pastures	Citrus	Other Agricultural Areas	

* Considered part of the St. Lucie watershed when discharging to the St. Lucie Estuary
Basin 1, North Coastal and Mid Coastal are not part of the SLRWPP

Figure 6. Land use within the St. Lucie River Watershed as of 2004.

POLLUTANT SOURCE CONTROL PROGRAM

Jodie Hansing and Carmela Bedregal

The Pollutant Source Control Program is a multifaceted approach for improving the management of pollution sources within the watershed. It includes source control programs being implemented by the coordinating agencies, including the BMPs, on-site treatment technologies, stormwater and wastewater infrastructure upgrades and master planning, and regulatory programs focused on water quality and quantity. Chapter 4 of this volume provides a detailed update on the implementation of regulation and BMP elements of source control programs for the St. Lucie River Watershed. A summary of the status of program elements based on the 2009 SLRWPP (SFWMD et al., 2009) objectives is presented here.

1. **Implementation of nonpoint source BMPs on agricultural and non-agricultural lands to ensure the amount of nutrients discharged off-site are minimized to the greatest possible extent**

    - The District and FDEP are authorized to implement the Environmental Resource Permit (ERP) program, which requires new activities or modifications of existing activities provide reasonable assurances that they will not (1) cause adverse water quality such that state water quality standards will be violated, (2) cause adverse flooding or water quantity impacts, or (3) harm wetland or other surface water systems. As of today, 68 percent of agricultural and non-agricultural acreage in the St. Lucie River Watershed have been issued an ERP permit by the District.

    - The FDEP is proposing statewide ERP legislation in coordination with the Office of Fiscal Accountability and Regulatory Reform (OFARR). This legislation addresses the adoption of statewide environmental resource permitting rules to govern the construction, alteration, operation, maintenance, repair, abandonment, and removal of surface water management systems. These new rules will rely primarily on the FDEP and water management district rules currently in effect, reconciling any differences for a statewide approach while accounting for differing physical and natural conditions. The applicant's handbook, adopted as a part of this rule, will include a discussion of stormwater quality and quantity criteria.

    - The FDACS works with agricultural producers to develop, adopt, and implement voluntary and incentive-based BMPs specific to various operations. To date, BMP manuals for citrus, vegetable and row crop, container nursery, sod, cow/calf, and specialty fruit and nut operations have been adopted. The equine manual is nearing adoption. As of March 2011, BMP enrollment of agricultural lands in the St. Lucie River Watershed is 52 percent.

    - The statewide Urban Fertilizer Rule [Rule 5E-1.003(2), F.A.C.] became effective in December 2007. Application of fertilizers 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 municipal separate storm sewer system (MS4) permits to prevent harmful pollutants from being discharged into water bodies. MS4 permits include a stormwater management plan. For the St. Lucie River Watershed, all MS4 permits are Phase II. Phase II MS4 permits are generic permits that include a requirement for modifying the stormwater

management program if it is not achieving the load allocations in an adopted TMDL and to comply with the conditions of a TMDL implementation plan.

- The University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Florida Yards and Neighborhood Program has been expanded from the original homeowner approach to include a broader audience. Beginning January 1, 2014, this certification program will be 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. In the St. Lucie River Watershed local Florida-friendly landscaping ordinances have been adopted, or are in the process of being adopted, for Martin County, the City of Stuart, the City of Port St. Lucie, St. Lucie County, and the Town of Sewall's Point.
- According to 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., are long-standing regulations that establish criteria to ensure discharges from nonpoint sources meet legislative objectives for water quality protection. The District will coordinate with the OFARR prior to initiating rule development to amend Chapter 40E-61, F.A.C., to expand the regulatory source control program in order to encompass phosphorus and nitrogen loading reductions in the St. Lucie and Caloosahatchee River watersheds. The program will include water quality performance measure methods for collective source controls.

2. Ensuring 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. The 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 a nutrient balance demonstration is completed by the applicant and approved by the FDEP. In 2011, there were three active biosolid application sites in the St. Lucie River Watershed. By January 1, 2013, all sites are required to be permitted in accordance with the revised biosolids rule.

3. Coordination with the Florida Department of Health (FDOH) to ensure 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 the District's 40E-61 Regulatory Nutrient Source Control Program

Sections 373.4595(4)(a)2.f, and 373.4595(4)(b)2.f, F.S., require 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. At this time, no FDOH-regulated septage disposal sites are located within the Northern Everglades watersheds. If any entities were to apply septage in the St. Lucie River Watershed, they would be required to do so in accordance with an agricultural use plan that limits applications based on nutrient loadings, and proposed amendments to the rule (Chapter 40E-61, F.A.C.) would require concentrations originating from these locations not exceed the limits proposed by an amended rule (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 from the Legislative Budget Commission.

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

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

5. **Implementation of a source 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 District has evaluated the existing water quality monitoring networks for the SLE and identified network improvements to capture all nutrient loading contributions. An assessment of historic TP, TN, inorganic nitrogen, and flow data for the watershed was also completed. Synoptic monitoring programs to identify future priority monitoring sites are ongoing.

Other pollutant source control activities implemented by the coordinating agencies pursuant to their respective authorities include outreach activities, planning, and issuance and oversight of National Pollutant Discharge Elimination System (NPDES) and Concentrated Animal Feeding Operation (CAFO) permits for point sources, and Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) project permits. Further detail is provided in Chapter 4 Volume I of the SFER.

CONSTRUCTION PROJECT AND OTHER RELATED PROJECTS

Pinar Balci, Lesley Bertolotti, Kelly Cranford and
Benita Whalen

CONSTRUCTION PROJECT

Reducing nutrient loading and high discharges to the SLE requires action at the regional, sub-regional, and local level. The SLRWPP Construction Project focuses on water quality and storage projects at each of these spatial scales with components that will improve hydrology, water quality, and aquatic habitats within the watershed and estuary. The Construction Project builds upon the source control program and includes a variety of activities including water quality projects, local stormwater retrofits, reservoirs, and habitat restoration projects. Other related activities include the dispersed water management program, the Lake Okeechobee Protection Plan (LOPP) Update, Herbert Hoover Dike (HHD) Restoration, and Adaptive Protocols for Lake Okeechobee. This section provides an update on the water quality and storage features associated with the Construction Project over the last three years. Specific projects captured in the Construction Project are included in **Attachment A**.

Regional and Sub-regional Project Updates

Regional and sub-regional projects are critical to achieving the water quality and storage goals of the SLRWPP. The regional project that will have the greatest benefit for the estuary is the Comprehensive Everglades Restoration Plan (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. Other projects include the Ten Mile Creek STA and Lake Point Restoration, which is a new sub-regional project discussed further in the *Watershed Strategies* section.

CERP Indian River Lagoon – South Project Implementation Report

The IRL-S PIR was authorized in the Water Resources Development Act (WRDA) of 2007. The document outlines a plan to restore the SLE and SIRL and the associated watershed. It also meets the WRDA 2000 requirement of completing a project implementation report (PIR) prior to implementing any CERP project. Specific IRL-S PIR projects considered in this SLRWPP include the C-44 Reservoir and STA, Natural Storage and Water Quality Areas, C-23/C-24 Reservoir and STA, North Fork Natural Floodplain Restoration, oyster substrate creation in the SLE, and muck removal from the SLE. More information on the individual features proposed in the IRL-S plan are presented in the IRL-S PIR, which is available at www.evergladesplan.org.

CERP IRL-S PIR Phase 1 Project-Partnership Agreement

In late 2008, the District initiated an effort to develop a Water Reservation rule for the IRL-S project, which is a WRDA 2000 requirement [Section 601(h)(4)(B)(ii)]. The rule was finalized in March 2010, reserving water from the C-23/C-24 reservoirs for flows to the North Fork of the St. Lucie River. In August 2010, the District and the United States Army Corps of Engineers (USACE) developed and executed a Construction Phasing Transfer and Warranty Plan, which outlines the plans and procedures, working relationships, and responsibilities for construction, operation, maintenance, repair, replacement, and rehabilitation of the Phase 1 IRL-S PIR components (reservoirs and STAs). Following the establishment of the Water Reservation rule

and execution of the transfer plan, the agencies executed the Phase 1 Project Partnership Agreement for the reservoir and STA features.

CERP IRL-S PIR C-44 Reservoir and STA

The objectives of the C-44 Reservoir and STA are to capture, store, and treat runoff from the C-44 basin prior to discharge to the SLE. Implementation of this project is expected to reduce damaging freshwater discharges, decrease nutrient load, and maintain desirable salinity regimes, all of which are expected to occur collectively as a result of NEEPP and CERP implementation. This project, located north of the C-44 canal, includes construction of a 3,400-acre reservoir and an adjacent 6,300-acre STA in southern Martin County. The District completed the design for the project components. The USACE is responsible for construction and will solicit three contracts over a seven-year period. Initial construction (Contract 1, awarded July 2011) includes the project intake canal, access road, and the Citrus Boulevard Bridge. Contract 2 will include the reservoir, pump station, and discharge canal, while Contract 3 will complete the project by constructing the STA cells. Contract 2 and 3 execution is anticipated in 2013 and 2016, respectively.

CERP IRL-S PIR C-23/24 Reservoir/STA

This project involves a north reservoir, a south reservoir, and a STA that covers 11,122 acres. The total storage capacity of the project is 94,468 acre-feet (ac-ft). The project purpose is to capture and treat runoff from the C-23 and C-24 basins, thereby improving the quality, quantity, timing, and distribution of water discharged to the SLE. Available lands for acquisition have resulted in a modification to the IRL-S PIR footprint of the two proposed reservoirs, whereby the southern reservoir encompasses more acreage than the northern reservoir. Meeting the requirements of the PIR using the modified footprint will be addressed in the design phase, which is scheduled for 2020.

Ten Mile Creek STA

The Ten Mile Creek Water Preserve Area (WPA) Critical Restoration Project was initially proposed under the Critical Restoration Project Program, which was established by WRDA 1996. The Ten Mile Creek WPA is an off-stream water storage and treatment facility adjacent to Ten Mile Creek, a tributary to the North Fork of the St. Lucie River. The project will control the quantity and timing of stormwater flow from Ten Mile Creek and reduce TN and TP loads, total suspended solids (TSS), metals, and agrochemicals. The project location is southwest of Fort Pierce, in St. Lucie County, just south of State Road 70 and north of State Road 712 (**Figure 7**). It consists of a 526-acre aboveground reservoir and an adjacent 132-acre STA. A 380-cubic foot per second (cfs) pump station (S-382) aimed to move water from Ten Mile Creek into the reservoir. A control structure (S-383) with two auxiliary pumps (15 and 25 cfs) between the reservoir and STA is designed to provide gravity or pumped discharge into the STA, depending on reservoir stage. A final control structure (S-384) is designed to convey water by gravity from the STA into Ten Mile Creek by way of canal 96 (**Figure 8**).

Construction of the WPA was physically completed in June 2006; however, due to problems identified during the operational testing and monitoring phase, the project cannot be operated as intended, and it has been in a passive operating state since 2009. During winter 2011, the Ten Mile Creek WPA Project will begin temporary operational testing of the reservoir for data collection purposes. In order to monitor and evaluate the performance of the reservoir, the temporary operational testing will be conducted for approximately three months. Upon completion of the limited operations of the Ten Mile Creek WPA, all water will be pumped out of the reservoir and back into Ten Mile Creek. It is anticipated that the project will be returned to a passive operating state. The data collected will help assist the USCAE in identifying the future operating plan for the Ten Mile Creek WPA.

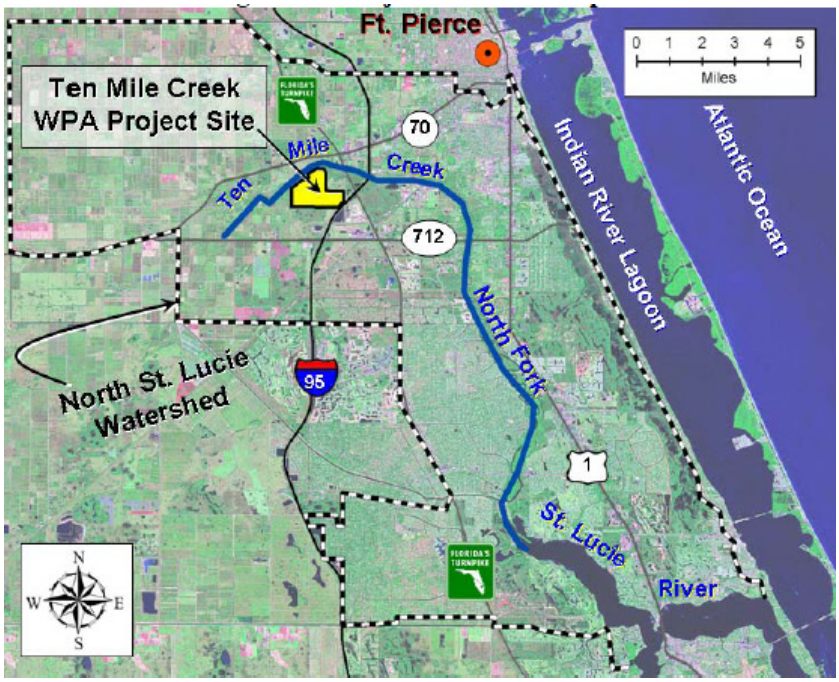


Figure 7. Location of the Ten Mile Creek Water Preserve Area (WPA) Project.

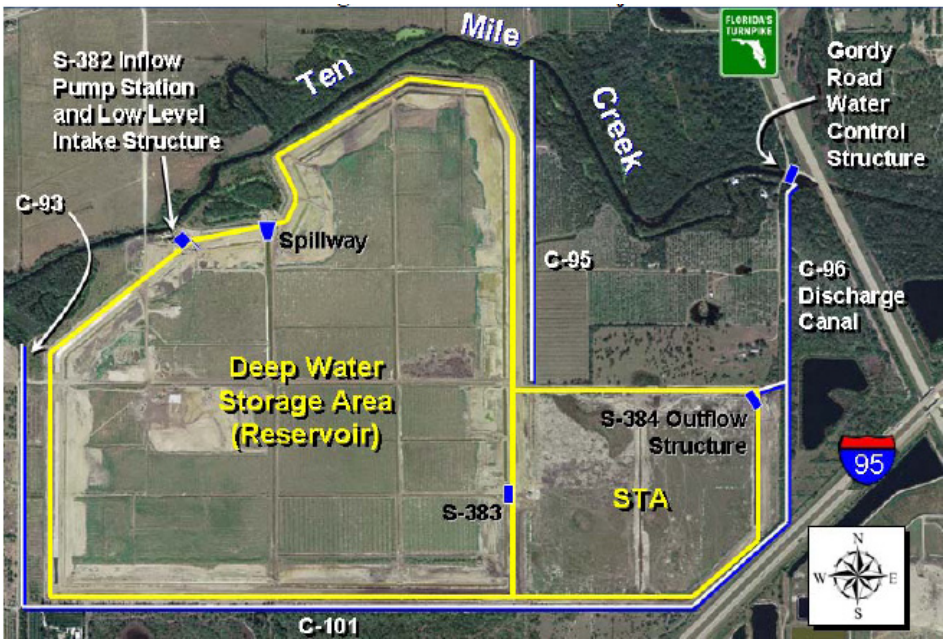


Figure 8. Ten Mile Creek WPA Project components.

Hybrid Wetland Treatment Technology

Hybrid Wetland Treatment Technology (HWTT) is a combination of wetland and chemical treatment technologies to remove phosphorus at the sub-basin and parcel scales (**Figure 9**). Chemical coagulants are added, either continuously or intermittently, to the front end of the wetland treatment system, which contain one or more deepwater zones to capture the resulting floc material. Recycling techniques are employed for additional phosphorus sorption. The HWTT system was developed to maximize nutrient removal per unit of chemical coagulant by incorporating novel design and multiple operational strategies. In addition to passive and active recycling/reuse of chemical floc, other optimization includes the sequencing and configuring of wetland unit processes to provide desirable nitrogen and phosphorus species transformations.

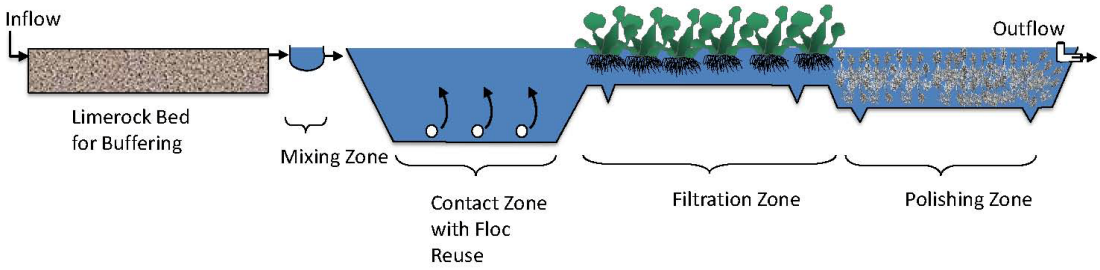


Figure 9. Hybrid Wetland Treatment Technology (HWTT) system features.

Six HWTT systems are operational in the Northern Everglades (**Figure 10**). One site, the 0.7-acre Ideal Grove system, is located in the C-24 sub-watershed. It is a continuous-flow system (subject to water flow availability) that uses water pumped from citrus grove canals. Average inflow and outflow nutrient concentrations for this continuous-flow system are listed in **Figure 11**. Continuous-flow systems show promising results. TP concentration reductions range between 92 and 94 percent for the Ideal Grove system and 87 and 95 percent for all the systems.

Figure 10. Locations of the Northern Everglades HWTT sites.

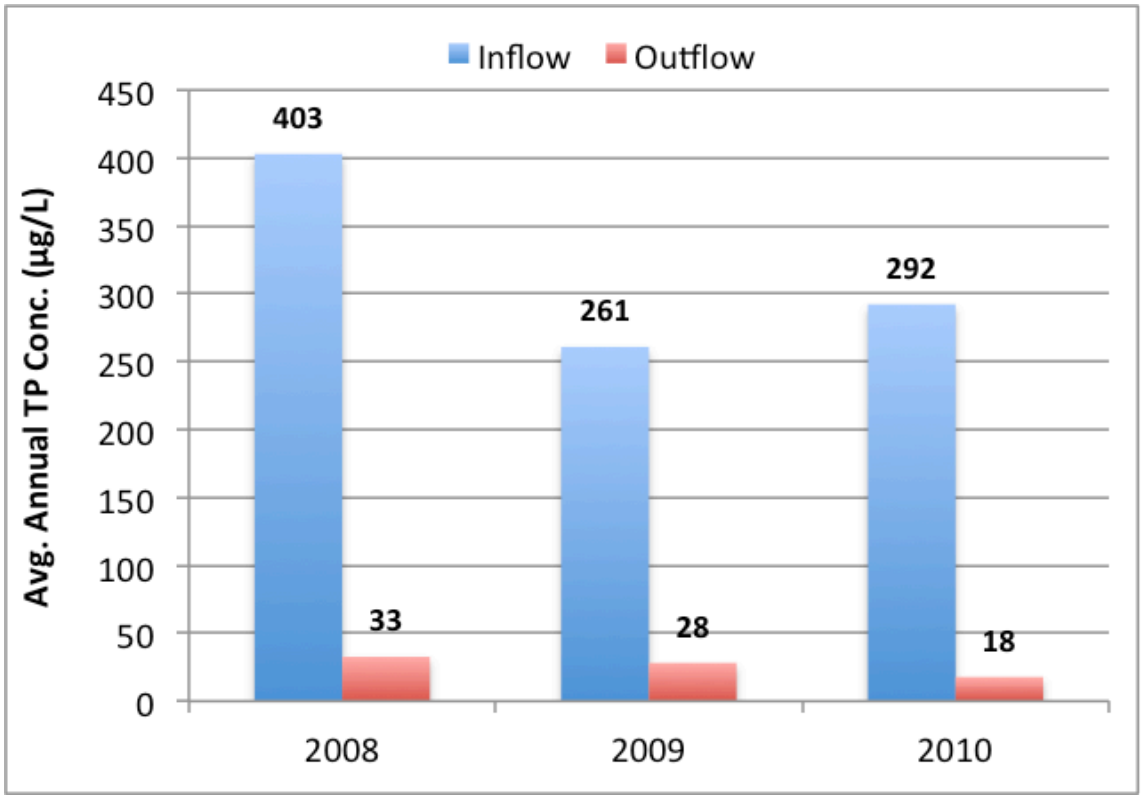


Figure 11. Comparison of inflow and outflow concentrations in micrograms per liter (µg/L) at the Ideal Grove HWTT site.

Local Water Quality Projects

Local projects (e.g., stormwater and wastewater projects) are local government initiatives that provide benefits on a local scale individually, but collectively can provide benefits on a sub-regional and regional scale. This section provides updates on local projects included in the 2009 SLRWPP (SFWMD et al., 2009) and any new local projects identified since 2008. It is anticipated that future plan updates will incorporate additional local construction projects, and their associated load reductions, that the FDEP is currently developing for the St. Lucie River Watershed BMAP.

Nonpoint source pollution results from the accumulation of contaminants from land surfaces, erosion of soils, debris, increased volumes of stormwater runoff, atmospheric deposition, suspended sediments, dissolved contaminants, and other anthropogenic sources. More recently, nonpoint sources of pollution can contribute more pollution than point sources, as more stringent regulations apply to point sources (SFWMD, 2002), highlighting the critical need for better management of nonpoint sources.

One of the main issues contributing to nutrient loading from the St. Lucie River Watershed is older developments lacking updated stormwater management systems or with failing septic tank systems. This results in runoff of untreated and un-attenuated stormwater and seepage of septage into lakes, canals, wetlands, rivers, and estuary, which disrupts natural physical, chemical, and biological processes in these systems. Local water quality projects are critical in reducing the nonpoint nutrient loading to the SLE through stormwater and wastewater retrofits.

The local water quality project updates related to the SLRWPP are discussed below. An overview of project descriptions and updates on all SLRWPP projects and programs, as well as

project description (management measure) sheets for new projects, are provided in **Attachment A**; all other project sheets are included in Appendix B of the 2009 SLRWPP (SFWMD et al., 2009).

Local Stormwater Projects

One way to help address nonpoint pollution is through implementation of local stormwater projects. For the SLRWPP, these projects include installation or upgrades of urban stormwater management systems (e.g., flow-through filtration marshes, wet detention ponds, baffle boxes, and replacement/installation of weirs and other structures) that increase retention/detention capacity, remove sediments and pollutants, and provide flood protection. The SLRWPP includes one new local stormwater project since 2009 [Eastern Watershed Improvement Project (SLE 60)].

The State of Florida, the District, and Martin County have initiated the implementation of four water quality and habitat improvement projects under a cost-share agreement as part of NEEPP. The projects funded in this partnership are the Manatee Creek Stormwater Retrofit Project (SLE 44), Old Palm City Phase III Stormwater Quality Retrofit Project (SLE 29), North River Shores Vacuum Sewer System (SLE 22), and Manatee Pocket Dredging Project (SLE 30). Two successful and recently completed local water quality projects include the Manatee Creek Stormwater Retrofit (SLE 44) and Tropical Farms/Roebuck Creek Stormwater Quality Retrofit (SLE 28).

Manatee Creek Stormwater Retrofit

Manatee Creek provides drainage for an approximately 833-acre basin located in Martin County, south of Cove Road, north of the Mariner Sands subdivision, west of Dixie Highway (County Road A1A), and extending one-half mile west of US Highway 1. Residential, commercial, and industrial development occurred within this basin before current requirements for water quality treatment were in place and discharges from the basin go directly to Manatee Pocket. Manatee Creek is listed as an Impaired Water Body on the State of Florida's 303d list.

Phase I of the Manatee Creek Stormwater Retrofit is complete and included construction of a wetland marsh that provides filtration for 107 acres of the basin. Martin County acquired the land for Phases II and III through the purchase of parcels, dedication of the decommissioned Dixie Park Wastewater Treatment Plant, and use of road right-of-way. The project is listed in the Martin County Capital Improvement Program and is funded by state NEEPP funds, *ad-valorem* taxes, State Revolving Fund loans, TMDL grants, and St. Lucie River Issues Team grants.

The project utilizes BMPs as well as constructed wetland filtration marshes to remove pollutants from basin stormwater runoff. Phases II and III provide an additional 15.3 ac-ft of water quality treatment in wet detention and marsh filtration at the decommissioned Dixie Park Wastewater Treatment Plant and at the confluence of two Manatee Creek sub-basins just prior to discharging to Manatee Pocket. The project was completed in 2011.

Tropical Farms/Roebuck Creek Stormwater Quality Retrofit

The Roebuck Creek Basin contains over 500 acres of rural residential and agricultural property and discharges into the St. Lucie River. Approximately 120 acres of the basin are single-family residential properties developed without water quality treatment. The old stormwater system was a typical ditch and drain system designed to divert water off the property expeditiously without regard for water quality. Rainfall was channeled through deep troughs and swales that conveyed the untreated water into Roebuck Creek, a tributary of the St. Lucie River. The improvements, located within the downstream reaches of the Roebuck Creek Basin, include a three-stage storm water treatment area with a pipe system that conveys the first inch of runoff to a 17 acre STA/lake system designed to remove pollutants and control discharges. More than 9,000

feet of 48-inch pipe laid throughout the 468-acre treatment area discharge water into two retention lakes. Runoff is funneled into the pipe system, slowed in stages by deepwater lakes then delivered to an 18-inch deep STA where nutrients are absorbed. Bio-filter dikes, which consist of algae-covered rip-rap rocks to take up additional nutrients, divide each lake and treatment pond. The ribbon cutting ceremony for this project occurred in May of 2011.

Other Local Stormwater Projects

In addition to the completion of the Manatee Creek Stormwater Retrofit and Tropical Farms/Roebuck Creek Stormwater Quality Retrofit, significant progress has been made with the following projects since 2008:

- White City Drainage Improvements (SLE 02) – canal D improvements are complete
- Indian River Estates (SLE 06) – alum enhancement project is complete and construction plans are complete for Phase II
- Tropical Farms/Roebuck Creek Stormwater Quality Retrofit (SLE 28) – complete
- Old Palm City Phase 3 Stormwater Quality Retrofit (SLE 29) – complete
- Stormwater Baffle Box Retrofit (SLE 31) – complete
- Danforth Creek Stormwater Quality Retrofit (SLE 32) – 11.4-acre parcel has been purchased and is currently in the design and permitting phase
- North St. Lucie River Water Control District Stormwater Retrofit (SLE 33) – four structures are complete
- Martin County Baffle Boxes (SLE 41) – eight baffle boxes have been installed
- Leilani Heights/Warner Creek Retrofit Phase 1, 2 and 3 (SLE 43) – Phase II is complete and Phase III construction has commenced
- Manatee Creek Water Quality Retrofit (SLE 44) – complete
- E-8 Canal Stormwater Retrofit (SLE 52) – Phase III complete
- Eastern Watershed Improvement Project (SLE 60, new) – one component is complete, one is under construction, and the other five components are permitted and some are out to bid

Local Wastewater Projects

Failing septic tank systems are another issue contributing to nutrient loading from the St. Lucie River Watershed. As part of the North River Shores Vacuum Sewer System (SLE 22), a local cost-share project under NEEPP, approximately 435 of the planned 750 sewer lateral connections are in place and it is anticipated that these homes will be connected by early 2012. Plans to convert the remaining 315 homes are 60% complete.

Local Restoration Projects

Local restoration projects focus on restoring or creating wildlife and aquatic habitats (e.g., muck/sediment removal, oyster habitat creation, wetland restoration, and land management, restoration and conservation) that often have ancillary water quality and storage benefits. The following local restoration projects have had significant progress since 2008:

- Creation of Suitable Oyster Substrate in the SLE at various sites identified in IRL-S PIR (Artificial Habitat Creation) (SLE 11) – 23 acres of oyster reef were created mainly in the middle and upper portion of the SLE
- Manatee Pocket Dredging Project (SLE 30) – dredging was initiated in July 2010 and is expected to be complete by the end of 2011

- Haney Creek Wetland Restoration (SLE 54) – construction is complete; purchase of additional lands for conservation and passive recreation will commence in 2012
- Halpatiokee Regional Park Aquatic Habitat Enhancement Project (SLE 63, new) – project is completed and is currently operational

DISPERSED WATER MANAGEMENT PROGRAM

The Northern Everglades watersheds are roughly seven times larger than the surface area of Lake Okeechobee. Runoff enters the lake and estuaries at rates much higher than under historical conditions, which has several undesirable results (e.g., increased nutrient loading, excess discharges of fresh water to tide). Therefore, coordinated efforts are underway to retain excess water before it enters Lake Okeechobee, the Caloosahatchee River, or the St. Lucie River. Currently, there is unprecedented unified stakeholder support to implement collaborative projects on public, private, and tribal lands, including paying landowners for the services of water retention and water quality improvement. These efforts complement water management of planned regional facilities and could be implemented more expeditiously.

DWM projects typically spread excess water across the landscape at shallow depths using relatively simple structures. Such projects optimize the use of existing facilities and require less new construction to retain cumulatively large volumes of water. The coordinating agencies are aggressively pursuing DWM implementation and expansion in the Northern Everglades by working with other agencies, non-profit organizations, Florida Native American tribes, and public and private landowners; a key example is the Northern Everglades–Payment for Environmental Services (NE-PES) solicitation discussed in this section. It is widely acknowledged that the components of the DWM Program (easements, cost-share, and payment for services) are very promising near-term options to reduce excess water and improve water quality in natural systems.

Overall, the long-term goal for the DWM Program is to provide 450,000 ac-ft of retention/storage throughout the Northern Everglades watersheds. Regional projects (e.g., reservoirs, aquifer storage and recovery projects, deep injection wells) and other state initiatives are still critical to reaching the storage goals for the region. Significant progress has been made through cooperative efforts with other agencies, local governments, and private land owners — while efforts to investigate the use of additional public lands, implement more projects on private and tribal lands, and optimize the projects currently in place continue. A total of 131,539 ac-ft of water storage has been achieved in the Northern Everglades and connected watersheds through partnerships that have provided water management alternatives since 2005[1]. Completed DWM projects in the St. Lucie River Watershed provide 7,117 ac-ft of water storage/retention, and an additional 1,079 ac-ft is expected from completion of near-term and long-term projects (**Table 5**). For some local and wetland restoration projects, where hydrology and habitat improvement is the primary goal, water quality is often a secondary benefit. Additional projects are under development as part of the DWM Program through utilizing public lands, payment for environmental services, easements, and cost-sharing in the Northern Everglades. Once a landowner has successfully participated in one type of program, there is often willingness to participate in other, longer-term programs, with the potential to retain and reduce even more nutrients and retain larger amounts of runoff.

The purpose of the following section is to provide an overview of the DWM Program, its components and the status of implementation in the overall Northern Everglades. The majority of these efforts have taken in place in the Lake Okeechobee Watershed to increase water storage,

[1] This total includes local projects within the watershed that are not listed in **Table 5**.

which ultimately provides benefits to the estuaries by reducing harmful discharges. However, there are multiple DWM projects that have recently been initiated and/or were completed in the St. Lucie River Watershed (**Table 5**). In addition, the District also initiated a water farming pilot project in the St. Lucie River Watershed that will utilize fallow/out-of-production citrus lands to store water and attenuate nutrients as described further below.

Payment for Services

NEEPP legislation encourages and supports the development of creative public-private programs (such as water retention and quality improvement on public, private, and tribal lands) to facilitate further restoration and protection of the Northern Everglades watersheds. As such, several state agencies are expanding opportunities for DWM whereby landowners manage water on parts of their property to provide water management services in either the form of water retention or nutrient (TP or TN) load reduction. These opportunities include the Florida Ranchlands Environmental Services Project (FRESP), Northern Everglades – Payment for Environmental Services (NE-PES) solicitation, water farming (assessment of utilizing fallow citrus lands), and other payment for services opportunities to store or dispose of excess surface water.

Florida Ranchlands Environmental Services Project

FRESP is a five-year pilot project to develop and field test a NE-PES program. Of the eight pilot projects, seven sites are located in the Lake Okeechobee Watershed and one site (Alderman-Deloney Ranch) is in the St. Lucie River Watershed. These pilot projects consist of working ranches retaining excess stormwater runoff or providing water quality improvement for contracted payments. The pilot projects were implemented from 2005 through 2007 and remain in operation, but are phasing into other programs. Using data collected from the pilot sites, FRESP showed that expanding the number of projects on ranchlands throughout the Northern Everglades can complement existing and planned regional water storage and treatment projects. These eight sites provided valuable information to demonstrate proof-of-concept and payment for environmental services (PES) program viability (**Table 6**).

Table 5. Dispersed water management (DWM) projects in the SLRWPP area.

Project Name	Project Area (acres)	Drainage Area (acres)	Estimated Storage (ac-ft)	Basin	Completion Date	Status
I. Operational						
Florida Ranchlands Environmental Services Project (FRESP): Alderman-Deloney Ranch Pilot Project (not a permanent project)	50	149	43 ac-ft	St. Lucie	December 2007	Operational
Wetland Reserve Program (WRP) Project – United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS): Allapattah Parcels A & B East	6,000	-	2,000	St. Lucie	-	Operational
WRP Project – USDA-NRCS: Allapattah A & B West	6,300	-	1,500	St. Lucie	-	Operational
WRP Project – USDA-NRCS: Audubon Society Loop Road WRP 66-4209-01-700	60	139	24	St. Lucie	December 2005	Operational
Indiantown Citrus Growers Association Water Storage Project, Phases 1, 2 & 3 (SLE-LO 12f)	492	1,680	3,550	St. Lucie	December 2007	Operational
Subtotal			**7,117**			
II. Funded Through Construction						
WRP: Goldstein Ranch	40	40	15	St. Lucie	Not Applicable (N/A)	Designed or Permitted
Northern Everglades – Payment for Environmental Services (NE-PES)		To Be Determined			N/A	Preliminary Design
Allapattah Flats (Interim Lands)	240	6,500	350	St. Lucie	N/A	Preliminary Design
C-23/C-24 Complex – Option 2 (Interim Lands)	TBD	734	58	St. Lucie	N/A	Preliminary Design
Subtotal			**423**			
III. Potential Projects, Construction Unfunded						
Cypress Creek Trail Ridge Natural Area (C-23) [Indian River Lagoon – South (IRL-S) project]	1,273	-	656	St. Lucie	N/A	Feasibility Study in Progress
Subtotal			**656**			
TOTAL		**9,093**	**8,196**			

Table 6. Annual average estimate of Florida Ranchlands Environmental Services Project water management alternative (WMA) acres, water retention, and total phosphorus (TP) retention.

Pilot Project	WMA Inundated Area (acres)	WMA Service Area (including inundated influenced acres) (acres)	PWRM Estimate of Incremental Retention Post WMA (ac-ft)	Annual Estimated TP Reductions Post WMA (lbs)	Annual Estimated TP Reductions Post WMA (mt)
Rafter T Ranch	942	1624	850	795	0.36
Lightsey XL Ranch	364	364	227	295	0.13
Payne & Sons Ranch	367	367	164	295	0.13
Syfrett Ranch	521	2197	939	878	0.40
Williamson Ranch	241	659	303	139	0.06
Alderman – Deloney Ranch	49	322	138	40	0.02
Buck Island Ranch	3,748	3,748	2,411	3,434	1.56
Total Across Water Retention WMAs	**6,232**	**9,281**	**5,032**	**5,876**	**2.7**
Lykes West Waterhole Pasture	2,500	2,500	NA	7,220 (2008) 18,520 (2010)	3.3 8.4
Total Across Phosphorus Reduction WMA	**2,500**	**2,500**	**5,600**	**7,220 (2008) 18,520 (2010)**	**3.3 (2008) 8.4 (2010)**
Total All WMAs	**8,732**	**11,781**	**10,632**	**13,096 (2008) 24,396 (2010)**	**6 (2008) 11 (2010)**

Source: World Wildlife Fund

Notes: PWRM = Potential Water Retention Model

Service estimation tools and streamlined regulatory processes were identified through the implementation of FRESP as critical to the next step of transitioning from the pilot project to a DWM PES program. These processes include (1) defining the service payment approach (implementing a market-driven competitive solicitation); (2) quantifying the "above and beyond" baseline required water management (estimation of amount of retention provided from Northern Everglades BMP implementation – a service payment is above this amount); (3) obtaining program federal authorization regarding expansion of wetlands and post-contract hydrologic reversion to a baseline (the USACE developed a Regional General Permit), and (4) developing a United States Fish and Wildlife Service and United States Department of Agriculture Natural Resource Conservation Service (USDA-NRCS) consultation key for threatened and endangered species to aid in returning to baseline hydrologic conditions. FRESP partners include eight local ranchers, the World Wildlife Fund, the Florida Cattlemen's Association, the FDACS, the FDEP, the UF/IFAS, the USDA-NRCS, the MacArthur Agro-ecology Research Center, and the District. Using market-based concepts, FRESP has demonstrated the potential of DWM on ranchlands to contribute to the delivery of essential environmental services while encouraging ranchers to maintain cattle production.

The pilot projects have been phasing into other programs: two FRESP pilot participants (C.M. Payne and Williamson Ranch) have converted to permanent Wetland Reserve Program (WRP) easements. The WRP design will utilize many of the facilities constructed under FRESP, and it is anticipated that a greater quantity of water management and treatment will be provided. One of the FRESP projects located in the St. Lucie River Watershed, the Alderman-Deloney Ranch Pilot Project, was submitted for consideration to the NE-PES.

Northern Everglades – Payment for Environmental Services

Northern Everglades ranchers are participating in a new payment for environmental service program with the District to increase water retention or improve water quality on their lands. The District administers the program in collaboration with the FDACS, FDEP, and USDA-NRCS. The NE-PES solicitation establishes relationships via contracts with private landowners to retain water to reduce flows and nutrient loads to the Lake Okeechobee, St. Lucie River, and Caloosahatchee River watersheds. Benefits of the program include the following:

- **Cost-effectiveness for the public.** Encourages innovation in providing needed ecosystem services from working cattle ranches as a complement to the construction of public works projects.
- **Economic sustainability for ranchers.** Creates a new commodity that ranchers can produce along with cattle and other activities that helps strengthen the ranchers' overall economic stability by retaining private land ownership.
- **Environmental benefits.** Aids in meeting Northern Everglades water retention and nutrient reduction goals and providing enhanced habitat for multiple species at a watershed scale. Also, enhanced profitability reduces the pressure to convert ranchlands to development or other agricultural uses that could exacerbate water problems and habitat loss. On-ranch implementation also provides for earlier environmental results ahead of public works construction schedules.
- **Practical to implement and administer.** Offers an open and competitive process, fixed-term contracts, and clear documentation procedures to ensure that participating ranchers, if selected, have the opportunity to demonstrate positive environmental stewardship while receiving payment for such valued services.

Fourteen proposals were submitted in response to the NE-PES solicitation released in January 2011. The District and FDEP evaluated and ranked the proposals. In July 2011, the District's Governing Board approved entering into negotiations with the respondents. Eight NE-PES contracts were approved by the Governing Board in October 2011. These contracts contain provisions for data collection and monitoring to document the services to be provided. The majority of the landowners participating in this program are located in the Lake Okeechobee Watershed and one site is located in the St. Lucie River Watershed. A future solicitation for additional projects in the Northern Everglades including the St. Lucie River and Caloosahatchee River watersheds is anticipated.

Water Farming Pilot Project

Another PES approach has been coined "water farming." This approach will utilize fallow/out-of-production citrus lands to store water and attenuate nutrients so storm water can be used as an alternative water supply. The result of water farming will be reduced releases and improved water quality to the St. Lucie and Caloosahatchee estuaries. To determine the overall feasibility of the water farming concept, information with respect to environmental benefits gained compared to the cost estimates associated with on-site construction, infrastructure improvements, environmental assessments, and facility maintenance needs to be evaluated. As a result, the District has entered into a cooperative agreement with the Indian River Citrus League

and is discussing an agreement with Gulf Citrus Growers Association to assess the feasibility of water farming. Under the cooperative agreement and utilizing guidelines developed jointly among the District and these entities, a "typical" citrus grove will be selected to gather pertinent scientific and engineering data and other information to determine the costs and benefits associated with the water farming concept. If successful, water farming will continue to Phase II – Project Implementation.

Easements

Wetland Reserve Program

The USDA-NRCS WRP offers technical and financial support to landowners who voluntarily agree to protect, restore, and enhance wetlands on their property by placing them in a long-term or permanent conservation easement. Restoration objectives are to maximize habitat for wetland-dependant wildlife and reestablish the original vegetated community and hydrology to the extent practical. As an ancillary result of the program, the amount of surface water leaving the participating lands will be reduced due to infiltration and evapotranspiration and the timing of the discharge will more closely match historical patterns. As such, nutrient concentrations entering the public water management system and ultimately the Northern Everglades will be reduced.

Since 1997, $471 million has been allocated for standard WRP projects in Florida. Of the 80 standard easements covering 199,905 acres, approximately 24 easements are in the restoration phase. An additional $89 million was spent on the Fisheating Creek Special WRP project, located in the Lake Okeechobee Watershed, to restore 26,000 acres of habitat. The District executed a Memorandum of Understanding in October 2010 to provide technical assistance to the USDA-NRCS in implementing their WRP projects. The District is currently assisting with developing the restoration plan for the Fisheating Creek Special WRP. Additionally, in August 2011, the USDA-NRCS announced additional resources ($100 million) for the WRP in the Northern Everglades. Additional lands will be acquired with permanent conservation easements and hydrology restored to altered wetlands.

Other Programs

The District continues to identify other opportunities to store or dispose of excess surface water until the planned regional facilities become operational. For example, the District has acquired easements from landowners for restoration projects, such as the Lake Okeechobee Isolated Wetland Program.

Cost Share

Historically, most cooperative landowner efforts have fallen under the cost-share agreement approach. With this approach, a portion of the project is funded by the landowner and the other portion by another entity. Typically, the landowner assumes responsibility for the long-term operation and maintenance of the cost-shared water management facilities. Cost-share partners typically have included landowners, the FDACS, the USDA-NRCS, local governments, and the District.

Environmental Quality Incentive Program

Implementation of certain FDACS BMPs has resulted in an increase in water retention within the watershed. The USDA-NRCS' Environmental Quality Incentive Program promotes environmental quality and agricultural production as compatible goals. In the Lake Okeechobee Watershed, the FDACS and USDA-NRCS work closely together and improvements are often jointly funded. Since October 2005, an estimated 2,160 ac-ft of retention has been created over 105,348 acres (as of July 1) on projects participating with the FDACS.

Interim Lands (District and State Owned Lands)

The District also continues to evaluate the use of publicly owned lands for water management projects. Parcels scheduled to become regional restoration projects present an opportunity to provide water retention through interim, low-cost alterations to the existing surface water management systems. These parcels would then play an interim role of contributing to the watershed restoration effort while the final designs are completed and approved. If the public lands are being leased, then water management strategies will be jointly developed with the lessees to reduce discharges while not adversely affecting flood protection (including adjacent properties) and water quality. New language to retain more storm water on District lands has been developed for incorporation into all new and renewed leases.

Allapattah Flats and the C-23/C-24 Complex are two interim land sites in the St. Lucie River Watershed that are planned for DWM projects in Fiscal Year 2012 (October 1, 2011–September 30, 2012) (FY2012). The interim project for Allapattah Flats will involve capturing and retaining stormwater runoff on the lower portions of the site through the installation of control structures. Similarly, the interim project for the C-23/C-24 Complex will include retaining stormwater runoff in the existing furrows and ditches upstream of control structures.

Related State and Federal Restoration Efforts

Lake Okeechobee Protection Plan Update

The Lake Okeechobee Protection Plan (LOPP) is a companion NEEPP document to the River Watershed Protection Plans (RWPPs), which are available online at www.sfwmd.gov/northerneverglades. It was originally developed under the Lake Okeechobee Protection Act (now NEEPP), and was updated in 2004, 2007, and 2011. The most recent update was submitted to the Florida legislature on March 1, 2011 (SFWMD et al., 2011). It provides the most recent information available on the coordinating agencies' efforts to meet phosphorus reduction and storage goals in the Lake Okeechobee Watershed and defines current and future proposed phosphorus reduction and storage projects. It includes updates to the Lake Okeechobee Watershed Construction Project Phase II Technical Plan elements and additional NEEPP components designed to benefit the lake ecosystem. The lake can contribute significant freshwater flows and nutrient loads to the estuary and LOPP aims to minimize these impacts through nutrient reduction strategies and storage north of the lake. The primary LOPP goals are to provide storage north of Lake Okeechobee and to meet the Lake Okeechobee TP TMDL [105 metric tons (mt) of TP to the lake from the watershed]. Key highlights of the 2011 LOPP Update are as follows:

- Enrolled approximately 1.3 million acres (77 percent) of agricultural lands in the FDACS-adopted BMP program on which landowners are applying owner-implemented BMPs focused on reducing TP loads to Lake Okeechobee. Almost two-thirds of the agricultural acreage with owner-implemented BMPs (838,780 acres) has also administered cost-share BMPs.
- Constructed more than 30 TP reduction projects including isolated wetland restoration projects, Dairy Best Available Technology projects, former dairy remediation projects, and public-private partnership projects.
- Implemented seven HWTT projects, including the Grassy Island site, which was brought online in 2011. Six of the seven sites are currently operational.
- Completed construction of two regional STAs (Taylor Creek and Nubbin Slough) and began construction of another STA (Lakeside Ranch, Phase I).

- Removed approximately 1.9 million cubic yards of muck from Lake Okeechobee, exposing thousands of acres of natural lake bottom sand and promoting the return of native plant species. In addition, the project removed an estimated 142 mt of TP from the lake.
- As of March 2011, achieved a total of 129,143 ac-ft of water storage in the Northern Everglades and connected watersheds through partnerships that have provided water management alternatives since 2005. A total of 89,664 ac-ft is within the Lake Okeechobee Watershed. Additional water storage sites are being developed as part of the DWM Program.
- Adopted revisions to Chapter 62-640, F.A.C., effective on August 29, 2010. These revisions are designed to improve application and management of Class B biosolids and improve the distribution and marketing of Class AA biosolids. By 2013, no Class B biosolids application will be permitted in the Lake Okeechobee Watershed unless a nutrient balance demonstration is completed by the applicant and approved by the FDEP.

Herbert Hoover Dike Restoration

Water management decisions regarding Lake Okeechobee are highly dependent upon the Herbert Hoover Dike (HHD), an approximately 70-year-old earthen levee that was constructed around a major portion of Lake Okeechobee for flood control purposes. For decades, it has served this purpose; however, it is in need of rehabilitation and was classified by the USACE as one of the nation's dams in most need of repair. Until the rehabilitation is complete, the USACE's goal is to manage Lake Okeechobee water levels between 12.5 and 15.5 ft throughout the year, which is considered a safe range for the dike (USACE, 2008).

Since 2007, the USACE has substantially funded the HHD Restoration Project each fiscal year: $56 million in 2008, $80 million in 2009, $124 million in 2010, and $107 million in 2011. The federal FY2012 budget for HHD is $85 million. The 2000 HHD Major Rehabilitation Report divided the 143-mile dike into eight reaches with the initial focus on Reach 1 (Port Mayaca to Belle Glade). The USACE is replacing this reach-by-reach approach with a system-wide risk-reduction approach as required for safety modifications to dams. A Dam Safety Modification Report will detail and prioritize features to be implemented.

The USACE's initial rehabilitation effort is the construction of a cut-off wall in Reach 1, which is intended to block existing piping (internal erosion) pathways and prevent additional erosion through the dike. Of the 21.4 miles of cut-off wall planned for Reach 1, all are under contract and 15.6 miles are complete. The USACE is implementing a plan to replace or remove the 32 federally owned culverts on the HHD. Contracts to execute this work are anticipated within five years, if funds are available. Two culvert replacement contracts were awarded in FY2011. Coordination with the SFWMD and permitted users has been ongoing to ensure maintenance of drainage and water supply capabilities.

Adaptive Protocols for Lake Okeechobee Operations

The Adaptive Protocols for Lake Okeechobee Operations are intended to provide operational guidance to the District. As local sponsor for the Central and Southern Florida (C&SF) Project, the District interacts with the USACE on Lake Okeechobee operations within the confines of the federally adopted lake regulation schedule. Operation of the lake affects a wide range of environmental and economic issues so water managers must carefully consider the sometimes conflicting needs of the C&SF Project. A key goal of implementing the adaptive protocols is to improve water supply, flood protection, and ecosystem benefits within the constraints of the approved lake regulation schedule and water control plan.

The Final Adaptive Protocols for Lake Okeechobee Operations document (SFWMD, 2010a) describe how the District makes recommendations to the USACE concerning the 2008 Lake Okeechobee Regulation Schedule and the C&SF Project Water Control Plan for Lake Okeechobee and Everglades Agricultural Area (USACE, 2008) provisions while considering the District's multiple statutory objectives and responsibilities outlined in Chapter 373, F.S. The adaptive protocols are intended to be used when the lake stage is in the Low, Baseflow, and Beneficial Use sub-bands to provide guidance to water managers for discretionary releases for ecosystem benefits or to improve conditions related to the C&SF Project purposes. The document provides operational guidance in support of District recommendations but is not intended to establish, dictate, or regulate water levels or operations. Full discretion of the USACE to operate the C&SF Project is retained, as provided in the Water Control Plan (USACE, 2008).

The analyses conducted for the final version of the adaptive protocols were based on assumptions regarding how water would be released by the USACE in the Low, Baseflow and Beneficial Use sub-bands. The performance gains demonstrated by the analyses are a result of both components of the release guidance: (1) releases in the Baseflow and Beneficial Use sub-bands; and (2) the strategy to request the USACE limit the Low sub-band maximum release rates during the early part of the dry season. This second component helps conserve early dry season water to increase its potential availability for later in the dry season when the demand is largest. The USACE is not mandated to follow this second component per the Final Supplemental Environmental Impact Statement for the Lake Okeechobee Regulation Schedule (USACE, 2007).

The adaptive protocols will be periodically assessed and adjusted, as necessary, to deal with potential issues not accounted for in the current document and to reflect new knowledge gained as the protocols are implemented. Also, there are inherent uncertainties in how the system will be operated that may require adjustments to the application of the established guidance.

ST. LUCIE RIVER WATERSHED RESEARCH AND WATER QUALITY MONITORING PROGRAM

Chris Buzzelli, Zhiqiang Chen, Teresa Coley, Peter Doering, Marion Hedgepeth, Chenxia Qiu[2], Rebecca Robbins, Detong Sun, Yongshan Wan, and Fawen Zheng

The St. Lucie RWQMP builds upon the District's existing research program and is intended to carry out, comply with, or assess the plans, programs, and other responsibilities created by the SLRWPP. The program includes an assessment of the water volumes and timing from the Lake Okeechobee and St. Lucie River watersheds and their relative freshwater and nutrient contributions to the estuary. One of the objectives of this component is to track progress towards achieving the SLRWPP's water quality and storage targets. In addition, the RWQMP adopts a resource-based management strategy which evaluates the health of several key resources, known as valued ecosystem components (VECs) including (1) oyster populations; and (2) freshwater, brackish, and marine submerged aquatic vegetation (SAV). Multiple research and modeling efforts to increase our understanding of the ecosystem and reduce the uncertainties are also undertaken as part of this component.

To assess the SLE's health and evaluate management and restoration efforts, the District has maintained a monitoring program since the early 1990s. Several physical and chemical parameters, such as freshwater inflows, salinity, nutrients, chlorophyll *a* (Chl*a*) and dissolved oxygen (DO) have been monitored on a monthly or bimonthly basis at designated locations (**Figure 12**). Additional monitoring programs have been developed to assess changes in abundance and distribution of VECs. The current status of the estuary and the long-term trends in these parameters and VECs are evaluated, in addition to updates on the District's estuary research and modeling efforts.

The RWQMP is divided into several parts as follows:

- **Ecosystem Status.** Summarizes overall status of the ecosystem between Water Years 1995 (WY1995) (May 1, 1994–April 30, 1995) through WY2008, and from WY2009 through WY2011, including hydrology, water quality, and VECs.
- **Long-Term Trends.** Evaluates for long-term trends in flows, water quality, and SAV on a calendar year basis from 1995 through 2010.
- **Research Project Updates.** Provides status updates on nutrient budget, DO dynamics, and low salinity zone research projects.
- **Modeling Plan Status.** Provides status updates on watershed and estuary hydrology, hydrodynamic, and water quality modeling tools used to predict and evaluate progress toward plan objectives.
- **Monitoring Update:** Provides updates on water quality and VEC monitoring efforts.

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

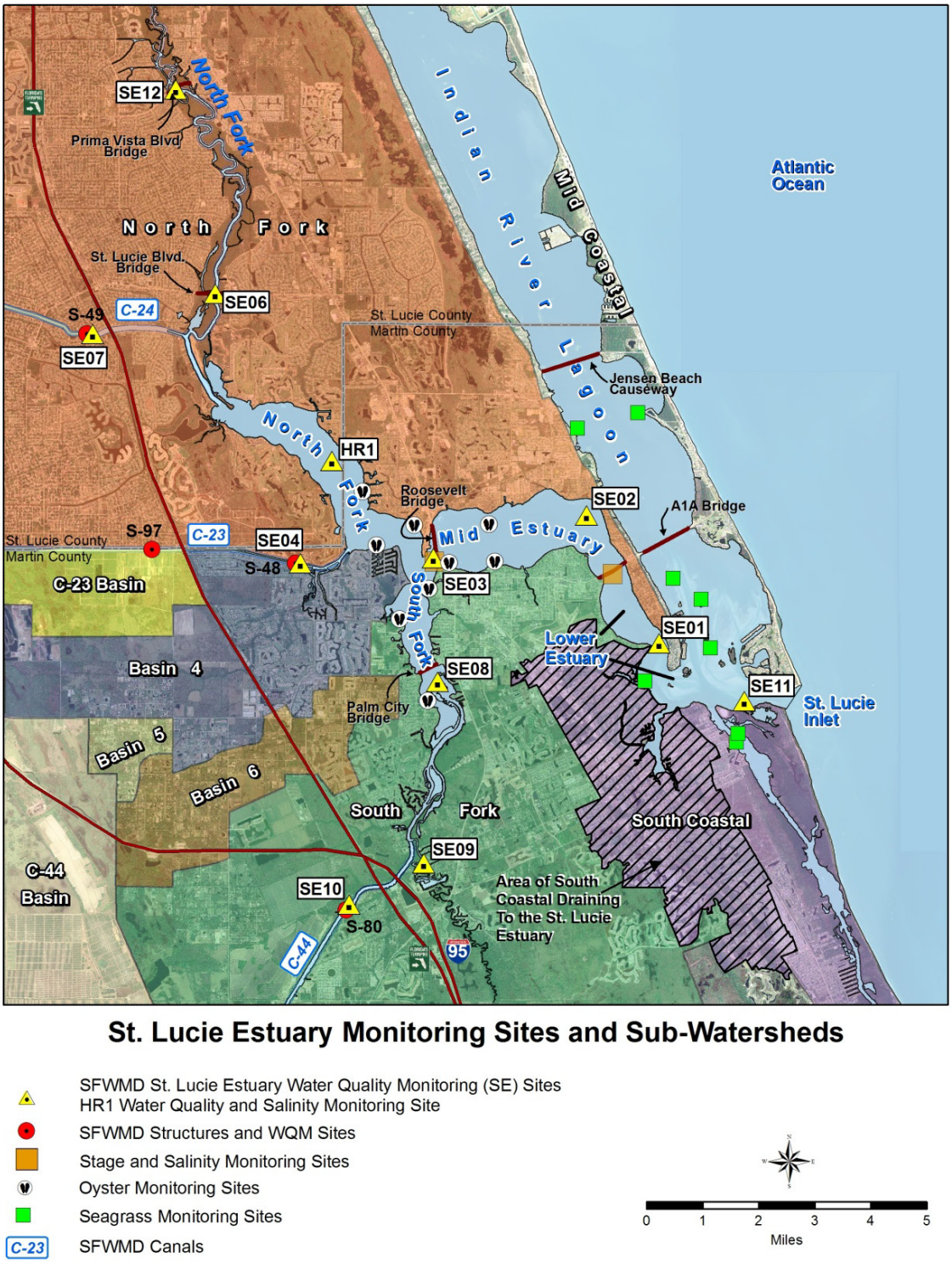


Figure 12. Surface water quality monitoring stations, inflow structures, and long-term salinity and temperature monitoring stations in the SLE and its watershed. [Note : SFWMD = South Florida Water Management District; WQM = water quality monitoring.]

ECOSYSTEM STATUS

This section provides the flows and loads from the St. Lucie Watershed and Lake Okeechobee to the SLE over the long-term period (WY1995–WY2008) as well as for the past three water years (WY2009–WY2011) and provides a snapshot of the health of the estuary over these time periods. It begins with discussions of freshwater inflows and nutrient contributions to the SLE which are directly correlated to water quality in the estuary. The water quality data within the estuary is then presented followed by the status of VECs, which are greatly affected by water quality.

Freshwater Inflows

Freshwater flows to the estuary from the St. Lucie River Watershed are measured for the C-44/S-153, C-23, and C-24 sub-watersheds at District control structures and provide adequate monitoring for calculating flow and nutrient load discharges representing the vast majority of outflows from these sub-watershed areas. The remaining sub-watersheds (North Fork, Basin 4-5-6, South Fork, and South Coastal) are characterized by numerous tributary discharges to the estuary but monitoring data are limited. Therefore, total sub-watershed flows and loads have not been measured for these areas.

Total annual freshwater inflows to the SLE over the last three water years ranged from approximately 313,000 to 419,000 ac-ft, with the minimum flow occurring in WY2011. As shown in **Table 7**, these inflows were lower than the long-term average, particularly in WY2011 due to extreme drought conditions. Other key points regarding freshwater inflows are as follows:

- Flows from the watershed to the SLE exceeded those from Lake Okeechobee for the long term average and in 2009 and 2010.
- In WY2011, the lake contributed 71 percent of the total flows to the SLE. This was a result of very low flows from the watershed during the extreme drought conditions in WY2011.
- WY2010 was marked by high dry season flows due to El Niño. In contrast, during WY2009 almost all flow occurred in the wet season, which was dominated by Tropical Storm Fay (**Figure 13**).

Preferred monthly average inflows to the SLE are between 350 and 2,000 cfs, based on relationships between inflows and estuarine salinity. These flows are expected to maintain salinity in the range of 8–25 practical salinity units (psu) at the Roosevelt Bridge. **Figure 13** provides the flows for WY2009–WY2011. Total flows generally remained below the upper target of 2,000 cfs, with the primary exception following Tropical Storm Fay when discharges exceeded 10,000 cfs for a short period. The low flow target of 350 cfs was not met for several months during the dry seasons, particularly during the drought of WY2011 when flows were low nearly all year.

Table 7. Annual measured freshwater flows and estimated TP and total nitrogen (TN) loads from the S-80 structure to the St. Lucie Estuary (SLE) during Water Years 1995–2011 (WY1995–WY2011).

Water Year	Total Freshwater Flow to SLE (ac-ft)	Total Freshwater from Lake Okeechobee to SLE* (ac-ft)	TP (mt)	TP from Lake Okeechobee to SLE* (mt)	TN (mt)	TN from Lake Okeechobee to SLE[1] (mt)
Average WY1995–WY2008	816,000	347,000	269	74	1,720	762
WY2009	419,000	102,000	234	24	923	232
WY2010	402,000	44,000	142	8	761	80
WY2011	313,000	222,000	68	40	510	357

[1]Freshwater inflows and nutrient loads from Lake Okeechobee to the SLE were estimated by comparing flow and load data at S-308 and S-80 to exclude flows and loads from the lake releases diverted to agriculture.

Nutrient Loads

During WY2009–WY2011, TP loads to the SLE through structures S-80, S-49, and S-48 ranged from 68 to 234 mt and TN loads from 510 to 923 mt, respectively (**Table 7**). Overall, there was a direct relationship between nutrient loads and flow from both the watershed and Lake Okeechobee. As shown in **Table 7**, total loads of both TN and TP were lower during the last three water years relative to the long-term averages, especially during the WY2011 drought and highest relative (percent) contribution of loads from Lake Okeechobee to the estuary occurred in WY2011. It should also be noted that on average, during WY1995–WY2008, WY2009, and WY2011, the contribution of the St. Lucie River Watershed to the total estuarine TP load is disproportionately higher than its contribution to total freshwater inflow. For example, on average (WY1995–WY2008) while only 57 percent of flows to the estuary were from the watershed, these flows contributed 72 percent of the TP loading to the estuary.

Estuarine Salinity and Water Quality

One of the main watershed influences affecting SLE's ecological health are undesirable low salinity conditions, a consequence of freshwater discharges from the watershed and Lake Okeechobee (SFWMD et al., 2009). SLE salinity shows temporal variation and, as with many estuaries, salinity is inversely related to freshwater inflows (**Figure 13**). **Table 8** shows the number of days per year when salinity either fell below or exceeded the salinity envelope (8–25 psu) established at the Roosevelt Bridge. Typically in the SLE, salinity falls below 8 psu more often than salinity exceeds 25 psu, as evident in the long-term averages; however this was not as prevalent during WY2009–WY2011 (**Table 8**) due to drought and El Nino conditions (**Figure 13**). As a result of lower overall flows, all three water years had more days that exceeded the upper limit of the envelope (25 psu) than the long-term average, and in WY2011, days above 25 psu exceeded days below 8 psu. As such, VECs in the estuary were subjected to higher salinity stresses more often in WY2009–WY2011 than the long-term average (WY1999–WY2008).

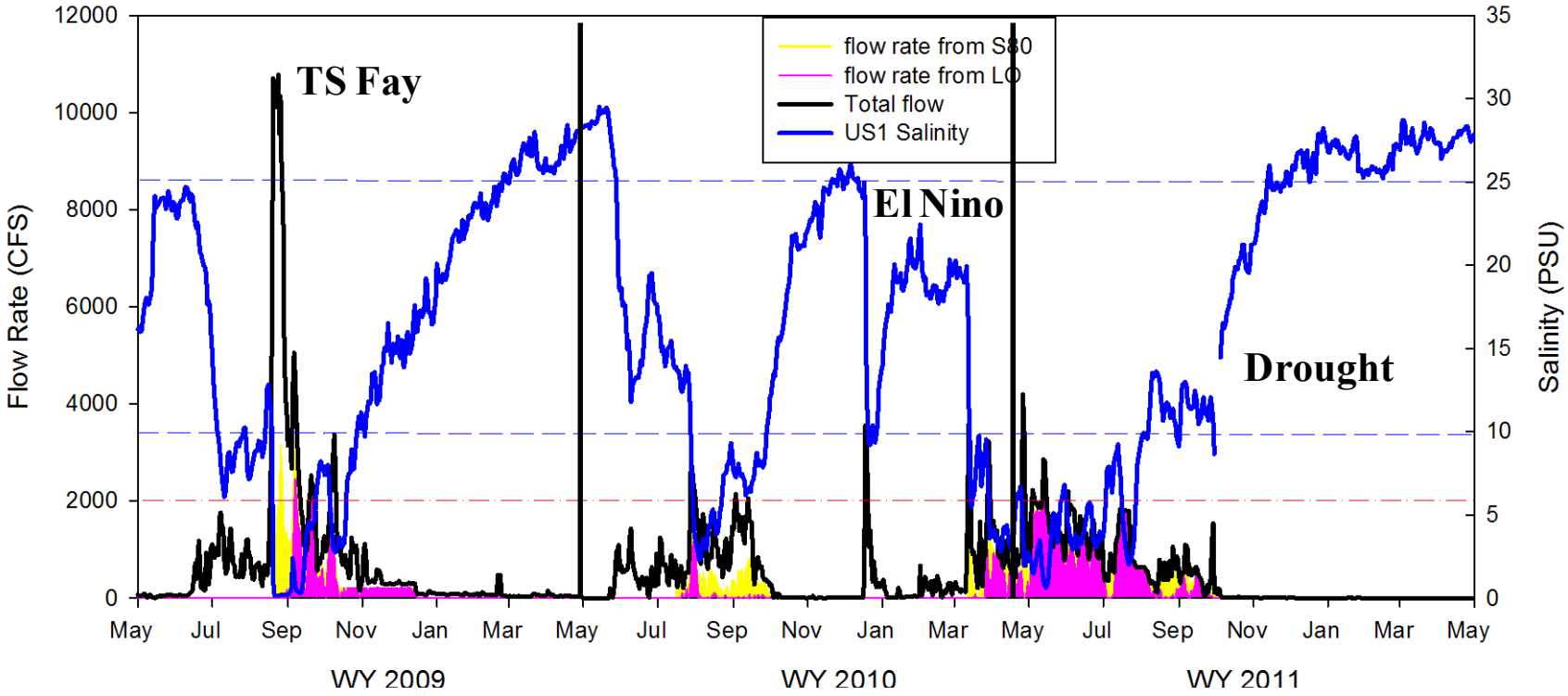


Figure 13. Daily flows [in cubic feet per second (cfs)] from to the SLE and surface salinity [in practical salinity units (psu) at a depth of approximately 1.0 meter) at the US1 station (blue line) in Water Years 2009–2011 (WY2009–WY2011). The two dashed blue lines represent the salinity envelope [8–25 psu] for the US1 station and the red dash and dot line shows the target flow rate of 2,000 cfs. The differences between Lake Okeechobee (pink) and S-80 (yellow) flows represent flows from the C-44 Sub-watershed. [Note: In the legend, Lake Okeechobee is abbreviated to LO.]

Table 8. Days outside the proposed salinity envelope at the US1 station [less than 8 practical salinity units (psu) or greater than 25 psu] in WY2009–WY2011 compared to the average for WY1999–WY2008, when data were available.

Water Years	Days <8 psu	Days >25 psu
WY1999-WY2008	103	24
WY 2009	75	64
WY 2010	89	46
WY 2011	84	155

Note: The derived days may underestimate actual times of exceedances due to missing data in salinity monitoring data but should give rough estimates

Water quality in the SLE shows high spatial and temporal variation (SFWMD et al., 2009). The balance of several water quality parameters [TP, TN, dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), Chl*a*, and bottom DO] can be altered from excess nutrient and freshwater inputs. An imbalance in these parameters can lead to eutrophication (excess nutrients), algal blooms, low DO, and fish kills, which are further described in the 2009 SLRWPP (SFWMD et. al. 2009). The SLE water quality stations are located in the Lower Estuary (SE11 and SE01), Middle Estuary (SE02 and SE03), North Fork (SE04, HR1, SE06, SE07 and SE12), and South Fork (SE08, SE09 and SE10) (**Figure 12**). One site in each of the four segments was chosen, based on their location relative to the segments (e.g., HR1 is located the middle of the North Fork) and salinity gradients from the inlet to the Upper Estuary, to illustrate representative water quality conditions in WY2009–WY2011 and during WY1995–WY2008.

Descriptive statistics were performed on data at the four representative stations and summarized below; however, the key finding is that annual mean concentrations of TN and TP exceeded the TMDL target concentrations (TN = 0.72 mg/L, TP = 0.081 mg/L) both during WY2009–WY2011 and WY1999–WY2008 (**Table 9** and **Figure 14**) in all segments but the Lower Estuary.

- Mean nutrient concentrations are directly related to freshwater inputs. During WY2009–WY2011, nutrient concentrations were lower than the long-term average (**Table 9** and **Figure 14, left and middle columns**) consistent with reductions in freshwater inflows.
- The majority of dissolved nitrogen in the SLE is organic (**Table 9**).
- Chl*a* is an indicator of eutrophication. Annual average Chl*a* exceeded the 11.0 microgram per liter (µg/L) concentration for impaired water bodies for three years in the South and North Forks, and one year in the Middle Estuary (**Table 9**).
- DO concentrations increased in the North Fork, Middle Estuary, and Lower Estuary in WY2009–WY2011 relative to long-term averages (**Table 9**).

Table 9. Statistical summary of selected water quality parameters [in milligrams per liter (mg/L) or micrograms per liter (µg/L)] for WY2009–WY2011 and WY1995–WY2008 in the South Fork (SE09), North Fork (HR1), Middle Estuary (SE03), and Lower Estuary (SE11).

Statistics	Total Nitrogen (mg/L)				Dissolved Inorganic Nitrogen (mg/L)				Total Phosphorus (mg/L)			
	WY1995-WY2008	WY2009	WY2010	WY2011	WY1995-WY2008	WY2009	WY2010	WY2011	WY1995-WY2008	WY2009	WY2010	WY2011
South Fork												
mean	1.22	1.05	1.07	1.03	0.22	0.14	0.18	0.132	0.193	0.154	0.184	0.143
median	1.13	1.03	1.06	1.00	0.17	0.17	0.18	0.16	0.173	0.152	0.202	0.145
25th percentile	0.91	0.86	0.87	0.86	0.06	0.04	0.08	0.064	0.144	0.118	0.160	0.129
75th percentile	1.35	1.30	1.27	1.28	0.30	0.24	0.30	0.206	0.209	0.206	0.216	0.153
North Fork												
mean	1.02	0.90	0.98	0.73	0.12	0.08	0.12	0.041	0.225	0.183	0.225	0.134
median	0.95	0.71	0.91	0.90	0.06	0.02	0.12	0.027	0.191	0.159	0.213	0.125
25th percentile	0.74	0.55	0.65	0.54	0.02	0.01	0.01	0.016	0.143	0.132	0.149	0.105
75th percentile	1.25	1.06	1.32	0.93	0.22	0.14	0.23	0.064	0.270	0.242	0.284	0.182
Middle Estuary												
mean	1.04	0.79	0.98	0.75	0.18	0.09	0.13	0.107	0.199	0.157	0.186	0.124
median	0.99	0.67	0.98	0.78	0.13	0.05	0.12	0.106	0.162	0.129	0.175	0.118
25th percentile	0.74	0.59	0.57	0.51	0.05	0.02	0.03	0.062	0.127	0.112	0.134	0.105
75th percentile	1.32	1.05	1.32	1.02	0.29	0.15	0.23	0.144	0.236	0.217	0.270	0.154
Lower Estuary												
mean	0.67	0.35	0.18	0.31	0.10	0.06	0.01	0.022	0.078	0.049	0.027	0.036
median	0.64	0.16	0.14	0.23	0.05	0.01	0.01	0.009	0.048	0.019	0.017	0.027
25th percentile	0.36	0.13	0.12	0.15	0.02	0.01	0.01	0.005	0.034	0.010	0.015	0.013
75th percentile	0.92	0.49	0.19	0.56	0.13	0.06	0.02	0.027	0.091	0.076	0.040	0.050

Table 9. Continued.

Statistics	Orthophosphate (mg/L)				Chlorophyll *a* (µg/L)				Bottom Dissolved Oxygen (mg/L)			
	WY1995-WY2008	WY2009	WY2010	WY2011	WY1995-WY2008	WY2009	WY2010	WY2011	WY1995-WY2008	WY2009	WY2010	WY2011
South Fork												
mean	0.114	0.082	0.129	0.089	12.13	12.83	12.17	11.00	5.78	5.57	4.77	4.99
median	0.099	0.073	0.130	0.085	9.00	12.00	6.00	12.00	6.10	5.52	4.87	5.21
25th percentile	0.070	0.067	0.116	0.080	4.10	9.00	4.00	7.00	4.51	4.66	4.39	3.65
75th percentile	0.143	0.109	0.159	0.116	17.00	20.00	19.00	16.00	7.10	6.62	6.62	6.02
North Fork												
mean	0.167	0.130	0.166	0.091	12.15	8.00	17.33	11.58	5.37	5.66	5.01	6.29
median	0.144	0.107	0.166	0.097	9.90	8.00	14.00	11.00	5.70	6.21	5.79	6.62
25th percentile	0.092	0.100	0.114	0.071	5.80	4.00	6.00	6.00	4.00	4.22	4.19	5.52
75th percentile	0.210	0.179	0.216	0.112	13.70	11.00	22.00	20.00	6.69	6.83	6.72	7.42
Middle Estuary												
mean	0.139	0.101	0.132	0.083	9.44	6.86	14.75	6.17	5.70	6.12	5.38	6.35
median	0.114	0.087	0.120	0.080	6.70	6.00	8.00	6.00	5.73	6.33	5.74	6.33
25th percentile	0.079	0.068	0.103	0.068	4.50	5.00	4.00	4.00	4.64	5.20	4.41	5.78
75th percentile	0.179	0.154	0.179	0.109	11.10	8.00	16.00	9.00	6.91	6.86	6.22	7.04
Lower Estuary												
mean	0.049	0.027	0.012	0.018	3.89	2.25	2.50	3.92	6.32	6.85	6.62	6.57
median	0.027	0.006	0.006	0.010	3.00	2.00	2.00	4.00	6.33	6.81	6.74	6.76
25th percentile	0.012	0.002	0.004	0.004	2.00	0.50	1.00	2.00	5.71	6.39	6.09	5.93
75th percentile	0.067	0.040	0.015	0.030	4.20	4.00	3.00	5.00	6.86	7.78	7.39	7.10

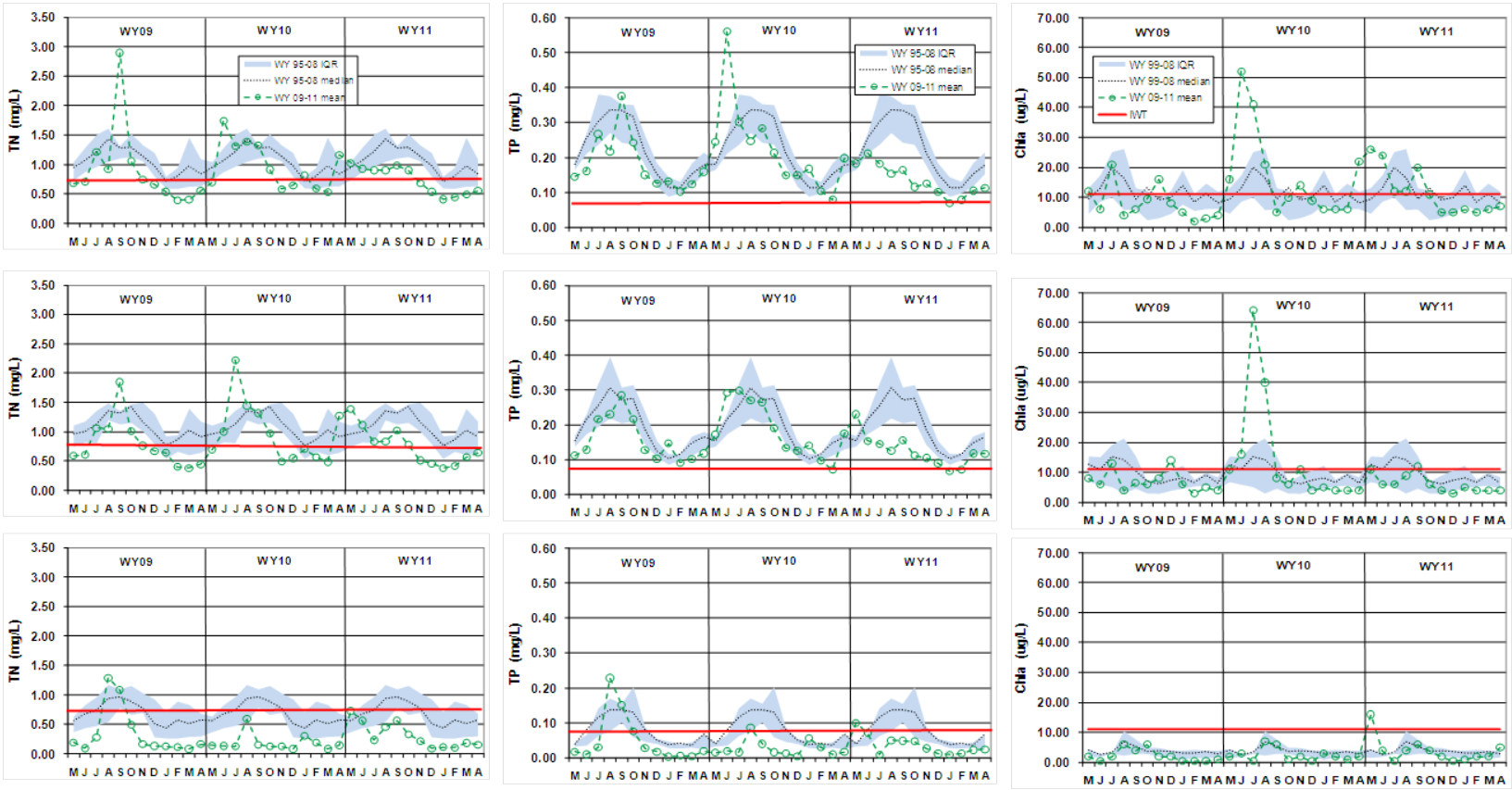


Figure 14. Monthly total nitrogen (TN) [in milligrams per liter (mg/L)] (left column), total phosphorus (TP) (in mg/L)(middle column), and chlorophyll *a* (Chl*a*) (in µg/L) (right column) in the North Fork (top row), Middle Estuary (middle row), and Lower Estuary (bottom row) during WY2009, WY2010, and WY2011 as compared to the 25th, 50th, and 75th percentiles from WY1995–WY2008. Monthly "means" are mostly single sampled values with only a few averages over more than two samples in each month. The solid red lines are targets established for TMDLs (TN TMDL = 0.72 mg/L; TP TMDL = 0.081 mg/L) and impaired water bodies (Chl*a* TMDL = 11.0 µg/L) for the SLE.

Submerged Aquatic Vegetation

Eight locations within the SLE and the SIRL have been monitored since December 2008 (**Figure 12**). One of the sites, Willoughby Creek, is located in the Lower Estuary and is monitored monthly. At this site, shoal grass (*Halodule wrightii*) and Johnson's seagrass (*Halophila johnsonii*) are the dominant species (**Figure 15**), which both are reported as species tolerant to a wide range of salinity (Irlandi 2006; NOAA 2007). Despite this tolerance, extremely low salinities following Tropical Storm Fay in September of 2008 substantially reduced the percent cover of both species. As reported in the *2011 South Florida Environmental Report (SFER) – Volume I*, Chapter 12 (SFWMD, 2011), a recovery of both species at this site was apparent with a present coverage of more than 80 percent. Very low coverages of Paddle grass (*H. decipiens*) have also been observed at this site.

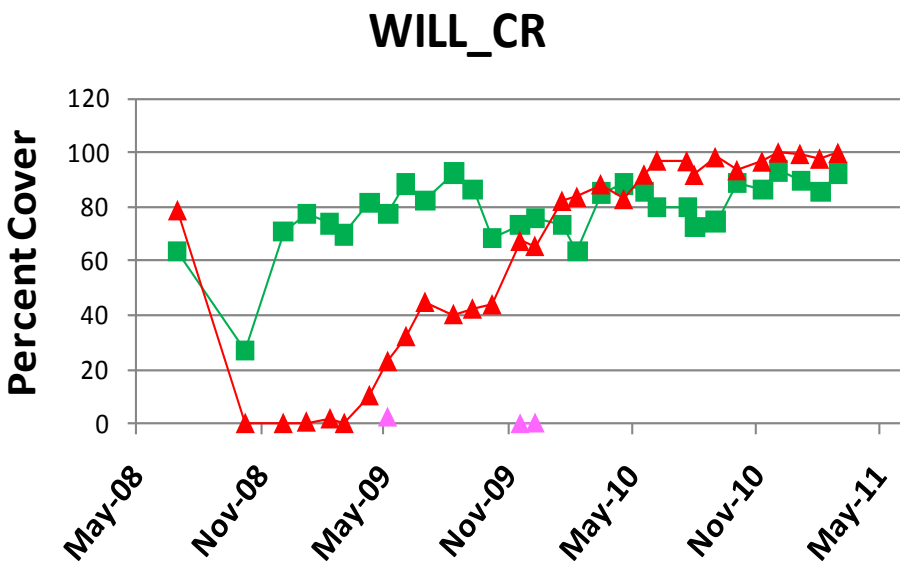


Figure 15. Percent occurrence by seagrass species for the patch-level monitoring site at Willoughby Creek or WILL_CR. The vertical bars are standard deviations from 30 quadrates at each site. Green squares are shoal grass, red triangles are Johnson's grass, and pink triangles are paddle grass.

Eastern Oyster

A suite of measurements have been monitored to detect changes in the distribution, abundance, and condition of eastern oyster (*Crassostrea virginica*) populations in the SLE since 2005 (**Figure 12**). The lower salinity threshold of oysters is generally accepted to be 10 psu (Woodward-Clyde, 1998) with salinities below 10 psu leading to harm and mortality. The upper salinity threshold is more ambiguous and is related to disease and increased sensitivity to predation (Woodward-Clyde, 1998). Live oyster densities were greatest in the middle segment of the estuary. Live density reached 500 oysters per square meter (/m^2) in 2008 in the middle segment, before sharply declining to almost zero following tropical storm Fay in September of 2008 and then recovering in 2009 to 300 live oysters/m^2 (**Figure 16**) and returning to almost 500 in 2010. Dead oyster densities were greater than 300 oysters/m^2 in the central segment in late 2008, but were very low throughout 2010.

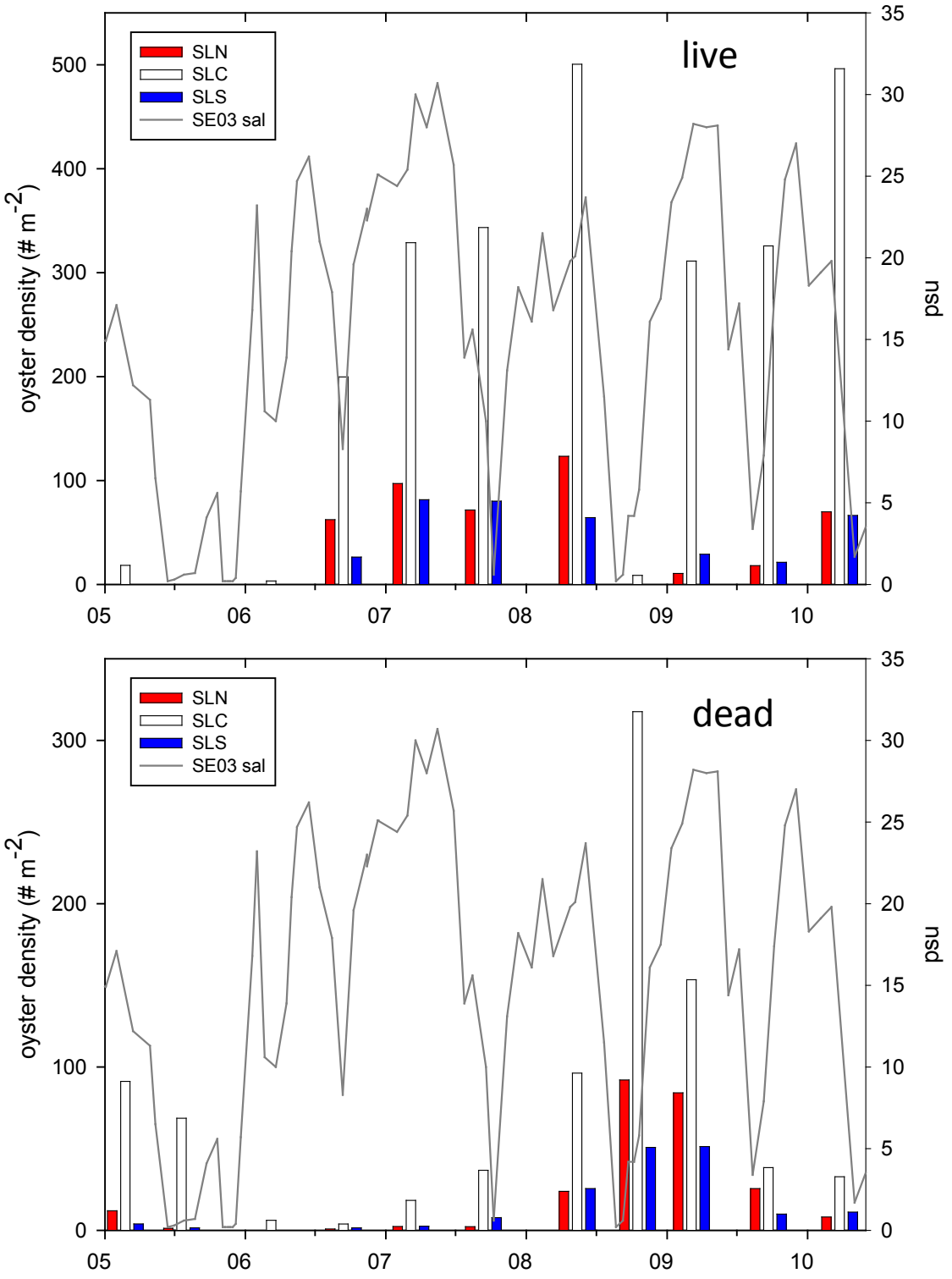


Figure 16. Time series of live and dead eastern oyster densities [in number per square meter (#m-^{2})] in the North Fork (SLN), South Fork (SLS), and middle segment (SLC) of the SLE, and salinity at station SE03 for calendar years 2005–2010 (CY2005–CY2010). [Note: SE03 sal refers to salinity at station SE03]

LONG-TERM TRENDS (1995–2010)

Long-term trends were assessed by comparing rainfall, flows, and nutrient concentrations and loads for two time periods: CY1995–CY2005 and CY2006–CY2010. The first time period (CY1995–CY2005) corresponds to the POR analyzed for the original St. Lucie RWQMP (SFWMD et al., 2009, Appendix E) and is considered the "base period". This base is compared to the "current period", the time since the 2009 SLRWPP was released, to determine if significant changes in water quality and flow can be established between these two PORs. Where appropriate, potential long-term, linear changes over the entire POR (CY1995–CY2010) were evaluated using the Seasonal Kendall Tau trend analysis.

Rainfall

Yearly rainfall was calculated for each sub-watershed and the entire watershed (area weighted) (**Figure 17**) for CY1995–CY2010. The annual average rainfall for CY1995–CY2005 was 53.0 inches, whereas annual average rainfall was 49.7 inches for CY2006–CY2010, about 6.2 percent less than that of CY1995–CY2005. This was primarily because both CY2006 and CY2010 were very dry years, especially CY2006, which was the driest year within the CY1995–CY2010 POR.

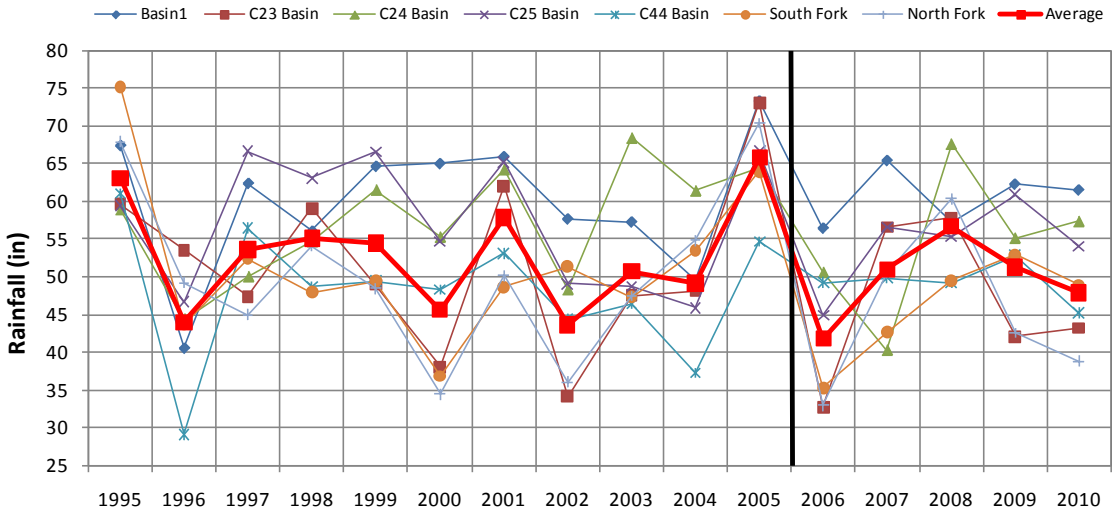


Figure 17. Annual rainfall [inches (in)] for each sub-basin from CY1995 to CY2010. Average rainfalls for the entire watershed are sub-basin area weighted mean values.

Flows

As described earlier, only freshwater inflows at structures S-49 (C-24 Sub-watershed), S-97 (C-23 Sub-watershed), S-308 (Lake Okeechobee), and S-80 (C-44/S-153 Sub-watershed) were evaluated. Flows from ungauged areas, representing approximately 30 percent of the watershed, were not included. Freshwater inflows from Lake Okeechobee to the SLE at S-80 were calculated as previously described and do not include water withdrawn from the C-44 Canal for irrigation. Overall, as expected from the rainfall analysis, all sub-watersheds and Lake Okeechobee had significantly lower flows (Mann-Whitney test, $p < 0.001$) to the SLE during CY2006–CY2010 than CY1995–CY2005 (**Figure 18**). A Seasonal Kendall Tau trend analysis revealed no significant decreasing trends ($p > 0.05$) across the entire POR (CY1995–CY2010). During the wetter CY1995–CY2005 period, flows from Lake Okeechobee accounted for nearly half the total

measured discharge to the SLE (46 percent), which fell to 28 percent during the drier CY2006–CY2010 period.

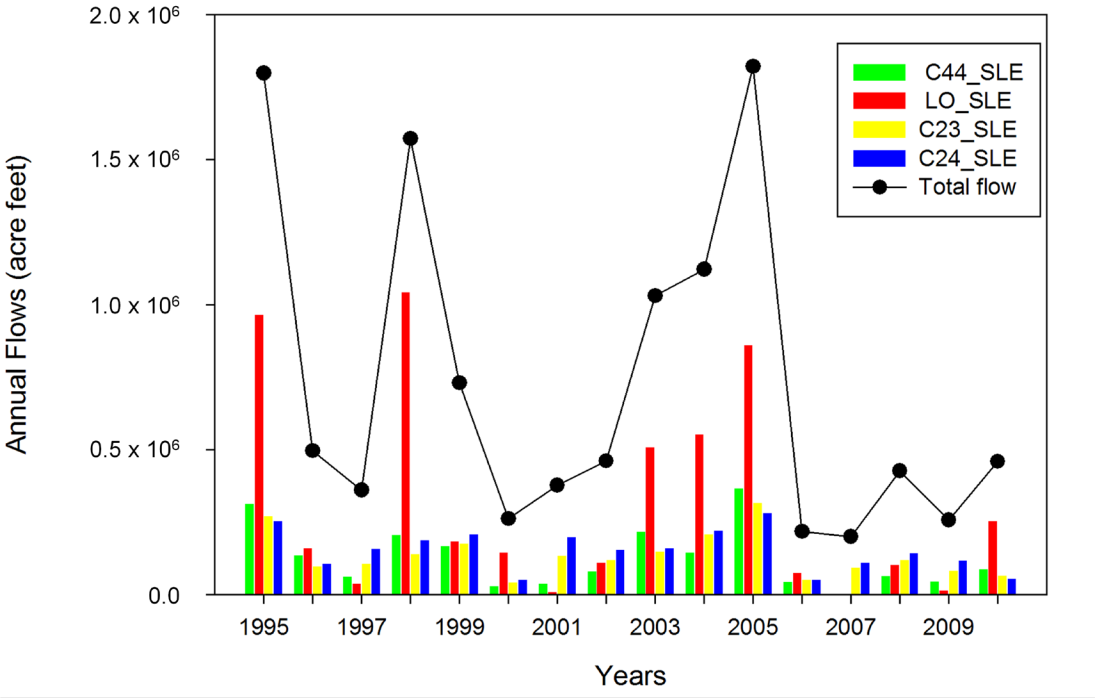


Figure 18. Annual total flow and flows for each sub-watershed and Lake Okeechobee to the SLE CY1995–CY2010. [Note: In the legend, Lake Okeechobee is abbreviated as LO.]

Watershed Nutrient Concentrations and Loads

TN and TP concentrations at the structures (S-80, S-48, and S-49) showed large temporal variations (**Figure 19**), which were positively correlated with flow. Overall, most TN and TP concentrations at the structures were higher than the TMDL targets (**Figure 19**). Although concentrations in CY2006–CY2010 were slightly higher than CY1995–CY2005, there was no significant change between the two periods except TP concentrations from S-80 (C-44/S-153 sub-watershed) (Mann-Whitney test, $p < 0.01$) (**Table 10**). A Seasonal Kendall Tau test indicated that neither TN nor TP concentrations showed long-term trends in nutrient concentrations and loads from CY1995–CY2010 ($p > 0.05$).

Consistent with findings of the 2009 RWQMP (SFWMD et al., 2009, Appendix E), the total measured annual discharge and total annual nutrient loads to the SLE are highly correlated (R^2 = 0.975 for TN and R^2 = 0.809 for TP). Nutrient loading from each sub-watershed and Lake Okeechobee are provided in **Table 11** and trends in nutrient loading that reflect this correlation are discussed below. As presented in **Table 11**, TN and TP loads at the water control structures (S-308, S-80, S-48, and S-49) exhibited large annual variations with higher loads in wet years (CY1995, CY1998, and CY2005) than dry ones (CY2000 and CY2006). Also, both total average TN and TP loads were significantly lower during CY2006–CY2010 than during CY1995–CY2005 (Mann-Whitney test, $p < 0.05$).

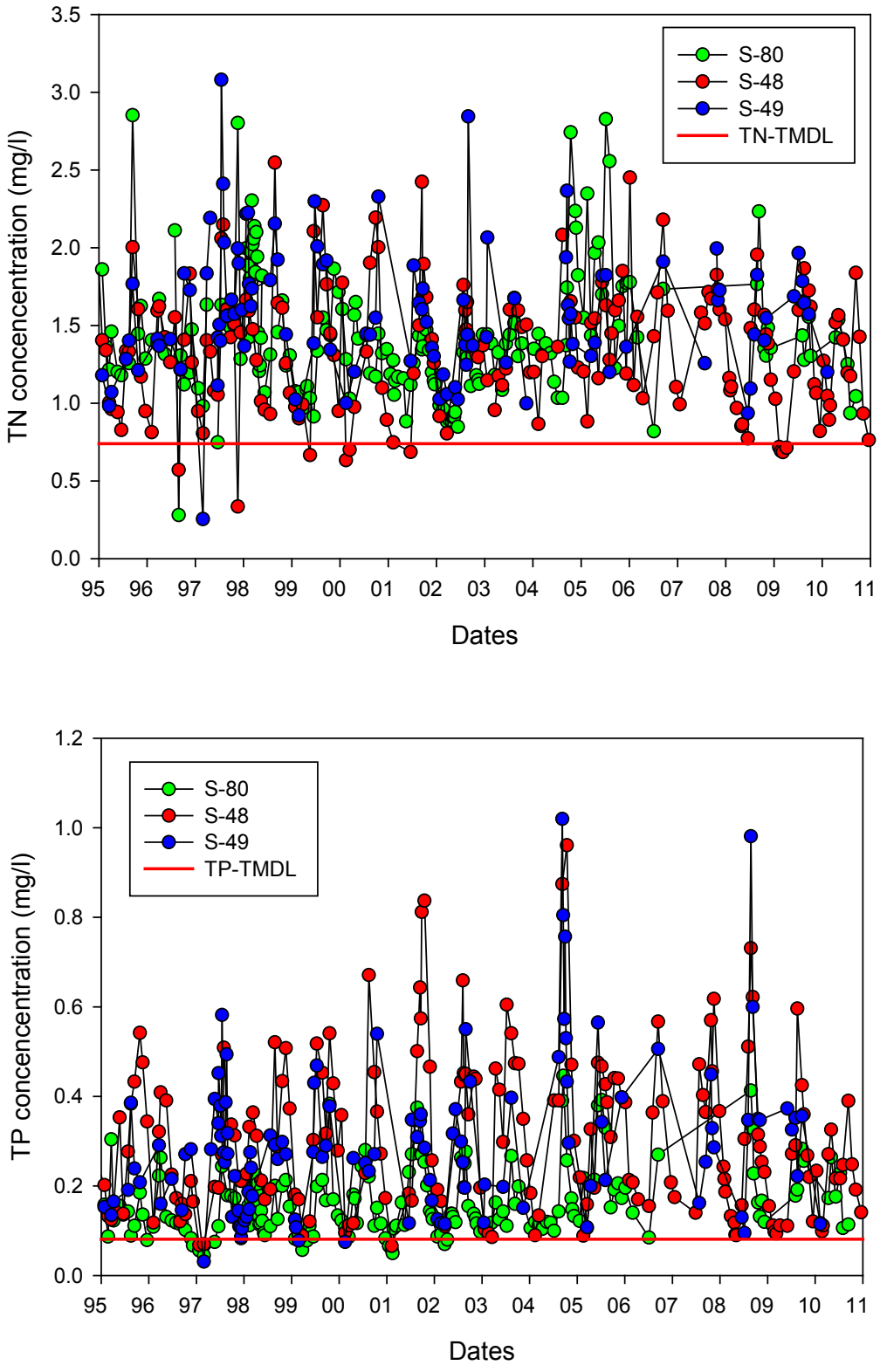


Figure 19. Time-series of TN (top) and TP (bottom) concentrations from structures S-80, S-48, and S-49 for CY1995–CY2010. The horizontal lines represent the SLE TMDLs of 0.72 mg/L for TN and 0.081 mg/L for TP.

Table 10. TN and TP concentrations (in mg/L) statistics at structures S-80, S-48, and S-49 during the calendar years 1995–2005 (CY1995–CY2005) and CY2006–CY2010 periods. The only significant change is the increase in TP from S-80 (Mann-Whitney test, $p < 0.01$).

	Statistic	S-80 (C-44)		S-48 (C-23)		S-49 (C-24)	
		CY1995–CY2005	CY2006–CY2010	CY1995–CY2005	CY2006–CY2010	CY1995–CY2005	CY2006–CY2010
TN	counts	153	20	142	59	91	17
	mean	1.432	1.42	1.354	1.326	1.567	1.567
	standard deviation	0.415	0.313	0.402	0.397	0.435	0.308
	minimum	0.028	0.819	0.335	0.685	0.254	0.936
	maximum	2.852	2.232	2.547	2.451	3.079	1.993
	25^{th} percentiles	1.17	1.297	1.068	1.029	1.292	1.404
	50^{th} percentile	1.363	1.416	1.342	1.384	1.505	1.643
	75^{th} percentile	1.604	1.542	0.106	1.6	1.821	1.785
TP	counts	157	21	123	61	99	19
	mean	0.16	0.2	0.325	0.274	0.284	0.346
	standard deviation	0.077	0.08	0.18	0.156	0.164	0.201
	minimum	0.045	0.085	0.066	0.09	0.031	0.095
	maximum	0.446	0.413	0.961	0.731	1.02	0.981
	25^{th} percentiles	0.111	0.114	0.177	0.155	0.162	0.238
	50^{th} percentile	0.136	0.178	0.313	0.234	0.271	0.347
	75^{th} percentile	0.2	0.256	0.442	0.365	0.354	0.364

Table 11. TN and TP loads (in mt) from each sub-watershed and Lake Okeechobee for CY1995–CY2010. [Note: No loads came from either the lake or the C-44/S-153 Sub-watershed in 2007 as neither discharges to the SLE.]

Year	Lake Okeechobee to SLE		S-80 (C44)		S-48 (C-23)		S-49 (C-24)		Total	
	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
CY1995	1,734	149	984	71	526	140	433	75	3,676	435
CY1996	269	23	241	27	169	30	192	29	871	109
CY1997	82	6	100	11	232	44	361	60	776	121
CY1998	2,666	251	231	22	313	74	418	63	3,627	410
CY1999	452	41	224	48	468	122	446	88	1,590	299
CY2000	283	26	38	3	82	18	92	19	495	65
CY2001	12	1	58	9	304	91	406	84	780	186
CY2002	194	20	99	23	237	59	269	65	797	168
CY2003	916	88	309	72	283	83	294	61	1,801	305
CY2004	1,474	146	398	82	518	176	499	163	2,890	568
CY2005	1,971	236	1,091	122	614	180	524	125	4,200	663
CY2006	168	20	33	4	107	22	101	25	408	70
CY2007	0	0	0	0	207	59	212	49	420	108
CY2008	232	24	142	44	280	84	278	84	933	235
CY2009	21	2	81	14	166	36	241	56	508	107
CY2010	416	46	144	27	115	21	81	9	756	103
CY1995–CY2005 average	**914**	**90**	**343**	**45**	**341**	**92**	**358**	**76**	**1,955**	**303**
CY2006–CY2010 average	**167**	**18**	**80**	**18**	**175**	**44**	**183**	**45**	**605**	**125**

Estuarine Water Quality

Notched box-and-whisker plots were used to analyze differences for five water quality parameters (salinity, TN, TP, Chl*a*, and bottom DO) between the CY1995–CY2005 and CY2006–CY2010 periods (**Figure 20**). In addition, the Mann-Whitney test was used to determine whether differences were statistically significant (**Table 12**). Based on these plots and test results, salinity exhibited significant increases and TN exhibited significant decreases for all segments. TP also decreased from CY1995–CY2005 to CY2006–CY2010 in all segments except the South Fork, where no significant change was detected. Similarly, Chl*a* decreased in the Middle Estuary and Lower Estuary, but no significant changes were found for the South Fork and North Fork regions. Bottom DO decreased in the South Fork and increased in the other three segments.

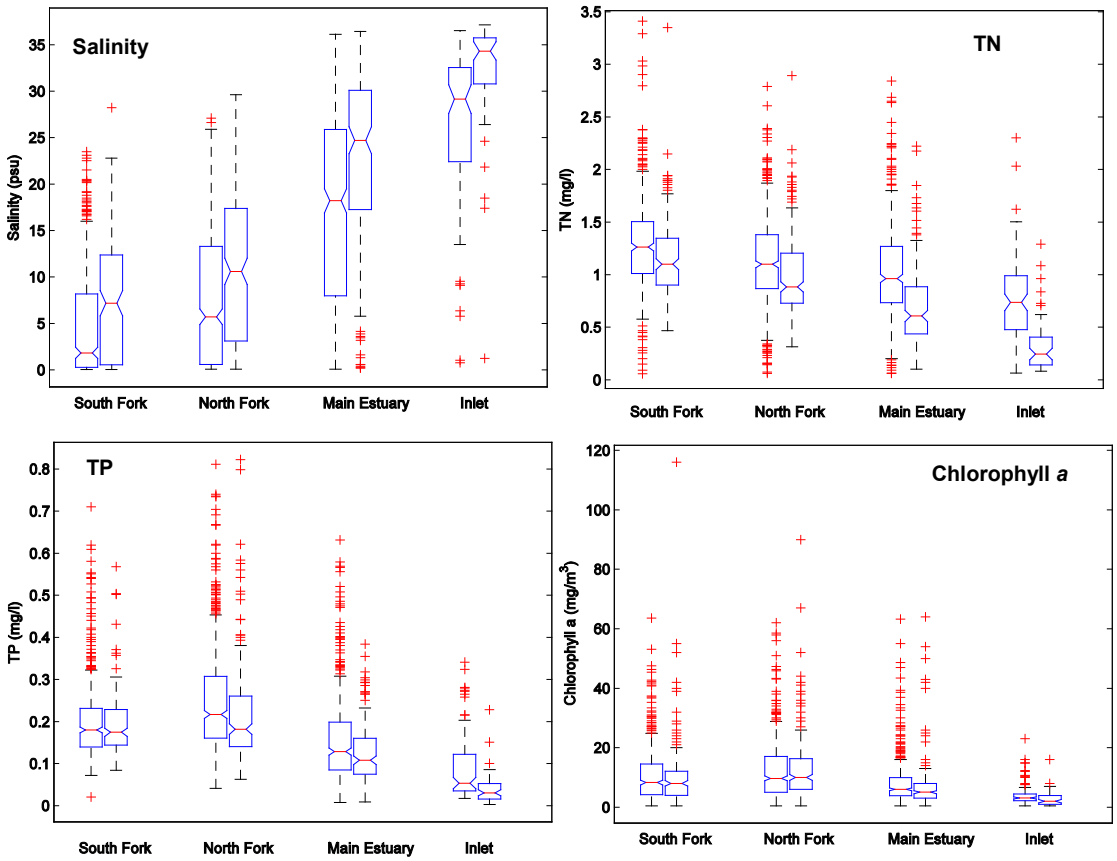


Figure 20. Notched box-and-whisker plots comparing annual concentrations of salinity, TN, TP, and Chl*a* in four regions of the SLE during CY1995–CY2005 (first plot) and WY2006–WY2010 (second plot). The notch in the box is the 95 percent confidence interval around the median. Two medians are significantly different at the five percent significance level if the notches do not overlap.

Table 12. Comparison of salinity, bottom dissolved oxygen (DO), TN, TP, and chlorophyll *a* (Chl*a*) over two periods (CY1995–CY2005 and CY2006–CY2010) using the Mann-Whitney test for significance.

Parameter	Trend[1]			
	South Fork	North Fork	Middle Estuary	Lower Estuary/Inlet
Salinity	Increasing	Increasing	Increasing	Increasing
Bottom DO	Decreasing	Increasing	Increasing	Increasing
TN	Decreasing	Decreasing	Decreasing	Decreasing
TP	Not Significant	Decreasing	Decreasing	Decreasing
Chl*a*	Not Significant	Not Significant	Decreasing	Decreasing

[1] "Increasing" or "Decreasing" indicates statistically significant trends from the first period to the second period at $p < 0.05$ level; "Not Significant" means not significant at the $p < 0.05$ level.

To further describe the long-term changes in water quality in the estuary, parameters were tested over CY1995–CY2010 using a Seasonal Kendall Tau analysis (Helsel and Hirsch, 2002; **Table 13**). Results show different trends in parameters among the four estuarine segments. The most evident trends were identified at the lower estuarine stations, where all parameters exhibited statistically significant trends: increased salinity, decreased nutrient concentrations and Chl*a*, and increased bottom DO concentrations.

Table 13. Seasonal Kendall Tau values at selected stations for salinity, TN, dissolved inorganic nitrogen (DIN), TP, dissolved inorganic phosphorus (DIP), Chl*a*, and bottom DO from January 1995–December 2010.

Stations	Salinity	TN	DIN	TP	DIP	Chl*a*	Bottom DO
South Fork SE_09	0.103	-0.091	0.041	0.0817	0.0127	0.003	-0.088
North Fork HR1	0.124	-0.242[1]	-0.085	-0.076	-0.125[1]	0.063	0.215[1]
Main Estuary SE_03	0.129	-0.236[1]	-0.091	-0.066	-0.125[1]	-0.088	0.127
Inlet SE_11	0.238[1]	-0.391[1]	-0.284*	-0.292[1]	-0.290[1]	-0.167[1]	0.264[1]

[1]Statistically significant at $p < 0.05$

Submerged Aquatic Vegetation

The SFWMD and the St. John's River Water Management District (SJRWMD) are collaborating on a seagrass mapping program in the lower SLE and the IRL. True seagrass beds in the SLE are restricted to the Lower Estuary with scattered patches occasionally present in the Middle Estuary and North Fork (RECOVER, 2009; SFWMD et al., 2009). Therefore, the effort is only focusing on the lower portion of the SLE, which includes analysis of aerial photographs and fixed monitoring transects. Aerial imagery of the study area from 1996 to 2009 has been analyzed and indicate that the aerial extent of seagrass was lowest in 1996 (**Figures 21** and **22**), which was most likely a result of impacts from the extreme wet conditions in the St. Lucie River Watershed in 1994. A subsequent recovery was apparent through 2003; however, the 2004 and 2005 hurricanes interrupted this recovery, causing significant declines in coverage (56 percent decline between 2003 and 2005 surveys). Relatively low and stable acreage persisted through 2007, with a 31 percent increase from 2007 to 2009 (**Figure 22**).

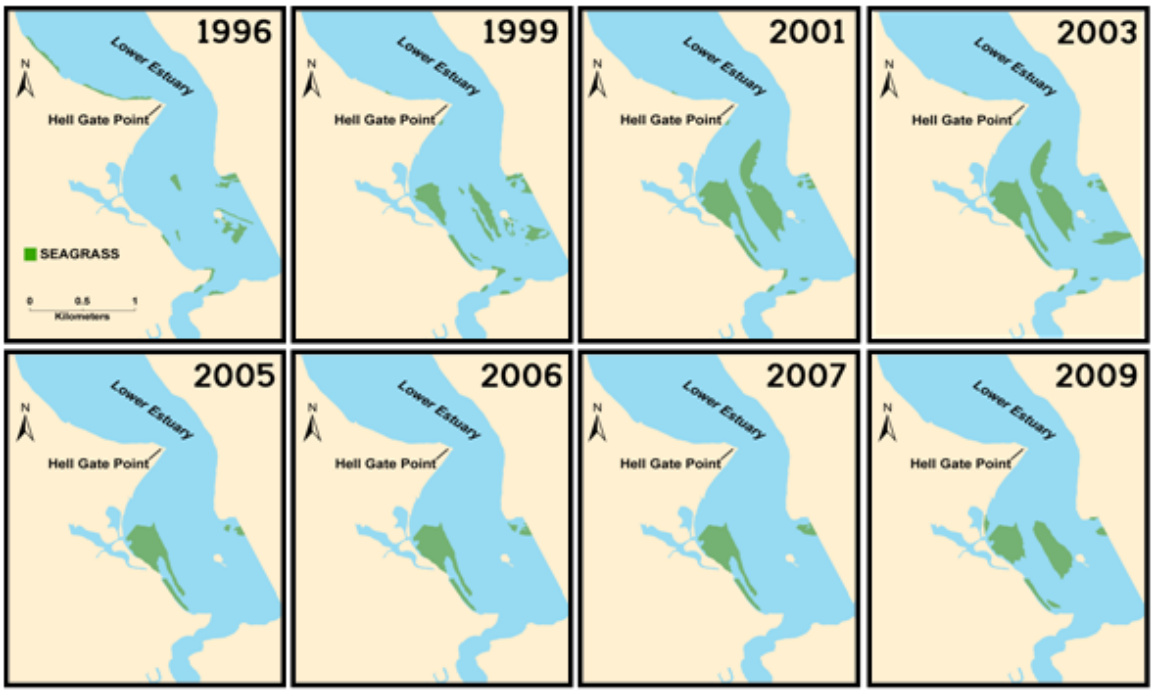


Figure 21. Seagrass bed distribution changes in the SLE from aerial photos taken from 1996 through 2009.

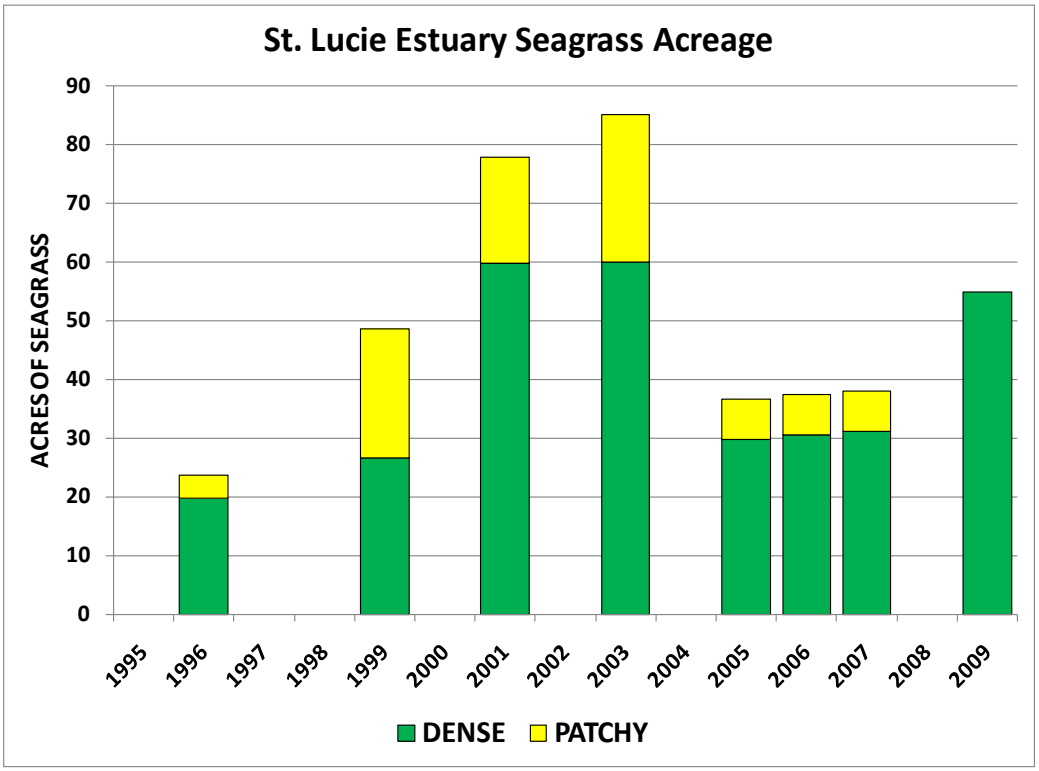


Figure 22. Seagrass bed acreage changes in the SLE (1996–2009).

Fixed transects in the study area are monitored semiannually (winter and summer) to help evaluate long-term trends in seagrass percent cover and species composition. One of the long-term transects is located within the lower SLE (Transect 67), generally situated at the north side of the estuary mouth. During the study, two seagrass species (shoal grass and Johnson's seagrass) were observed at Transect 67. In 1995, following the very wet conditions of 1994, seagrass percent cover at Transect 67 was 10 percent and this increased to 50 percent by the following year (**Figure 23**). A gradual decline then followed, with less than one percent cover recorded following hurricanes in 2004 and 2005. Post-hurricane recovery is indicated by increases in overall seagrass density from 2006 to 2010.

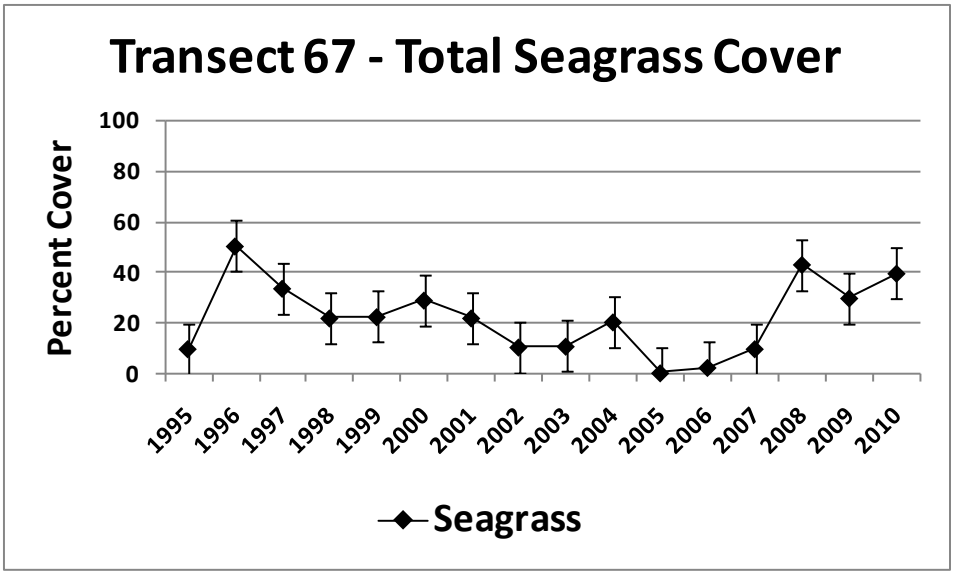


Figure 23. Total visual percent cover estimates for seagrass averaged for each summer monitoring event [mean ± standard error (SE)].

In summary, trends from mapping efforts and transect data are not in agreement for 1996–2003, but are similar for 2003–2009. While bed acreage increased, density along Transect 67 declined prior to the hurricanes. Both map and transect data showed declines after the hurricanes and recovery following impacts. The within-bed trends for the SLE are based on only one transect. Since 2008, Willoughby Creek was added as another monitoring site in the estuary, which will provide more species-level data on seagrass response to freshwater discharges. The SFWMD and SJRWMD are preparing a 2011 IRL seagrass map that will include the SLE. It is anticipated that the results will allow continued evaluation of seagrass acreage and distribution trends.

RESEARCH AND WATER QUALITY MONITORING PLAN STATUS

Research Project Updates

The goal of the St. Lucie River Watershed RWQMP is to conduct studies and develop models and other tools that can assist in predicting the response of the SLE to changes in freshwater inflow and reductions in nutrient loads. The intent of the research projects is to address key uncertainties in nutrient load targets (e.g., TMDLs), flow and salinity envelopes, and operational rules for infrastructure. The latter is particularly important because water management practices influence the delivery of nutrients and the variability of salinity in the downstream estuary.

The 2009 St. Lucie River Watershed RWQMP (SFWMD et al., 2009, Appendix E, Chapter 5) outlined and justified research projects under three main areas: nutrient budget, DO dynamics, and the low salinity zone (**Table 14**). Projects under the first two areas concern water quality, nutrient loads, and the estimation of nutrient cycling rates. Together, these projects support the development of models that can be used to predict estuarine water quality responses to the nutrient load reduction scenario proposed by the 2009 SLRWPP. Projects under the low salinity zone area aim to quantify the influence of freshwater discharge on this critical estuarine nursery habitat for commercially and recreationally important finfish and shellfish species. Those projects support the refinement of salinity and flow envelopes. They also support development of operational rules for dry season freshwater discharges from canals and water treatment and storage projects.

Table 14. Research areas identified in the 2009 SLRWPP.

Research	Purpose	Management Objectives	Applications
Nutrient Budget	Identification and understanding the origin, magnitude, and management of controllable, problematic nutrient loads.	This research supports the SLRWPP goal to achieve the nutrient Total Maximum Daily Load (TMDL) for the SLE.	Quantify nutrient loads from various sources and support water quality modeling to reduce the uncertainty of the TMDL and increase the capability to predict effects of various management measures (e.g., BMAPs).
DO Dynamics	Identification and understanding of the causative agents (e.g., high levels of biological oxygen demand and Chl*a*) for DO impairments in the SLE.	This research supports the SLRWPP goal to improve DO conditions in the SLE.	Identify the factors causing the DO impairment in the SLE, to guide the selection of appropriate management solutions.
Low Salinity Zone	Characterization and quantification of the effects of freshwater discharges on production in, and utilization of, the low salinity zones in the North and South Forks of the SLE.	This research supports the SLWRPP goal to minimize the occurrence of undesirable salinity ranges in the SLE.	Refine SLE salinity envelope and provide environmental guidelines for delivery of fresh water to North and South Forks of the SLE.

This update focuses on research activities and projects conducted since the development of the original plan in 2009. A brief description of project objectives, salient results, and further information needs are presented in **Table 15**. For more detailed descriptions of these projects, see the 2009 and 2010 SFERs – Volume I, Chapter 12 (SFWMD, 2009a; SFWMD, 2010b) and the 2009 SLRWPP (SFWMD et al., 2009, Appendix E, Chapter 5).

Benthic Nutrient Fluxes

In shallow coastal estuarine systems like the SLE, the water column and sediments can be tightly coupled with respect to the biogeochemical cycling of nitrogen and phosphorus. Sediment can function as a sink (i.e., permanent burial) or a source (i.e., inputs to the estuary) through the transfer, or flux, of nutrients between the water column and sediments and can contribute significantly to the total nutrient load. A recent study in a northwestern Florida estuary identified sediments as a significant source of inorganic nitrogen and phosphorus to the water column relative to inputs from the main freshwater source during drought conditions (DiDonato et al., 2006).

Table 15. Research projects reported annually for the SLRWPP.

Research	Project	Project Objectives	Conclusions/Applications
Nutrient Budget	Dry Season Benthic Flux Measurements	Characterize and quantify the exchange of nutrients between the sediments and water column in the SLE during dry season and drought conditions. Estimate relative magnitudes of internal nutrient loads from the sediments and nutrient loads supplied by surface waters through structures. Help determine how rapidly the system will respond to reductions in surface water loads.	Results of this study will be used to provide the low range for internal nutrient cycling between the sediment and water column in a water quality simulation model. Wet season measurements of sediment-water column exchange of nutrients are needed to provide the upper range of these rates of nutrient input/removal.
	St. Lucie Estuary Nutrient Budget	Estimate/quantify major source and sink terms for nutrient inputs to the SLE, such as external and internal loads.	A rudimentary budget for dissolved organic nitrogen and dissolved organic phosphorus has been constructed to examine retention/export of nutrients under various freshwater inflow regimes. Results are being analyzed.
	MERLIN (Marine Environmental Research Laboratory for In Situ Sampler) Short Term Water Quality Analysis	Collect continuous data to characterize and quantify variability of nutrients (nitrogen and phosphorus) and other water quality parameters [e.g., salinity, temperature, photosynthetically active radiation (PAR)] on sub-daily timescales in the SLE.	The data collected by MERLIN will be used to calibrate/validate the water quality simulation model.
DO Dynamics	DO Data Analyses	Characterize DO variability and identify the factors causing DO impairment in the SLE.	The results of this study will be used to guide freshwater release and nutrient reduction strategies, based on both physical (e.g., stratification) and biological (e.g., Chl*a*) processes, designed to minimize or eliminate the development of hypoxic or anoxic conditions in the SLE.
	Sediment Oxygen Demand (SOD)	Characterize (spatially) and quantify net oxygen exchange between the sediments and water column in the SLE during dry season conditions.	The results of this project identify light availability at the sediment surface as a driver for oxygen exchange between the sediments and water column in the SLE. This information should be used to guide future PAR, SOD, and water column DO monitoring over diel (light and dark) cycles to accurately quantify net SOD in areas where light availability at the sediment surface is adequate to support benthic photosynthesis (e.g., the South Fork).
Low Salinity Zone	Estuarine Turbidity Maximum (ETM)	Characterize and understand the structure of the SLE ETM zone including salinity/density structure, turbidity structure, suspended sediment distribution, DO, and Chl*a*.	The results of this study will be used to inform operations decisions based on the behavior of the ETM as a result of complex interactions between factors including changing freshwater inflow and changing tidal forcing.
	Groundwater Seepage Study	Quantify groundwater seepage into the SLE.	Results showed that significant uncertainty exists for estimates of seepage, with large variation in daily seepage values. Part of this study was used for the seepage input in the St. Lucie Hydrodynamic Model (CH3D).

Due to the lack of information about benthic nutrient fluxes available for the SLE, two studies were conducted during the dry season in February 2008 to estimate benthic fluxes of nitrogen and phosphorus (Cornwell et al., 2008; Howes et al., 2008). The goals of one study were to (1) provide estimates representative of system-wide benthic nutrient flux rates in the estuary, (2) identify "hot spots" of benthic nutrient fluxes, and (3) provide data to support current and future water quality modeling efforts. Systemwide estimates were based on measurements from sediment cores collected from 50 sites distributed throughout the estuary. Results revealed the following information on internal cycling between the water column and sediments in the SLE (Howes et al., 2008):

- Overall, rates of sediment nutrient efflux are generally low throughout the SLE.
- The distribution of water column-sediment oxygen uptake (**Figure 24**) and efflux of nutrient-related dissolved constituents is positively related to the distribution of sediment organic matter (**Figure 25**) and, to a lesser extent, benthic Chl*a* levels.
- Sediment Chl*a* levels (benthic phototrophs) appeared to have a significant impact on nutrient efflux mainly in the upper reaches of the South and North Forks, where light penetration and Chl*a* levels were high.
- Unlike many estuaries, where a dominant longitudinal gradient in sediment rates shows a decline from estuarine headwaters to tidal inlet, the SLE system shows the highest rates of metabolism and flux rates in the lowermost basin.
- The rates and fluxes of SLE sediments were typical of estuarine sediments under similar environmental conditions (light, temperature, organic matter, etc.).
- While oxygen uptake rates were moderate to low throughout the system, the rates of nutrient fluxes and denitrification were also appropriately low. Denitrification was found to account for approximately half of the nitrogen remineralized, consistent with findings from other estuarine systems.

The goals of the second study were to identify the contribution of diffusive and advective fluxes (exchanges) in the SLE by comparing fluxes measured from cores in the laboratory with fluxes measured in the field with chambers (Cornwall et al., 2008). Key findings were as follows:

- No evidence of advective fluxes was found.
- Light levels are an important determinant of the direction and magnitude of nutrient exchange across the sediment-water interface. When light levels are sufficient, microalgae sequester nutrients at the sediment surface, inhibiting transfer to the overlying water.
- Reductions in water clarity will allow a higher transfer of nutrients to the overlying water where these nutrients can fuel algae blooms.
- The effects of light and benthic microalgae on the transfer of dissolved nutrients across the sediment-water interface are not typically included in water quality models. However, this process may have to be incorporated into the water quality models for shallow estuaries in South Florida such as the SLE.

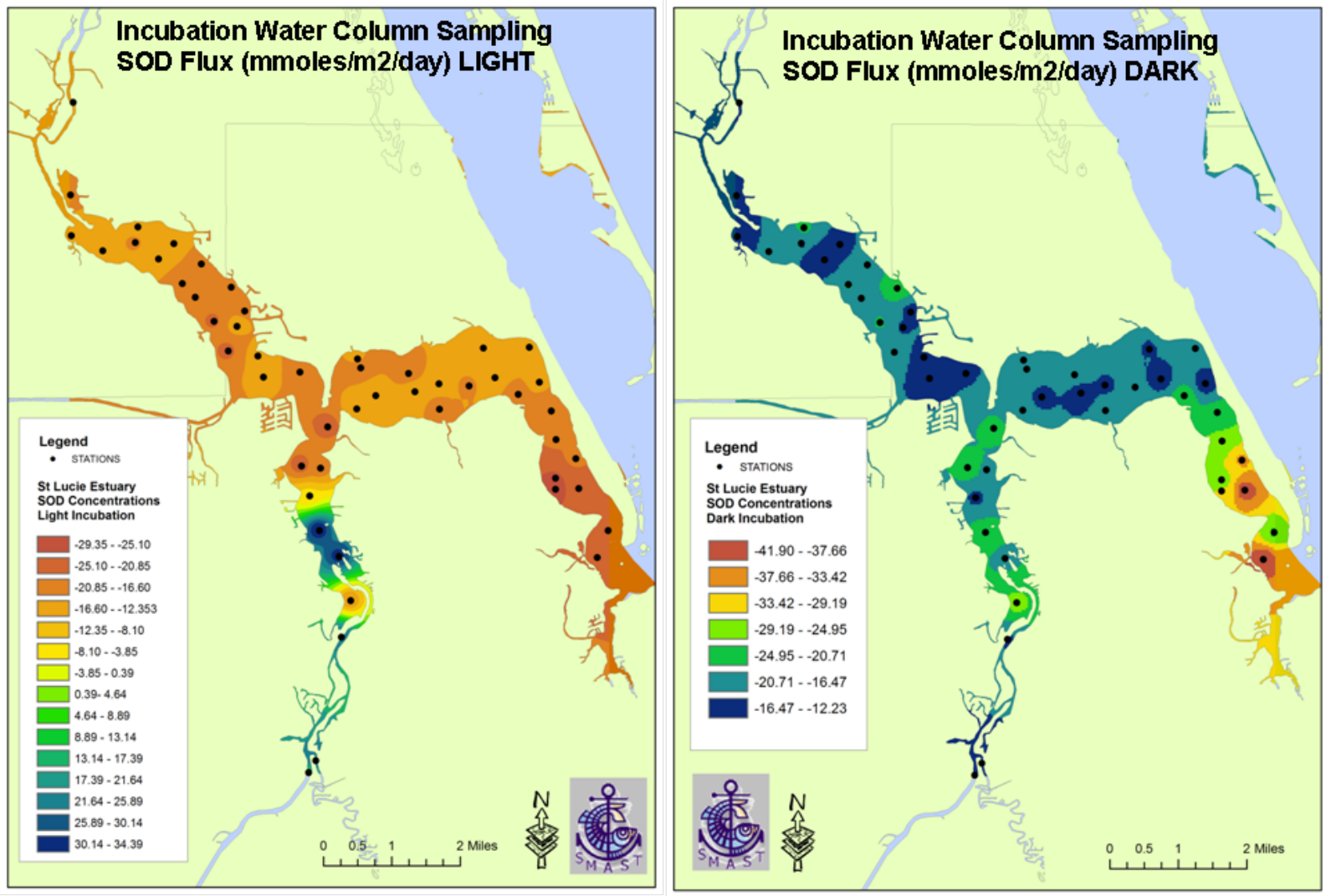


Figure 24. Distribution of sediment oxygen demand (SOD) in millimoles per square meter per day (mmoles/m2/day) under light (left) and dark (right) conditions throughout the SLE in late January 2008 (Howes et al., 2008).

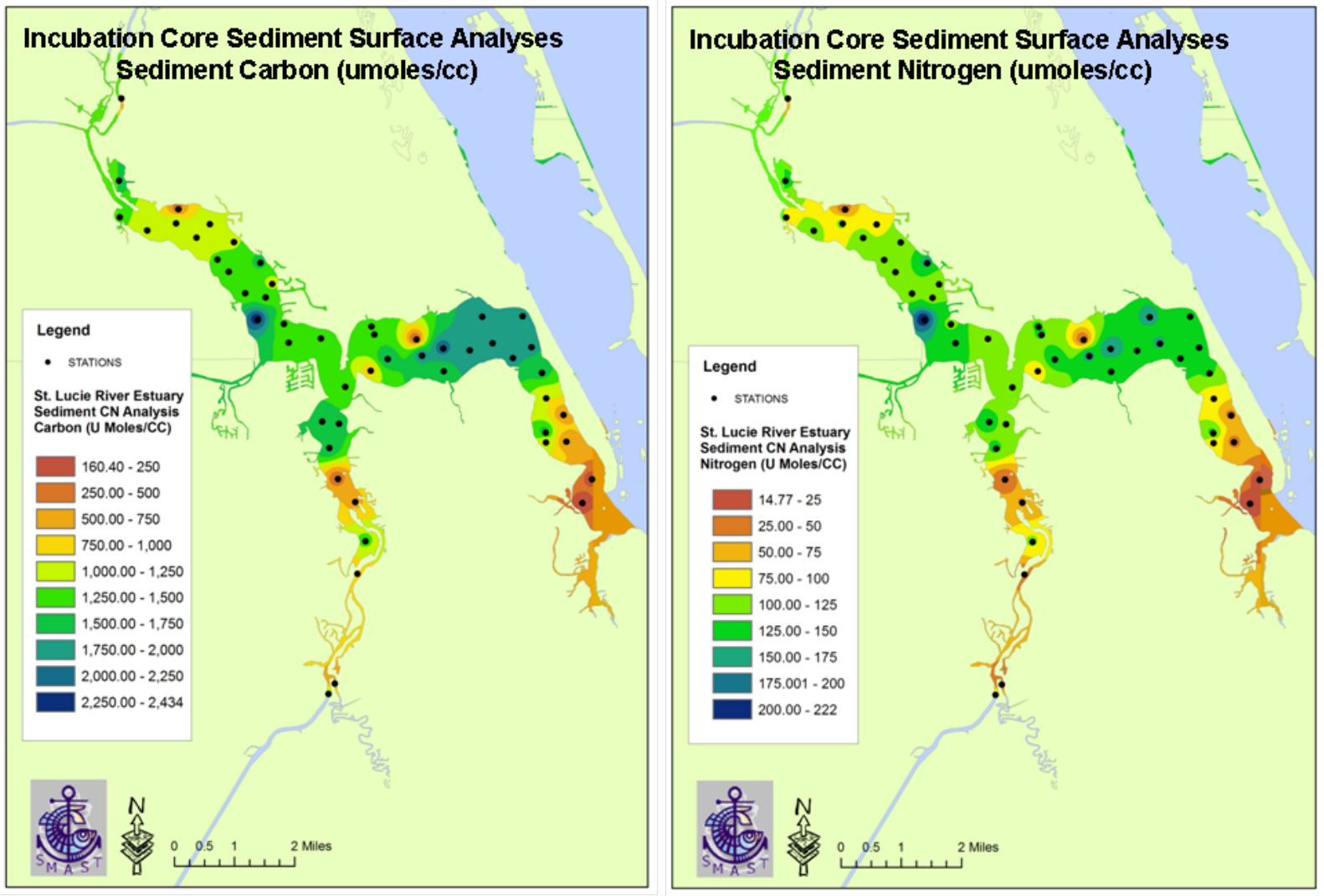


Figure 25. Distribution of total organic carbon (left) and TN (right) in micromoles per cubic centimeter (umoles/cc) integrated over the surface three centimeters throughout the SLE in late January 2008 (Howes et al., 2008).

St. Lucie Estuary Nutrient Budget

The objectives of this study, initiated in 2011 and in progress, are to (1) identify major pathways using appropriate conceptual model-based available data and knowledge, (2) estimate and quantify major source and sink terms such as external and internal loads, and (3) identify possible data gaps and uncertainties. Two approaches will be used for this effort: empirical data and modeling simulations. The level of detail in empirical budgets varies as a function of the number of terms included in the model (SFWMD et al., 2009). As a first step, the Land Ocean Interactions at the Coastal Zone approach (Gordon et al., 1996) was applied. This treats the entire estuary as a "black box" with no defined internal processes, only external inputs (e.g., atmosphere, stormwater runoff) and outputs. The second approach utilizes the SLE water quality simulation model. This approach is considerably more complex and includes many nutrient recycling terms within the estuary, as well as external inputs (e.g., atmosphere, canals, and rivers). Both projects are under way and results are being analyzed and interpreted.

MERLIN Short-Term Water Quality Analysis

To improve monitoring flexibility and obtain critical continuous data, the District began designing and constructing a floating monitoring platform prototype in 2006. The Marine Environmental Research Laboratory for In Situ Sampler (MERLIN) can collect high frequency (about one data point every two hours) time series water quality data and meet all quality assurance objectives (RECOVER, 2009). Testing of the platform is under way.

Dissolved Oxygen Dynamics Project

Low oxygen concentrations are often associated with excess nutrient loading (Gray, 1992) and have been a recognized problem in the SLE (Chamberlain and Hayward, 1996). Hypoxic conditions (DO $\leq$ 2 mg/L) suffocate most marine organisms, and anoxic conditions (DO = 0) provide an unsustainable environment (Diaz, 2001). The FDEP determined that the SLE is impaired for DO (FDEP, 2004). Causative agents are believed to be both BOD and Chl*a* (i.e., excessive phytoplankton). These two agents suggest different origins as causes for the impairments. This project supports the management goal of improving DO concentrations in the estuary. To determine if lower nutrient loads will improve DO concentrations in the estuary, it is necessary to quantify the relative importance of factors that control DO and how they interact to exert that control (**Table 16**).

Table 16. Sources, sinks, and other measurements required to quantify the dynamics of DO in the SLE.

Sinks	**Status**
External Biological Oxygen Demand Load	Requires new measurements
Benthic Sediment Oxygen Demand	One dry season data available; need more dry/wet season data
Water Column Respiration	Requires new measurements
Sources	**Status**
Primary Productivity	Requires new measurements
Re-aeration	Modeled
Physics	**Status**
Stratification	Requires new measurements
Concentration Time Series	**Status**
DO	Requires new measurements
Chl*a* Biomass	Requires new measurements
Light Extinction	Requires new measurements

Dissolved Oxygen Data Analysis

In 2009 the spatial variability and temporal variability of bottom DO were examined using existing water quality monitoring measurements collected monthly, weekly, and every 30 minutes (SFWMD, 2010b). The major findings of this study were as follows:

- Bottom DO shows a strong longitudinal gradient from the upper to lower estuary. A higher incidence of hypoxia was observed in the upper estuary (e.g., up to 30 percent more frequent at stations located near water control structures).
- Bottom DO exhibits a distinct seasonal pattern, with hypoxia more frequently observed in the wet season than the in dry season.
- Physical processes (e.g., stratification, temperature) are important factors controlling hypoxia. Thus, it is imperative these physical factors be taken into account when evaluating the success of proposed management solutions (e.g., reduced nutrient loading) on achieving management goals.
- Lower DO is often associated with higher Chl*a*, suggesting it is possible to improve DO in the estuaries by reducing nutrient loads, which would result in a reduction of phytoplankton production and concurrent Chl*a* concentrations.

As this study shows, physical processes (e.g., stratification, temperature) are important factors controlling hypoxia. Analytical tools need to accurately simulate such physical processes. The study also provides a potential linkage between nutrients and DO concentration through Chl*a*. Physical processes influence DO and flushing influences the accumulation of Chl*a*. Estuarine physics may play a pivotal role in determining where and when high Chl*a* occurs, and when its decomposition causes hypoxia or anoxia. High frequency electronic sampling daily and weekly may provide data necessary to better understand these interactions.

Sediment Oxygen Demand

In February 2008, the spatial variability of sediment oxygen demand (SOD) was measured at 50 sites in the SLE as a component of a project designed to measure nutrient and oxygen exchange between the water column and sediments (see the *Benthic Nutrient Fluxes* section). The major finding of this study is light and benthic microalgae (i.e., sediment Chl*a*) are important factors influencing SOD on a diel cycle in areas of the SLE where light reaches the sediment surface. Sediment oxygen uptake showed large differences from light to dark. For example under light conditions, the upper reach of the South Fork showed net oxygen production, while the remainder of the estuarine area showed net oxygen uptake under both light and dark conditions.

This study highlighted the importance of light and benthic microalgae in modifying SOD by mitigating sediment oxygen uptake in the sediments with oxygen production during photosynthetic activity by microalgae at the sediment surface. This process is not normally included in water quality models, but may need to be incorporated for shallow South Florida systems. Similar studies are required for the wet season when rates of sediment metabolism (i.e., oxygen consumption in the sediment) may be higher due to higher input of organic matter.

Low Salinity Zone Project

One of the SLE management goals is to minimize the occurrence of undesirable salinity patterns in certain areas. Low freshwater inflow requirements of the estuary have been based on salinity tolerances of the eastern oyster, which prefers meso- to polyhaline waters (14–28 psu) (Montagna et al., 2007). Information on the background and importance of low salinity zones are detailed in the 2009 SLRWPP (SFWMD et al., 2009).

The Low Salinity Zone Project examines the effects of freshwater discharges on utilization of oligohaline nursery habitat (0–10 psu) by fish larvae, their predators, and their prey. A prominent feature of the low salinity zone is a turbidity maximum, which is often a region of high productivity. Studies were conducted to document the occurrence of a turbidity maximum in the SLE as described further below. Another source of water affecting salinity in an estuary is groundwater. A study was conducted to analyze and model existing data for groundwater inflows. Results were used to enhance the SLE Hydrodynamic Model (CH3D).

Estuarine Turbidity Maximum

The objectives of this study were to (1) identify and locate the estuarine turbidity maximum (ETM) zone in the North and South Forks of the SLE, (2) study the salinity/density structure, turbidity structure, suspended sediment distribution, DO and Chl*a* within the ETM, and (3) study tidal and seasonal variations of the ETM zone. The study took place in the 2007 wet season and 2008 dry season (Fugate and Andresen, 2008). During each season, two field surveys were performed each for spring and the neap tide conditions.

ETM dynamics were investigated using a series of transects in three branches of the SLE. The measurement and sampling provided profile data of salinity, temperature, DO, and turbidity along longitudinal transects. Three types of ETMs were identified in these surveys. The most common was produced near the bottom around the head of the salinity intrusion. The location of these ETMs may represent an average position of the 0 psu salinity contour. In the North Fork, this classical ETM was often accompanied by an ETM further upstream in the well mixed, freshwater region where there is tidal influence but without water column stratification. The third type of ETM was found in relatively salty water that occurred at a longitudinal salinity front. The results of the ETM study have been used during water reservation establishment for the North Fork of St. Lucie River, which was completed in 2010. The data collected have also been used in the development of a three-dimensional suspended sediment transport model.

Groundwater Seepage Study

The objective of this project was to quantify the groundwater seepage into the SLE through data analysis and modeling. Existing data on groundwater seepage were evaluated for seasonal variation of seepage into the estuary in response to the groundwater table and rainfall. Mathematical models from simplified analytical models based on the Darcy theory to a complex two-dimensional numerical groundwater model were developed, calibrated/verified, and compared. Both the analytical model and the numerical model produced reasonable seepages compared with measurements. Time series groundwater seepage data were generated using a 1965–2008 POR. The total seepage was broken down into Upper Estuary (upstream of the US 1 Bridge), Middle Estuary (between the US 1 and A1A bridges), and Lower Estuary (between the A1A Bridge and St. Lucie Inlet). Results showed significant uncertainty exists for estimates of seepage with large variation in daily seepage values. Part of this study was used for the seepage input to the SLE CH3D.

MODELING PLAN STATUS

Predictive and numeric modeling tools are essential to predict and evaluate progress toward the SLRWPP objectives. These tools can be used to evaluate and quantify the nutrient load reduction achieved by construction projects and operational modifications as well as progress toward restoring natural hydrology and targeted water quality. An integrated modeling framework combining the resource-based VEC approach and linked watershed and estuarine models is described in the 2009 SLRWPP (SFWMD et al., 2009) (**Table 17**). It is envisioned that these models, when applied individually or collectively, will serve as adaptive management tools to help measure progress or refine protection plan goals.

Table 17. Model inventory in the 2009 SLRWPP.

Model Category		Model[1]	Model Domain[2]	Model Outputs	Model Simulation Period	Responsible Agency[3]	Past Applications[4]
Models Reviewed in 2009 SLRWPP	Watershed Model	WaSh	St. Lucie River Watershed	Flow, stage, water quality	1965–2005	SFWMD/ FDEP	IRL-S PIR C-44 Reservoir, SLRWPP St. Lucie Water Reservation
	Watershed Model	NESREM	Northern Estuaries Basins and Lake Okeechobee	Flow and stage	1970–2005	SFWMD	Northern Everglades Program
	Optimization Model for System Planning and Operation	OPTI	St. Lucie River Watershed	Reservoir and STA operation scheme	1965–2005	SFWMD	IRL-S PIR SLRWPP St. Lucie Water Reservation
	Estuarine Hydrodynamic/ Water Quality Model	CH3D/ EFDC	SLE	Water level, salinity, velocity, water quality	1965–2005	SFWMD	St. Lucie Water Reservation System Operations such as Lake Okeechobee releases
	2D Hydrodynamic Model and Salinity Management Model	RMA/ LSMM	SLE/IRL	Water level, salinity, velocity	1965–2005	SFWMD	IRL-S PIR MFLs
	Oyster Stress Index	Oyster Index	SLE	Oyster stress level	Multiple year simulation	SFWMD	IRL-S PIR
Newly Developed	Oyster Stress	OYSTER v1	SLE	Oyster stress level, filtration rate, and oyster production	Multiple year simulation	SFWMD	N/A
	Seagrass	Syring v1	SIRL	Seagrass growth, shoot count, shoot density	Multiple year simulation	SFWMD	N/A
	Watershed Model		Estuarine Model		Ecological Model		

[1]WaSh = St. Lucie River Watershed Model; NESREM = Northern Everglades Regional Simulation Model; OPTI = St. Lucie Reservoir Optimization Model; CH3D = Hydrodynamic Model; EFDC = Environmental Fluid Dynamics Code; RMA = 2-D Estuarine Hydrodynamic and Salinity Model; LSMM = Long-term Salinity Management Model; OYSTER v1 = Oyster Survival and Filtration Model; Syring v1 = Syringodium Growth Model

[2]SLE = St. Lucie Estuary; IRL = Indian River Lagoon

[3]FDEP = Florida Department of Environmental Protection; SFWMD = South Florida Water Management District

[4]IRS-S PIR = Indian River Lagoon – South Project Implementation Report (USACE and SFWMD, 2004); MFLs = Minimum Flows and Levels; N/A = not applicable

Regional and Watershed Hydrology and Water Quality Modeling

Northern Everglades Regional Simulation Model

The Northern Everglades Regional Simulation Model (NERSM) was used to guide the formulation and evaluation of alternative plans during the River Watershed Protection Plan (RWPP) process. It simulates the interaction of the St. Lucie River Watershed with other NEEPP components (i.e., Lake Okeechobee and Caloosahatchee River Watershed) and operations of the Lake Okeechobee and project features defined in the RWPP. Recent work on NERSM involves adding the Everglades Agricultural Area (EAA) into the model domain. The purpose of the addition is to represent the entire South Florida water management system while providing a tradeoff in water deliveries among basins around Lake Okeechobee, in particular between the St. Lucie River and Caloosahatchee River watersheds and the EAA. The 2008 Lake Okeechobee Regulation Schedule is also incorporated into the latest NERSM whereas the 2000 Water Supply/Environmental Regulation Schedule was used in the 2008 RWPP. Another objective of this update was to add flexibility and robustness to the model so that water quality treatment efficiency of STAs in the EAA can be evaluated. These functionalities can potentially be applied to future RWPP updates to evaluate the nutrient reduction efficiency of STAs such as the proposed C-43 Water Quality Treatment Area.

Optimization Model (OPTI)

The St. Lucie Reservoir Optimization Model (OPTI) was developed for the SIRL Feasibility Study (USACE and SFWMD, 2004) to optimize the size and operation of the storage reservoir/STAs, which are essential features of the SLRWPP. In the original design, the C-23 and C-24 reservoirs were located next to each other, connected by an equalized culvert. Due to land acquisition issues, the USACE revised the design (USACE, 2009), resulting in separation of the two reservoirs. In addition, a new STA was added to the design that will work in concert with the C-23 reservoir. The newly designed C-23 reservoir/STA can take water from and release water to the C-23 and C-24 canals. In 2009, OPTI version 6 was modified to accommodate these new features (Labadie, 2010). The new model, OPTI7, was applied to optimize reservoir/STA operation in the St. Lucie River Watershed. The optimization results show that, with the model optimized operation rule, the new reservoir/STA system can meet the original freshwater inflow distribution requirement and supplemental irrigation needs while providing fresh water to maintain a low salinity zone in the North Fork as defined in the Technical Document to Support a Water Reservation for the North Fork of the St. Lucie River (SFWMD, 2009a). The model results passed the Project Delivery Team review organized by the USACE in 2010.

Watershed Loading Model

The St. Lucie River WaSh is a coupled watershed water quality model. The FDEP funded the model refinement to support the St. Lucie River and Estuary TMDL development (URS, 2008). As part of the refinement, land use classifications were updated; site-specific, aerial-based mean concentrations were developed and implemented; simulation of tidal flows in the SLE was implemented, and a water quality simulation was included.

The new model was reconfigured, calibrated, and validated for the St. Lucie River Watershed. Four separate but linked models were developed to represent the entire watershed. Three separate models were configured for the C-23, C-24, and C-44/S-153 sub-watersheds. Outputs from these models were used as flow and load inputs into the SLE tidal basin model. The SLE tidal basin model includes all of tidally connected portions of the estuary, as well as the area of the North Fork Sub-watershed upland of the Gordy Road structure. Data used for calibration and validation were from a 1995–2005 POR for the C-24, C-23, and C-44/S-153 sub-watershed. The tidal basin WaSh was not calibrated.

Estuarine Hydrodynamic and Water Quality Modeling

Estuarine hydrodynamic and water quality models are developed to simulate (1) the salinity distribution in the SLE under different flow and operation conditions including operations of Lake Okeechobee and project features defined in the RWPP; and (2) water quality conditions in the estuary and its response to nutrient loading reductions as defined by TMDLs. Information regarding the progress made on model refinement and applications in the SLE CH3D, Sediment Transport Model (CH3D-SED), and a water quality model is provided in this section. Simulation results of load reductions using the water quality model are also summarized.

CH3D Model Enhancement and Applications

The SLE CH3D hydrodynamic model went through vigorous calibration/verification processes for applications in (1) the St. Lucie Water Reservation Project, (2) operational support to analyze freshwater releases from Lake Okeechobee, and (3) the SLE Nutrient Criteria Case Study. Calibration, verification, and application for the St. Lucie Water Reservation were documented in Appendix D of the Technical Document to Support a Water Reservation for the North Fork of the St. Lucie River (SFWMD, 2009b). Overall, these efforts included (1) calibrating/verifying the CH3D model for the 1999–2005 period with improved groundwater input; (2) extending the period of simulation to 2008 to further verify the model using Acoustic Doppler Current Profiler information collected in 2007; and (3) performing a baseline simulation for the 1965–2005 period, in which tidal boundary conditions were created based on harmonic analysis and observations at a long-term station and freshwater inflow boundary conditions were created based on gauged flow at structures and WaSh model output.

CH3D-SED Sediment Transport Model

CH3D-SED (Sun, 2001) is a multiple-group suspended sediment transport model capable of simulating both fine (mud) and coarse sediment transport under combined current and wave actions. Sediment processes considered by the model include advection, settling, flocculation of fine sediment, erosion (resuspension), and deposition. The model is capable of simulating sediment resuspension induced by both mean currents and wind waves. The model was calibrated for the 1999–2006 period. Sediment parameters including settling velocity and size distribution (in suspension) collected during the SLE ETM study were used in the model. **Figure 26** shows that the CH3D-SED was able to simulate TSS reasonably well compared with monthly observations at the SE03, SE06, and HR1 sites during the simulation period.

St. Lucie Estuary Water Quality Model

The water quality model for the SLE was developed using the Environmental Fluid Dynamics Code (EFDC) Water Quality Model, which has similar eutrophication kinetics to the Chesapeake Bay Water Quality Model. It was calibrated for the 1999–2005 period with monthly grab sample data collected at the SLE water quality monitoring stations. Significant improvement has been achieved for the simulation of nutrients (SFWMD et al., 2009). More recently, further advancement has been made on dissolved inorganic nutrients, and noticeable progress has also been made for improving the simulation of Chl*a* (e.g., SE03, **Figure 27)**. **Figure 28** and **29** compare the modeled and observed TN and TP concentrations at SE03 from 1999 to 2005 (Roosevelt Bridge). The resulting r^2 value was 0.60 for TN and 0.56 for TP. Currently, this model is being applied to develop a nutrient budget for the SLE during the simulation period. Another important application of this water quality model is the simulation of estuarine response to nutrient load reduction.

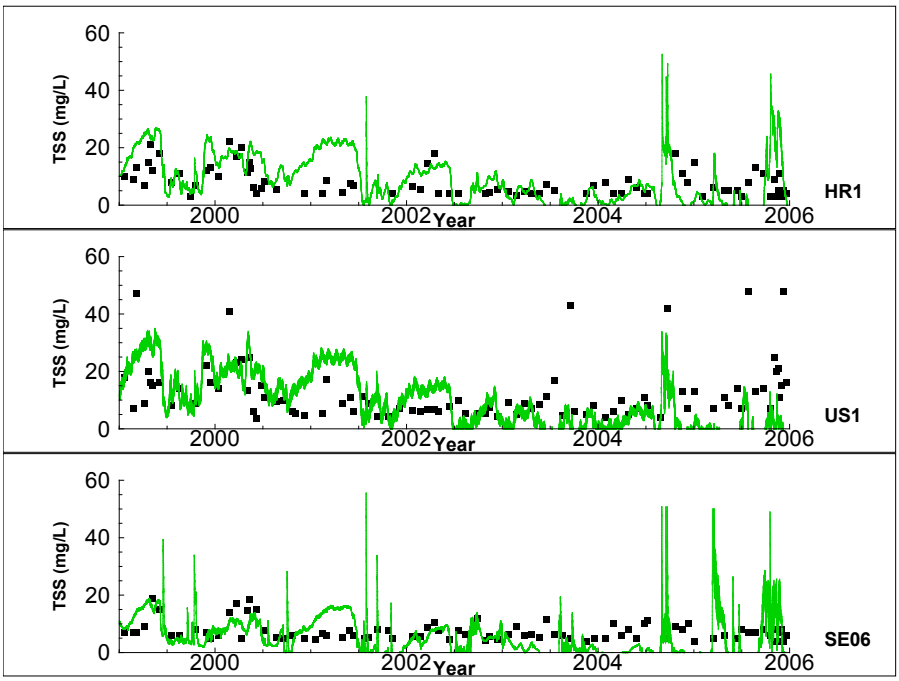


Figure 26. Comparison of modeled total suspended solids (TSS) (line) with monthly observations (diamonds) at the HR1, US1, and SE06 sites.

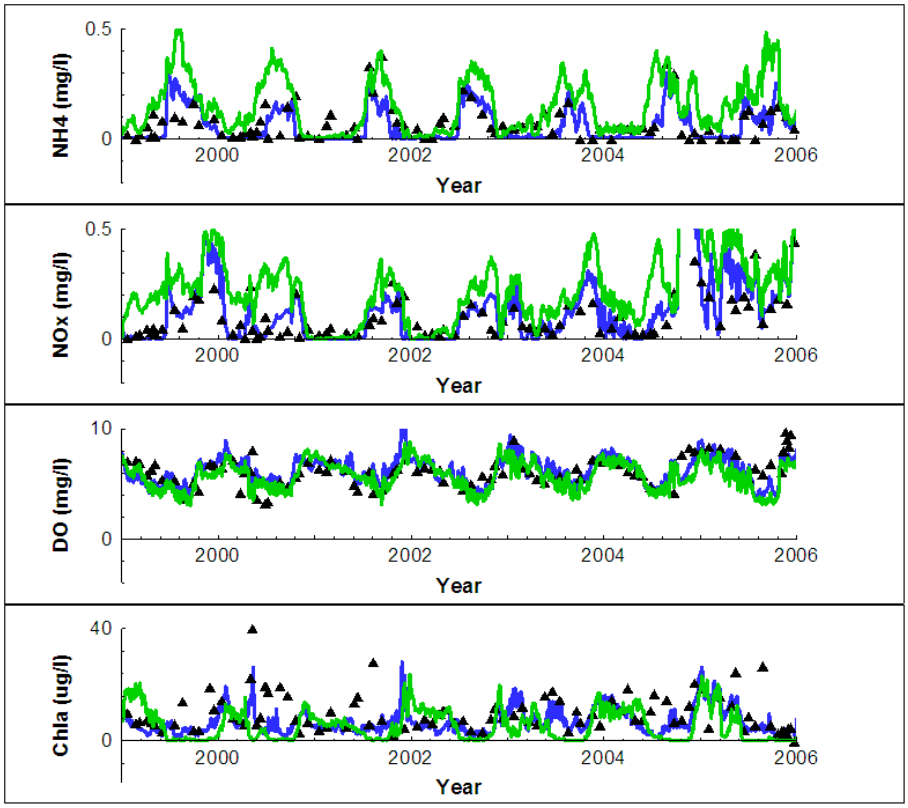


Figure 27. Comparison of simulated nutrients at the SE03 site as demonstrated by the new run (blue lines) and previous results (green lines) for ammonia (NH_4), nitrogen dioxide (NOx), DO, and Chl*a*.

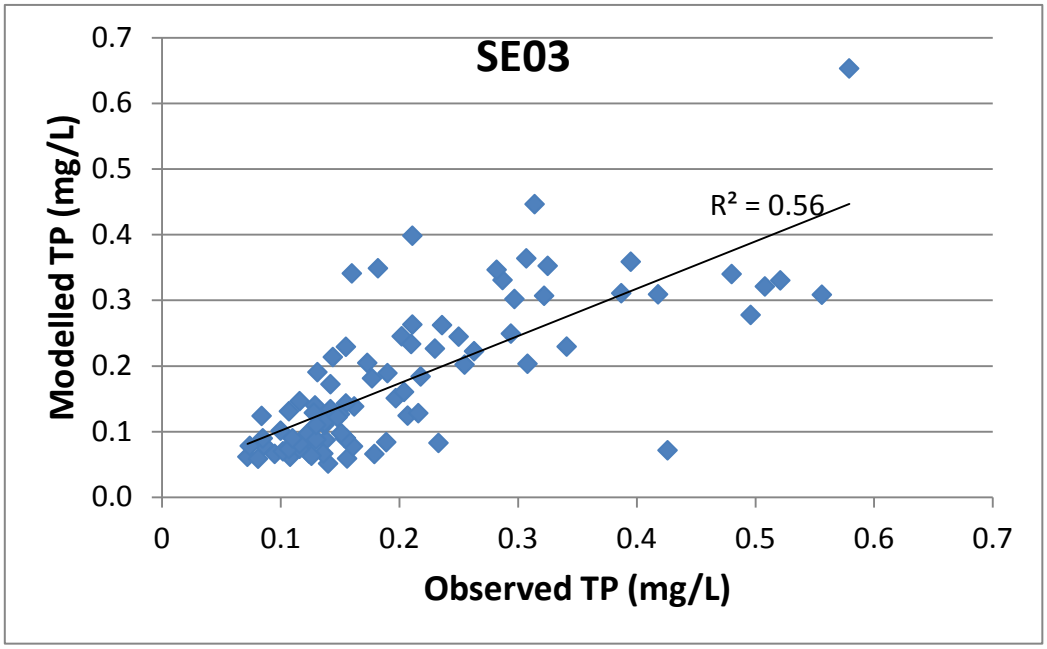


Figure 28. Comparison between modeled and observed TP (mg/L) at site SE03 for 1999–2005.

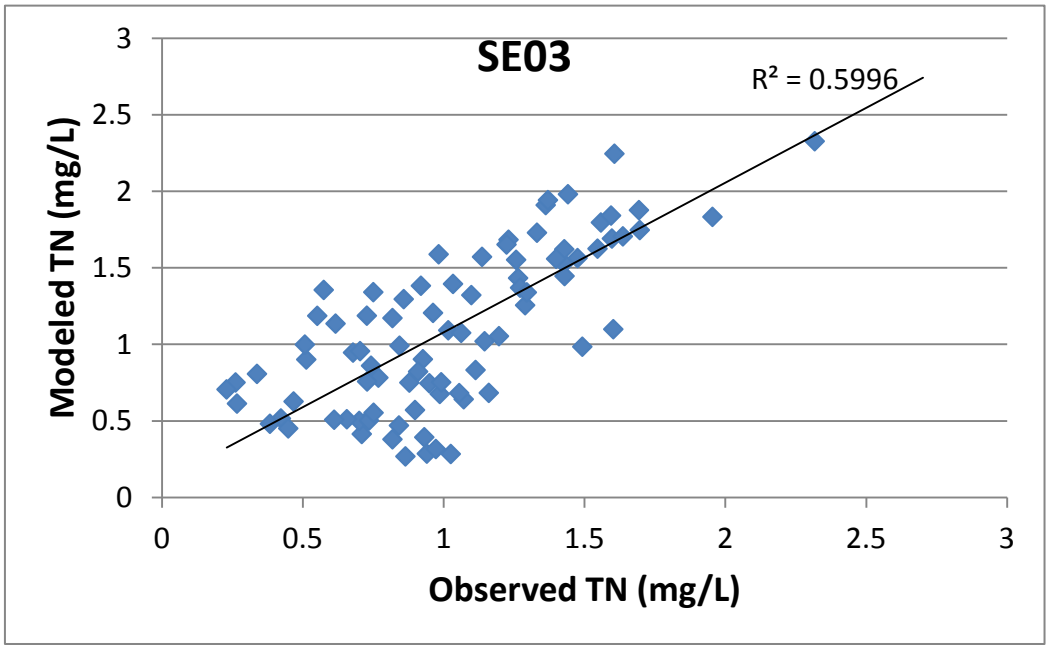


Figure 29. Comparison between modeled and observed TN (mg/L) at site SE03 for 1999–2005.

Simulation of Load Reduction

The SLE TMDL (FDEP, 2008) established target nutrient reduction goals at the Roosevelt Bridge. The load reduction was based on water quality targets (81 µg/L for TP; 0.72 mg/L for TN) at the same location. The targets were initially developed by the IRL–S Project Water Quality Sub-team and were documented in the IRL–S Final Integrated Project Implementation Report and Environmental Impact Statement (USACE and SFWMD, 2004). The load reduction goals for TMDLs were calculated based on the percentage reduction between the target load and the estimated existing load:

$$\text{Reduction Goal} = (L_{existing} - L_{target}) / L_{existing} = C - C_{target} / C$$

Where:

$L_{existing} = C \times Q$

$L_{target} = C_{target} \times Q$

Q = estimated annual mean flow

C = annual mean concentration

This process, as suggested by the FDEP, indicates that the load reduction is to be achieved by reducing concentration and has little to do with flow. The TMDL for SLE is measured at the Roosevelt Bridge, and applied at each sub-watersheds discharge point as 0.81 mg/L for TP and 0.72 mg/L for TN.

Two scenarios were simulated using the calibrated SLE water quality model to evaluate whether nutrient load reductions would achieve the nutrient targets. The first scenario was the reduction of TN load by 30 percent and TP load by 57 percent, as suggested in the IRL-S plan. The second scenario was the reduction of TN and TP, as defined in the TMDLs (FDEP, 2008). The SLE TMDL was based on a 10-year dataset from 1996 through 2005. The SLE water quality model was calibrated from 1999 through 2005. The first three years (1996–1998) were not included in the simulation, but will be added in the near future. In both scenarios, only the concentrations were reduced while the flows were unchanged.

Figures 30 and **31** show model results for TN, TP, DO, and Chl*a* at the SE03 station after load reductions, as suggested by the IRL-S plan and the TMDLs, respectively. Both load reduction scenarios can dramatically reduce TN and TP concentrations at the Roosevelt Bridge (SE03). The reductions were particularly evident during the wet season, with TMDLs showing better results than the IRL-S plan. **Tables 18** and **19** summarize the results as annual mean concentrations of TN, TP, DO, and Chl*a* at site SE03, comparing the existing condition and the two load reduction scenarios. The results indicate that (1) the IRL-S plan can meet the TN target except for 2004 and 2005 and can almost meet the TP target, and (2) TMDLs can meet the TN target by a significant margin and the TP target except for 2000, 2002, and 2004.

Overall, the water quality model results show slightly positive changes with respect to DO and Chl*a* concentrations on an annual basis. However, the responses by the model need to be examined further because of uncertainties of model assumptions and uncertainties in model parameters and boundary conditions.

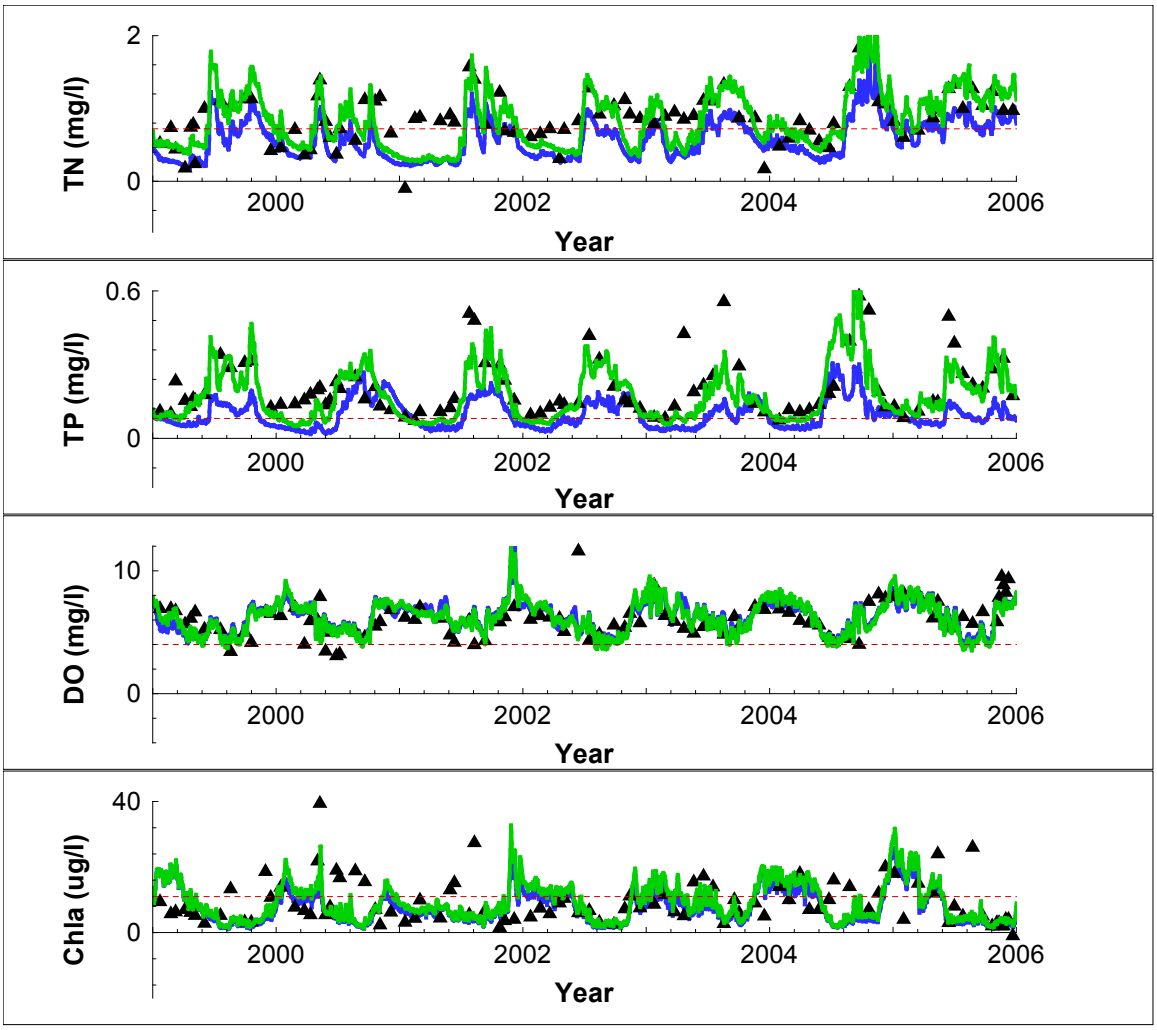


Figure 30. Concentrations of TN, TP, DO, and Chl*a* at site SE03 in response to load reductions suggested in the Indian River Lagoon – South Project Implementation Report (IRL-S PIR). The green line is the existing condition, the blue line is the response to load reductions, and the black triangles are observed values. Red dashed lines on the upper two graphs represent TMDL annual average target concentrations of 0.72 mg/L for TN and 0.081 mg/L for TP (FDEP, 2008). The red dashed lines in the lower two graphs indicate the existing Class III minimum DO criterion (4.0 mg/L) and the annual average Chl*a* concentration (11.0 µg/L) for Impaired Water Bodies.

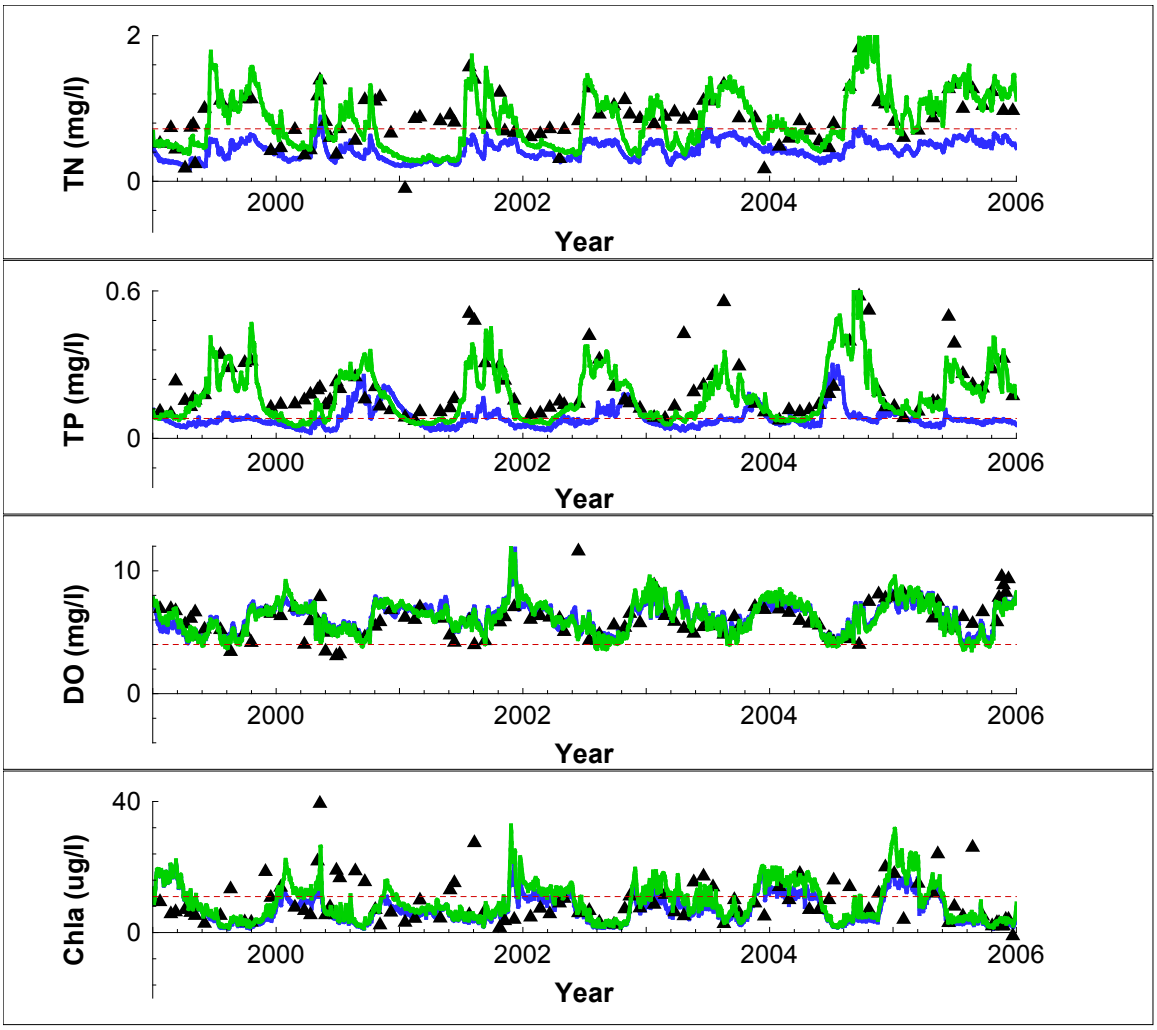


Figure 31. Modeled concentrations of TN, TP, DO, and Chl*a* at site SE03 in response to load reductions suggested by the Florida Department of Environmental Protection (FDEP) for the SLE TMDL. The green line is the existing condition, the blue line is the response to load reductions, and the black triangles are observed values. Red dashed lines in the upper two graphs represent TMDL annual average target concentrations of 0.72 mg/L for TN and 0.081 mg/L for TP (FDEP, 2008). The red dashed line in the lower two graphs indicates the existing Class III minimum DO criterion (4.0 mg/L) and the annual average Chl*a* concentration (11.0 µg/L) for Impaired Water Bodies.

Table 18. Comparison of annual concentrations of TN and TP between existing conditions and two load reduction scenarios: Indian River Lagoon – South Project (IRL-S) and Total Maximum Daily Load (TMDL). [Note: TMDL target concentrations are TP=81 µg/L and TN=0.72 mg/L.]

	TN (mg/L)				TP (mg/L)			
Year	Observed Annual Mean	Simulated as Existing Condition	IRL-S Load Reduction Simulation	TMDL Load Reduction Simulation	Observed Annual Mean	Simulated as Existing Condition	IRL-S Load Reduction Simulation	TMDL Load Reduction Simulation
1999	0.85	0.76	0.55	0.40	0.20	0.17	0.086	0.067
2000	0.87	0.76	0.57	0.45	0.17	0.16	0.095	0.091
2001	1.18	0.86	0.63	0.45	0.22	0.21	0.10	0.069
2002	0.96	0.70	0.53	0.44	0.18	0.16	0.10	0.089
2003	1.03	0.92	0.67	0.54	0.23	0.17	0.082	0.071
2004	1.22	1.26	0.91	0.52	0.23	0.23	0.127	0.10
2005	1.24	1.43	1.00	0.63	0.23	0.21	0.093	0.071

Table 19. Comparison of annual concentrations of DO (mg/L) and Chl*a* (µg/L) between existing condition and two load reduction scenarios.

	DO (mg/L)				Chlorophyll *a* (µg/L)			
Year	Observed Annual Mean	Simulated as Existing Condition	IRL-S Load Reduction Simulation	TMDL Load Reduction Simulation	Observed Annual Mean	Simulated as Existing Condition	IRL-S Load Reduction Simulation	TMDL Load Reduction Simulation
1999	5.70	5.44	5.45	5.67	7.51	9.02	8.52	8.46
2000	5.30	6.01	6.07	6.11	12.9	9.27	7.61	7.30
2001	5.64	6.57	6.68	6.67	8.21	7.69	6.72	6.62
2002	6.14	5.70	5.79	5.92	6.77	8.51	7.06	6.92
2003	6.04	6.65	6.74	6.79	9.23	10.62	8.87	8.30
2004	5.94	6.16	6.22	6.28	11.75	10.26	8.43	7.80
2005	7.30	6.72	6.81	6.83	8.23	8.28	7.02	6.05

Estuarine Ecological Modeling

Estuarine ecological models are required to (1) evaluate the ecological response to nutrient load reduction and operational modifications and progress toward restoration of natural hydrology; and (2) refine salinity envelopes and flow targets. Two modeling efforts were initiated by the District to simulate the effects of freshwater discharge on oyster survival and filtration in the SLE and on survival and growth of manatee grass (*Syringodium filiforme*) in SIRL.

Oyster Survival and Filtration Model

The widespread decline of eastern oysters induced by excessive fresh water from the St. Lucie River Watershed and Lake Okeechobee has resulted in increased efforts to restore the acreage of live oyster beds. An oyster survival and filtration model (OYSTER v1) was developed to assess ecosystem-scale benefits of oyster restoration in the estuary. The model predicts oyster biomass using physical representation of circulation in the SLE, phytoplankton dynamics, and oyster filtration. Oyster growth functional forms were derived from experimental and literature data to relate oyster biomass with salinity and temperature. Average daily salinity and temperature were derived using input data collected from a continuous monitoring station at the Roosevelt Bridge. Monthly average TSS concentrations were calculated from biweekly grab samples taken just below the surface.

A series of simulations spanned 10 years (3,650 days) mirroring water column data collected from 1998 through 2007. Results indicate oyster biomass varied as a function of temperature and salinity from near zero values following large freshwater discharge in 2002–2003 to maximum values near 150–200 grams of carbon per square meter early in 1999 and 2006. Filtration by oysters was greatly reduced at low salinity values with oyster filtration near zero during times of freshwater discharge (1999, 2001, 2004, and 2005 wet seasons). A relationship between the time needed to filter the entire estuary and the oyster habitat area was derived from the model (**Figure 32**). While living oysters could filter the entire volume of the estuarine segment in 55 days with 50 hectares of oyster habitat, this number is reduced to less than 20 days at 300 hectares with an estimated fivefold increase in net consumption of phytoplankton. Overall, results indicate that successful oyster habitat restoration in the SLE relies on reestablishment of biologically desirable flow and salinity envelopes in the Middle Estuary, which would stabilize oyster survival and improve estuarine water quality.

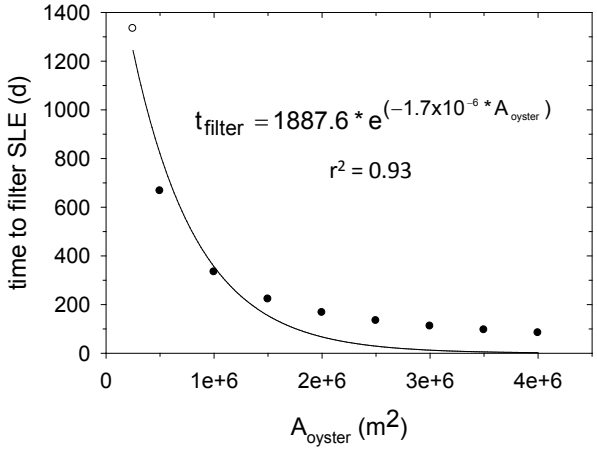


Figure 32. Relationship between the oyster habitat area (A_{oyster}) and the time (in days) required to filter the entire volume of the SLE Middle Estuary.

Syringodium Growth Model

Manatee grass provides essential habitat in the biologically rich IRL. Flood events, such as those that occurred in the 2004 and 2005 wet seasons, introduce material loads and fresh water that affects the species' survival and growth. A manatee grass growth model (Syring v1) was developed to better understand the affects of environmental variability, climatic events, and water management. The model simulates changes in manatee grass biomass under multiple, non-linear forcing variables including salinity, light, and temperature. A sigmoidal salinity growth curve was derived from experimental data (**Figure 33**, panel A). The spatial domain of the model is the seagrass meadow located near Boy Scout Island approximately three kilometers north of the St. Lucie Inlet, which fluctuated in total size from a maximum of 13.2 hectares to a minimum of 5.2 hectares from 2002 through 2007. The model had an integration interval of three hours with the simulations spanning 2,190 days.

The model was useful to predict manatee grass aboveground biomass with greater than 70 percent confidence (**Figure 33**, panels B–C). While salinity less than or equal to 20 psu stunted grass growth on shorter time scales, longer-term changes in submarine light with discharge were also relevant. Study results emphasized that submarine light attenuation through increased turbidity and color, and not phytoplankton biomass, was an important determinant to the survival and growth of manatee grass.

Monitoring Update

Four entities currently perform water quality monitoring in the St. Lucie Watershed and Estuary: District, FDEP, St. Lucie County, and Martin County. In addition, the District and Florida Fish and Wildlife Conservation Commission monitor seagrasses and oysters, respectively. The 2009 SLRWPP included an inventory of these monitoring efforts (SFWMD et al., 2009), updates to which are provided in **Attachment D**. The most notable change in monitoring since the 2009 plan include the following:

- The District's St. Lucie tributary monitoring network was discontinued in 2011 (effective in the first quarter FY2012).
- District salinity monitoring stations were reduced in 2009 from seven to three.
- St. Lucie County added two tributary sampling locations in Platt's Creek.
- Martin County Health Department discontinued testing for fecal coliform.

In preparation for revisions to the District's Regulatory Nutrient Source Control Program (40E-61 F.A.C) to encompass the St. Lucie Watershed, the District plans to optimize the existing monitoring network to maximize evaluation of source control performance across all sub-watersheds. The short-term objective, if technically and economically feasible, is to expand the monitoring network by implementing flow monitoring in three tidally influenced areas of the St. Lucie River Watershed.

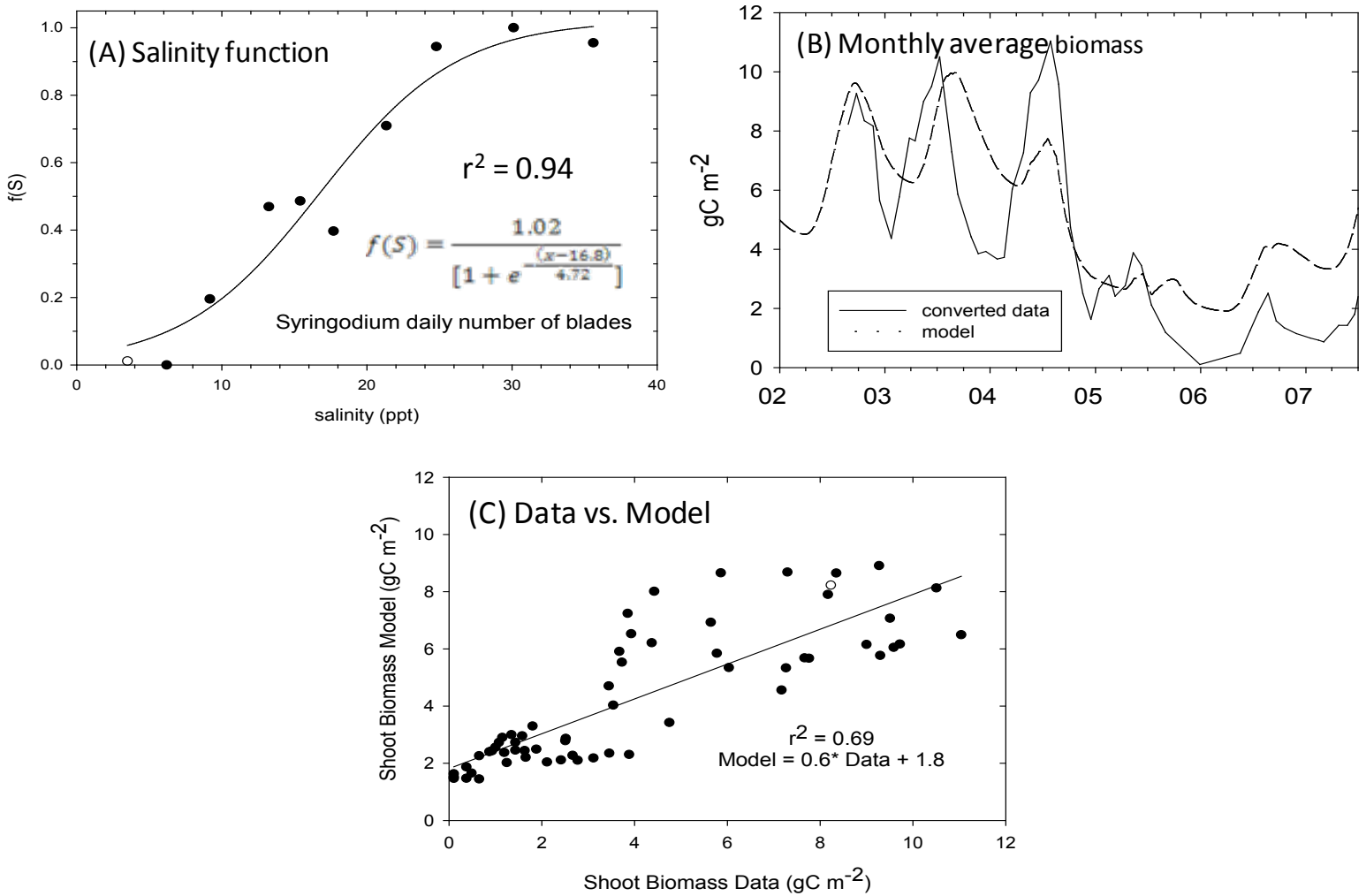


Figure 33. (A) Manatee grass growth response to range of salinities (3.5–35.0 psu), or the salinity function [f(S)]. (B) Time series of empirical data (solid) and simulated (dashed) manatee grass shoot biomass [in grams of carbon per square meter (gCm-2)] from 2002 to 2007. (C) Regression between manatee grass shoot data and model.

ST. LUCIE RIVER WATERSHED STRATEGIES

Pinar Balci, Lesley Bertolotti and Fawen Zheng

ISSUES AND ACTIONS

The health of the SLE has been affected over the years by many factors including natural system alterations, population growth, leaky septic tanks, and the timing and quantity of freshwater discharges from both the Lake Okeechobee and St. Lucie River watersheds, which have a direct effect on the salinity balance and water quality within the estuary. Given the diverse and complex challenges facing the SLE, an integrated approach is required at the source, local, sub-regional, and regional levels in order to achieve the TP and TN load reductions required by the state's TMDL Program as well as to meet desirable salinity ranges for the estuary. The SLRWPP is built upon such an approach designed to reach water quality targets and maintain appropriate salinity levels in the estuary. As part of NEEPP, the SLRWPP is being implemented by the coordinating agencies in collaboration with local governments. Approximately $5.9 million in state and District funds has been invested to implement SLRWPP activities and projects since 2007. In addition, $488.4 million has been invested toward the Comprehensive Everglades Restoration Plan (CERP) Indian River Lagoon - South project. Significant achievements over the past three years include the following:

- FDEP adoption of nutrient TMDL targets (nitrogen and phosphorus) for the St. Lucie Estuary in 2009.
- Continued cost-share investments by the state, the District, and area county/ municipalities in support of 49 local water quality improvement projects since 2000 within the St. Lucie River Watershed.
- In 2011, the District initiated the new NE-PES Solicitation Program in partnership with interested private landowners to obtain water management services of water and nutrient retention, thereby reducing flows and nutrient loads to Lake Okeechobee and downstream estuaries.
- Surface water storage on private, public, and tribal lands in the Northern Everglades has expanded to 131,539 ac-ft, of which 7,117 ac-ft are located in the St. Lucie River Watershed. Additional storage at sites on fallow citrus land is being investigated under the Water Farming Pilot Program.
- Key technical review and data evaluation activities were completed to help develop a future regulatory source control program in the St. Lucie River Watershed. The District will coordinate with the OFARR prior to initiating rule development to amend Chapter 40E-61, F.A.C.
- The USACE awarded the first of three contracts to construct the CERP IRL-S C-44 Reservoir/STA, which will provide 50,600 ac-ft of storage and is estimated to reduce TN and TP loads to the SLE by 26 and 82 metric tons per year (mt/yr), respectively. As local sponsor, the SFWMD has invested $229 million toward the project.
- Martin County and the District approved a strategic public-private partnership project located on 2,000 acres of land in the C-44/S-153 Sub-watershed approximately one mile from the Herbert Hoover Dike along the C-44 canal. The

project, known as Lake Point Restoration, will help treat and store water released from Lake Okeechobee to the C-44 canal.

- Revisions to Chapter 62-640, F.A.C., were adopted and took effect in August 2010. The revisions are designed to improve application and management of Class B biosolids and enhance distribution and marketing of Class AA biosolids. By 2013, no Class B biosolids application will be permitted in the Northern Everglades watersheds unless a nutrient balance demonstration is completed by the applicant and approved by the FDEP. To address stakeholders' concerns about Class AA biosolids spreading in the Northern Everglades, various measures were adopted during the rulemaking process, including the prohibition of having more than one dry ton of unapplied Class AA biosolids on a property without proper storage and more stringent reporting requirements.
- Six continuous flow-through Hybrid Wetland Treatment Technology (HWTT) systems are operational in the Northern Everglades, with the Ideal Groves HWTT located in the St. Lucie River Watershed. This technology is proving to be effective in reducing TP concentrations in surface waters, with such reductions ranging between 87 and 95 percent.
- The FDEP initiated the BMAP for the St. Lucie River Watershed and is continuing to work collaboratively with stakeholders on its development and identification of nutrient reduction projects to meet the adopted nutrient TMDLs.

2012 PLAN UPDATE – STRATEGIES

This 2012 SLRWPP represents the three-year update to the original 2009 plan (SFWMD et al., 2009). This update includes strategic projects and activities for water quality and quantity improvements to benefit the St. Lucie River Watershed and Estuary, focusing on projects that the coordinating agencies will be implementing over the next three years (2012–2014).

Addressing Water Quality: Strategies and Next Steps

Addressing water quality issues in the St. Lucie River Watershed and achieving the level of TP and TN load reduction required by the TMDL Program requires coordinated and integrated actions. Implementation of agricultural and urban BMPs, regulatory programs, and water quality improvement projects at different spatial scales are part of these integrated strategies. The following section describes the next steps in source control to address SLE water quality issues. It also includes a list of strategic construction projects and technologies as well as future research and modeling needs.

Source Control Program

As discussed in the *Pollutant Source Control Program* section of this report, source controls are integral to the success of the SLRWPP. The integrated management strategy to cost-effectively achieve the load reduction goals is based on the foundation of regulatory nutrient source control programs. Further details on these source control programs and their status are covered in Chapter 4 of this SFER volume, with near-term highlights of planned efforts provided below.

District Regulatory Nutrient Source Control Program

- The District will optimize the existing monitoring network to maximize evaluation of source control performance across all sub-watersheds. The short-term objective, if technically and economically feasible, is to expand the

monitoring network by implementing flow monitoring in three tidally influenced areas of the St. Lucie River and Caloosahatchee River watersheds (about 100,000 and 260,000 acres, respectively).

- The District will complete a preliminary proposal of performance measure methods to determine the collective performance of the source control programs at the sub-watershed level. Development of performance measure methods will be prioritized at the sub-watershed level and brought forward for peer and technical review by stakeholders. Next, the development of water quality monitoring requirements and performance measures will be considered at the individual level for sites with prior septage application and for agricultural sites where landowners opt not to participate in the FDACS BMP program.
- NEEPP directs the District to initiate rule development amending the Works of the District program in Chapter 40E-61, F.A.C., by developing a nutrient source control program utilizing BMPs for agricultural and non-agricultural lands for the St. Lucie River and Caloosahatchee River watersheds. The District will coordinate with the OFARR prior to initiating rule development to amend Chapter 40E-61, F.A.C. Agricultural lands participating in the FDACS program will be recognized as meeting the intent of the proposed amended rule. It is expected that the proposed rule amendments will include incentives to participate in nutrient reduction demonstration and research projects to provide the data necessary for optimizing BMP performance.

FDACS Agricultural BMP Program

- The FDACS will continue to enroll agricultural lands, fund cost-share programs as funds are available, conduct implementation assurance activities, and adopt or update BMP manuals, as needed. However it should be noted that due to funding and resource constraints, the identification of cost-share BMPs within the St. Lucie River Watershed has been delayed. As funding becomes available, the FDACS will continue working with landowners to identify cost-share BMP opportunities. In addition, the FDACS will continue to work with the UF/IFAS to evaluate BMP effectiveness.

FDEP Source Control Programs

- The FDEP will continue to develop the BMAP for the St. Lucie River Watershed in collaboration with stakeholders.
- The FDEP-adopted amendments to Chapter 62-640, F.A.C., improve site accountability and management of Class B biosolids that addressed several public concerns. The FDEP will continue to work with stakeholders to address their comments and concerns regarding the use of biosolids. As Section 373.4595, F.S., currently does not prohibit Class AA biosolids fertilizers, phasing out the use of Class AA materials would likely require additional legislation. However, as a fertilizer product, Class AA biosolids fertilizers would be subject to the same nutrient management BMPs as other fertilizers and soil and tissue testing is required by FDACS BMP rule to justify the application of fertilizers in the Northern Everglades.
- The FDEP will continue to implement and enforce the NPDES permit program as delegated by the USEPA and implement the ERP program in accordance with

Chapter 373, F.S. The FDEP also will continue to support the FDOH in implementing their source control programs.

Strategic Construction Projects and Technologies

The near-term efforts will focus on construction projects that will ultimately provide larger quality and storage benefits in areas that have greater needs and offer significant opportunities. Also, pursuit of regional and sub-regional projects discussed in the *Construction Project and Other Related Projects* section of this report will continue through identifying new projects and investigating promising technologies. Two examples of such opportunities include the (1) Lake Point Restoration Project, which aims to provide storage and water quality benefits while also having the potential to provide cost savings for capital projects; and (2) the CERP IRL-S C-44 Reservoir/STA Project, which will ultimately provide 50,600 ac-ft of storage and an estimated nutrient load reductions to the SLE of 26 mt/yr for TP and 82 mt/yr for TN. The CERP IRL-S C-44 Reservoir/STA Project was initiated in 2011 with the award of the first of three construction contracts.

Lake Point Restoration Project

The Lake Point Restoration Project is a public-private partnership intended to promote Everglades conservation and improve water quality, while providing essential raw materials for infrastructure and restoration projects. It is a long-term project to construct water storage lakes and stormwater treatment cells for reducing nutrients in water from the C-44 canal. The 2,260-acre Lake Point site is in Martin County, with its northern boundary fronting the C-44/St. Lucie Canal and its eastern boundary adjacent to DuPuis Management Area (**Figure 34**). Approximately 2,000 acres of the property was donated to the District for use as a stormwater management and treatment project, particularly for the benefit of the SLRWPP, with Lake Point retaining the rock mining and farming rights on about 1,000 acres for the next 20 years. In May 2009, both the District and Martin County Board of County Commissioners approved the project. Given the project's strategic location, one mile from Lake Okeechobee (and the Herbert Hoover Dike), the Florida Department of Transportation (FDOT)-certified materials being excavated from the facility will provide significant transportation savings to the (1) USACE's repair work on the Herbert Hoover Dike, (2) District in their continuing Everglades restoration projects, (3) Florida Fish and Wildlife Conservation Commission on their Three Lakes Wildlife Management Area maintenance, and (4) FDOT/Martin County as they build the Indiantown and Indian Street Bridge.

IRL-S C-44 Reservoir/STA Project

The IRL-S C-44 Reservoir and STA will provide significant benefits to the SLE through reducing damaging freshwater discharges, helping maintain desirable salinity regimes, and decreasing nutrient loading to the estuary. In July 2011, the USACE awarded the first of three contracts. This initial construction includes the project intake canal, access road, and Citrus Boulevard Bridge. The construction of the reservoir, pump stations, discharge canal, and STA cells will be performed under subsequent contracts. As the local sponsor, the District will provide assistance and support to the USACE as needed during construction of the facility, per the Phase 1 project partnership agreement. Also it is planned that operations and maintenance activities will be transferred to the District once the facility is operational.

Local Water Quality Projects

While local projects individually have localized significance for providing water quality improvements, stormwater attenuation, flood protection, and ecological habitat, collectively they also provide sub-regional and regional benefits. Since 2004, investments by the state, District, and area county/municipalities have supported 49 local water quality improvement projects. In

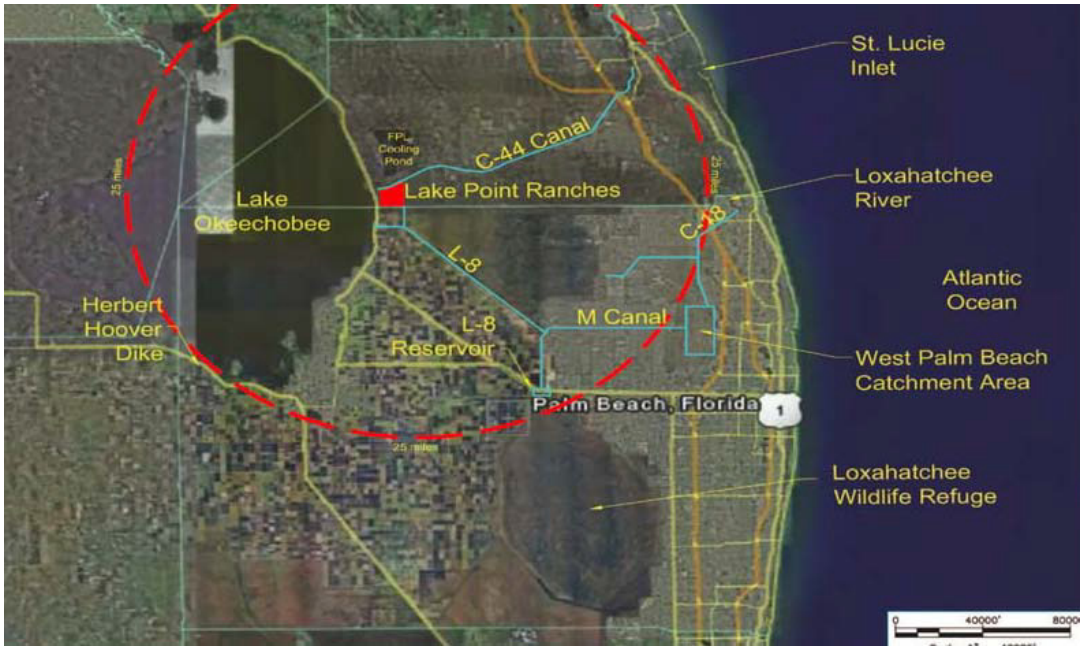


Figure 34. Vicinity of Lake Point Restoration project area (INTERA, Inc., 2010).

the near term (2012–2014), local projects in the SLRWPP are estimated to provide over 1 mt/yr of TP reductions and 4.5 mt/yr of TN reductions. Additional projects will be identified during the FDEP's BMAP current efforts to compile a comprehensive list of local water quality projects since 2000 and project-specific load reduction estimates. Once finalized, the FDEP's list and load reductions is expected to replace the current SLRWPP list of local water quality updates and the end result will likely be a greater total load reduction from local projects than currently estimated. The District and FDEP recognize the importance of local water quality projects (stormwater and wastewater retrofits and restoration projects), which is evident in the support provided in past years. It is anticipated that the coordinating agencies will continue to support local governments in such efforts as funding permits.

Alternative Nutrient Reduction Technologies

Chemical Treatment

Chemical treatment with aluminum sulfate, polyaluminum chloride, ferrous sulfate, or ferric chloride has been used for many years to reduce phosphorus levels in lakes and stormwater runoff (Wanielista, 1979; Wanielista et al., 1981; Harper et al., 1982; Lind 1997). Currently, multiple types of chemical treatment technologies exist that can be applied both in-stream and in off-line treatment systems. Chemical treatment is not just a stand-alone method; it is anticipated that chemical treatment can also be used with other control strategies that reduce water discharge volumes or phosphorus concentration, thereby achieving further TP load reductions. Treatment costs vary depending upon influent water quality, volume of water treated, and level of treatment desired. The location of chemical addition (pre-treatment versus polishing) also plays a major part in determining total treatment cost.

Completed in July 2009, the Northern Everglades Chemical Treatment Pilot Project Phase I was conducted to (1) investigate available information on chemical treatment technologies that have been tested within other water bodies to reduce TP loads in stormwater runoff, and (2) identify technologies appropriate for use within the Lake Okeechobee Watershed. Results of the study concluded that various chemical treatment technologies are viable and represent

effective options for reducing TP loads to the lake (Bottcher et al., 2009). Completed in October 2010, the District conducted Phase II of this project, which included implementation costs and site identification analysis for chemical treatment technologies in the Northern Everglades (SWET, 2010). Multiple areas identified as potentially appropriate for chemical treatment are located within each of the St. Lucie River sub-watersheds, except the Basin 4-5-6 Sub-watershed. The Phase II report recommends conducting further detailed site engineering assessments including additional landowner contacts, site-specific monitoring, topographic surveys, detailed engineering designs, small-scale testing for efficacy of chemical dosing, and development of operation and maintenance plans. This analysis provided valuable information for possible future implementation of chemical treatment at various spatial scales. Additional information on chemical treatment in the Northern Everglades is covered in Section 5.1.3.2 of the 2011 Lake Okeechobee Protection Plan Update (SFWMD et al., 2011).

New Alternative Technology Assessment

Assessment of new technologies is essential to successfully achieve nutrient reductions goals in the Northern Everglades. Also, the District is often approached by innovative firms with ideas for improving water quality, prompting a need for a more structured process to understand and assess these technologies. In order to streamline this process, the District designed the New Alternative Technology Assessment (NATA) Program, which aims to provide an opportunity for interested parties to demonstrate potential alternative technologies for the reduction of nitrogen or phosphorus external loading in water or sediments emanating from the Everglades watershed. While there is no dedicated funding for this effort, the District plans to provide a physical location for successful applicants to demonstrate their technology's potential to reduce nutrients. This arrangement allows for cutting-edge water quality research specific to South Florida ecosystems to be conducted cost-effectively. Project proposals are vetted through a selection process with a predetermined set of evaluation criteria and evaluated by a District scientific team. Two current NATA projects include testing permeable reactive barriers (PRB) technologies to reduce nutrients from groundwater before entering surface waters and nutrient binding materials to remove nutrients from surface waters. Further testing of these technologies will provide a better understanding of their potential for expanded use in the St. Lucie River Watershed. A summary of these projects is as follows:

- **Permeable Reactive Barrier.** PRB is a nutrient reduction technology currently being tested in the Lake Okeechobee Watershed. This project evaluates the incorporation of water treatment residuals or similar materials capable of intercepting and sequestering phosphorus in the Lake Okeechobee Watershed before the nutrient enters the rivers and canals leading to the lake. The District completed a laboratory study examining the feasibility of using PRB technology to reduce TP loads to the lake and testing of suitable materials for PRB construction and design for locations appropriate for the Lake Okeechobee Watershed. Currently, there is one PRB site in the Lake Okeechobee Watershed on private lands. The District is studying the effectiveness of this system, but due to drought conditions in 2011, sampling has just recently commenced. The preliminary results are promising and an additional site will be initiated during FY2012. If this is determined to be an effective nutrient reduction technology, the feasibility of its application could be expanded to include the river watersheds.
- **Nutrient Binding Materials.** Two products the District is currently testing involve nutrient binding materials to remove nutrients from surface waters. These technologies are being tested side by side in dedicated treatment test cells within STA-1West. Both utilize proprietary clay-like materials that bind phosphorus and

nitrogen. Concurrently, in-house staff is conducting phosphorus-flux studies on these two products, as well as a third similar bentonite product, to determine their ability to sequester phosphorus from soils in the Everglades Agricultural Area. Further testing of these technologies is expected to provide a better understanding of their potential for expanded use in the Northern Everglades.

Research and Modeling Strategies

Research Needs and Future Recommendations

Continued research, monitoring and development of tools are important to track progress toward achieving water quality goals. Recent research indicates that the first priority area for further investigation in the St. Lucie River Watershed is the development of a nutrient budget that includes both the watershed and estuary. A well-constrained nutrient budget is needed to identify and understand the origin, magnitude, and management of controllable, problematic nutrient loads to the SLE. The nutrient budget needs to include inputs and outputs from both the watershed and estuary. The high priority projects are as follows:

- **Identification and Quantification of Nutrient Inputs and Exports for the St. Lucie River Watershed.** A nutrient budget for the watershed will identify the major sources of nitrogen to the watershed, and locate areas of high nutrients and sites where major exports to the downstream receiving waters occur. This information will help guide the prioritization and placement of features included in future updates of the SLRWPP. Studies are needed to quantify nutrient inputs based on land use and rainfall, and exports to the atmosphere, groundwater, and estuary.
- **Estuarine Water Quality Model**. The estuarine water quality model is a tool that can predict effects of reductions from these on nutrient concentrations in estuarine receiving waters. Along with the watershed nutrient budget, the estuarine water quality model can be used to help guide the prioritization and placement of features/projects so that the TMDL concentration goals are met cost effectively.

Estuarine nutrient concentrations depend not only on external loads from the watershed, but also on internal recycling in the water column and bottom sediments. The contribution of internal loads from the sediments on water column concentrations can be as significant as external loads from the watershed. The next two projects provide information necessary to include rates of internal nutrient cycling in the water quality model:

- **Characterization and Quantification of Nutrient (Nitrogen and Phosphorus) Cycling within the SLE Water Column.** One approach to estimating nutrient uptake and regeneration rates in the water column is to measure the production and consumption of oxygen. These rates can be used directly to help calibrate parts of the water quality model that estimate the concentration of DO. By assuming or measuring the nutrient composition of organic matter in the water column, rates of nutrient uptake and regeneration also can be estimated. These rates can be used to help calibrate those parts of the model that estimate nutrient concentrations.
- **Characterization and Quantification of Nutrient (Nitrogen and Phosphorus) Cycling within the SLE between the Sediments and Water Column.** Nutrient input from sediments could be extensive enough to delay the response of the estuary to nutrient reductions from the watershed. The 2008 dry season data has

provided estimates of the lower boundary of these inputs. Wet season data are critical to quantifying the upper boundary of these inputs.

Modeling Needs and Future Recommendations

Modeling needs and recommendations from the 2009 SLRWPP were revisited in light of the modeling progress summarized in the RWQMP and the sufficiency or capability of existing models to evaluate or define pollutant load reduction to achieve TMDLs, salinity envelopes, freshwater inflow targets, and environmental operations. Most of these recommendations still hold for future work, as summarized below:

- The St. Lucie Watershed Model (WaSh) is a coupled watershed water quality model. The WaSh model for the tidal basin needs to be calibrated using flow and water quality data collected in the St. Lucie Tributary Monitoring Program. Simulated nutrient loading into the estuary with WaSh will be reevaluated after the tidal basin model is calibrated. Site-specific management measures can be implemented in the model to simulate magnitude of nutrient loading reduction.
- The water quality model for the SLE was developed using the Environmental Fluid Dynamics Code (EFDC) Water Quality Model. The model has proven to be a useful tool to evaluate estuarine responses to nutrient loading reduction from the watershed; however there still remains a need to refine the calibration of DO dynamics and primary production in the water column. Empirical relationships of important water quality processes and control factors also need to be explored further and incorporated into the water quality model. Applications of the model will emphasize nutrient budget and evaluation of the effectiveness of constructions projects and source control programs.
- Future efforts in estuarine ecological modeling will focus on quantifying the responses of seagrasses (e.g., tape grass), oysters, and other key indicators to fluctuations in multiple environmental factors. Mathematical prediction of the distribution and status of these Valued Ecosystem Components (VECs) offers a framework to measure the performance of watershed projects. Individual models for each VEC within the estuary will be linked spatially by hydrodynamics and water column processes. The resulting ecosystem models will be able to evaluate changes in depth, salinity, light, and nutrients on algal, macrophyte, and faunal survival. Habitat mapping, water quality monitoring, and ecosystem model output will be combined into a spatial database to contrast and visualize changes in VECs under different climatic and management scenarios.

Water Quality Evaluations: Estimated Nutrient Load Reductions

Water quality evaluations toward meeting the SLE TMDL for TP and TN was accomplished using algorithms in a Microsoft Excel spreadsheet tool that estimated nutrient loads and load reductions anticipated from implementing various management alternatives. This simplified approach was selected because of time constraints and, more importantly, limitations in the data needed to populate a more complex, process-based model. The POR is 1996–2005 for consistency with the FDEP's BMAP and a 2004 land use dataset was used. Land use data is used for two reasons in the SLRWPP water quality analysis: (1) as an input to the WaSh model to determine output flows and concentrations for the North Fork, South Fork, and Basin 4-5-6 sub-watersheds, which are inputs to the water quality spreadsheet; and (2) in estimating load reductions associated with implementation of urban and agricultural BMPs. The 2008 land use data were not available for incorporation into this update; therefore, the 2004 land use dataset was the most recent available within the POR. The 2008 land use may be considered for the next 2015 update. Measured flows and nutrient concentrations during the POR (1996–2005) from S-49

(C-24 Sub-watershed), S-48 (C-23 Sub-watershed), and S-80 excluding flows and loads from Lake Okeechobee at S-308 (C-44/S-153 Sub-watershed), and WaSh model flows and loads from the North Fork, South Fork, and Basin 4-5-6 sub-watersheds were inputs to the spreadsheet. These flows and loads were used to calculate average annual concentrations of TP [in parts per billion (ppb)] and TN [(in parts per million (ppm)].

Projects and activities that aim to reduce nutrient loads and increase water storage are defined in three distinct phases: (1) current (completed or constructed) implementation measures; (2) near-term implementation measures, which are being implemented or anticipated to be completed during the 2012–2014 period; and 3) long-term projects, which will be implemented or completed beyond 2015. A list of all activities and projects and their status are provided in Table A-1 in **Attachment A**. The nutrient loading rates and reductions factors associated with BMPs and technologies for the St. Lucie River Watershed are described in **Attachment B** whereas assumptions for BMP implementation rates are provided in **Attachment C**. Nutrient reductions associated with local, sub-regional, and regional projects are estimated based on available data and 2009 SLRWPP evaluations (SFWMD et al., 2009). Generally, loading rates for local projects were determined by applying estimated loading rates based on land use type and acreage of effective area, and load reduction factors based on literature reviews were applied. Load reductions for CERP IRL-S Project features were based on load reductions estimates published in the 2004 IRL-S PIR (USACE and SFWMD, 2004). The Ten Mile Creek WPA estimates were based on the current design estimates and may need to be revised if future revisions are made to this project. [Note that other project specifics on load reduction estimate methodologies are provided in the project description sheets in **Attachment A or** the 2009 SLRWPP, as appropriate.]

After totaling the TN and TP load reductions for a given phase, the equivalent concentrations were calculated for the runoff from each sub-watershed and were compared to the TMDL concentrations of 81 ppb for TP and 0.72 ppm for TN, which are the TMDL targets in the St. Lucie River and Estuary. If the combination of potential load reductions for a sub-watershed resulted in a concentration below this TMDL level, then the concentration was adjusted to match the base level and the corresponding load was recalculated accordingly.

Estimated Nutrient Load Reductions from Current Activities

This section summarizes the existing nutrient loads to the estuary from the St. Lucie River Watershed and estimated TN and TP reductions anticipated from current projects and activities. During the 1996–2005 POR, loading from the watershed to the estuary was 266.8 mt/yr for TP and 1,191.3 mt/yr for TN excluding Lake Okeechobee discharges. The estimated TN and TP load reductions from current activities are shown in **Table 20**. Collectively, these activities are estimated to provide annual average load reductions of 29.4 mt/yr (11 percent) for TP and 114 mt/yr (9.6 percent) for TN. A summary of these activities is presented in **Attachment A**, Table A-1, with some examples below:

- **Urban and Agricultural BMPs.** Agricultural BMPs include two categories: owner-implemented and cost-shared. Owner-implemented BMPs reflect those that would likely be implemented by land owners without incentives, while the cost-shared BMPs are those that are more expensive to construct (culvert replacements, retention/detention, etc.) and could be reasonably funded through federal and state cost-share programs. Agricultural BMPs are expected to provide the greatest load reductions in the current phase, with an estimated reduction of 25.8 mt/yr for TP and 93.6 mt/yr for TN. Current urban BMPs load reduction estimates are 0.6 mt/yr for TP and 8.7 mt/yr for TN.

- **Local Water Quality Projects.** Load reductions from eight local water quality projects are included for the current phase. Generally, these are relatively small projects, mostly in the North Fork, South Fork, and Basin 4-5-6 sub-watersheds, with total estimated reductions of 2.4 mt/yr for TP and 6.8 mt/yr for TN.
- **Regional/Sub-regional Projects.** The near-term phase includes one sub-regional project (Ideal Groves HWTT site) which, based on site-specific measured data, is anticipated to provide a reduction of 0.03 mt/yr for TP.
- **Dispersed Water Management (DWM) Projects.** These projects mainly provide water retention with ancillary water quality benefits and contribute to overall water storage improvement in the St. Lucie River Watershed. They include cost-share efforts such as the Indiantown Citrus Growers Association Water Storage – Phases 1, 2 and 3 and USDA-NRCS WRP projects. The estimated nutrient load reduction from DWM projects are 0.7 mt/yr for TP and 4.9 mt/yr for TN.

Table 20. Current nutrient reduction activities in the St. Lucie River Watershed with lead agencies and estimated TN and TP load reductions [in metric tons per year (mt/yr)].

	Total Nitrogen (mt/yr)	Total Phosphorus (mt/yr)	Lead Agency
Baseline Load	1,191.3	266.8	–
Baseline Concentration	*1.47 ppm*	*329.68 ppb*	–
Load Reductions from Current Activities			
Urban BMPs	8.69	0.57	FDEP
Agricultural BMPs	93.61	25.77	FDACS
DWM Projects	4.92	0.68	SFWMD, FDACS
Local Water Quality Projects	6.78	2.37	SFWMD, local governments
Regional/Sub-regional Projects	–	0.03	SFWMD
Total Reductions from Current Activities	114.00 (% reduction: 9.6%)	29.42 (% reduction: 11%)	–
Remaining Load	1,077.31	237.33	–
Remaining Concentration	*1.33 ppm*	*293.31 ppb*	–

Estimated Nutrient Load Reductions from Near-Term Activities

This section summarizes estimated TP and TN reductions anticipated from near-term projects and activities (**Table 21**). Collectively, these activities are expected to provide additional annual average load reductions of 7.32 mt/yr (2.7 percent) for TP and 39.03 mt/yr (3.3 percent) for TN over the next three years (2012–2014). A summary of these activities is presented in **Attachment A**, Table A-1, with some examples below:

- **Urban and Agricultural BMPs.** These BMPs are estimated to provide nutrient load reductions of 6.1 mt/yr for TP and 33.8 mt/yr for TN with a significant portion of it resulting from implementation of agricultural BMPs.

- **Local Water Quality Projects.** Six local water quality projects are included for the near-term phase. These are relatively small projects, with modest loading reductions totaling about 1 mt/yr for TP and 4.5 mt/yr for TN.
- **DWM Projects.** These include multiple planned projects such as several interim sites (C-23/C-24 Complex, and Allapattah Flats, WRP projects, and NE-PES Program projects (note that load reductions benefits from this program are yet to be determined). These projects will provide ancillary water quality benefits, with an estimated load reduction of 0.2 mt/yr for TP and 0.8 mt/yr for TN.

Table 21. Near-term nutrient reduction activities in the St. Lucie River Watershed with lead agencies and estimated TN and TP load reductions.

	Total Nitrogen (mt/yr)	Total Phosphorus (mt/yr)	Lead Agency
Load After Current Phase	1,077.31	237.33	–
Concentration After Current Phase	*1.33 ppm*	*293.31 ppb*	–
Load Reductions from Near-Term Activities			
Urban BMPs	12.40	0.78	FDEP
Agricultural BMPs	21.39	5.29	FDACS
DWM Projects	0.76	0.22	SFWMD, FDACS
Local Water Quality Projects	4.48	1.03	SFWMD, local governments
Regional/Sub-regional Projects	–	–	–
Total Reductions from Near-Term Activities	39.03 (% reduction: 3.3%)	7.32 (% reduction: 2.7%)	–
Remaining Load	1,038.28	230.01	–
Remaining Concentration	*1.28 ppm*	*284.27 ppb*	–

Estimated Nutrient Load Reductions from Long-Term Activities

Under the long-term activities, several management strategies are being considered to provide additional TN and TP reduction capability such as additional urban and agricultural BMPs, additional potential sites under the DWM Program, chemical treatment at parcel levels, regional projects such as the CERP IRL-S C-44 Reservoir/STA and C-23/C-24 Reservoir/STA projects, and other regional storage/treatment facilities. Long-term projects provide the majority of the overall plan load reductions and are estimated to further reduce the loads to the estuary by approximately 79 mt/yr (29 percent) for TP and 358 mt/yr (30 percent) for TN (**Table 22**). A summary of each of these activities is presented in **Attachment A**, Table A-1. Long-term (2015 and beyond) nutrient load reduction strategies and projects include the following (note that some of these measures can be implemented sooner if funding permits):

- **Urban and Agricultural BMPs.** These BMPs will provide estimated load reduction of 7.3 mt/yr for TP and 61.6 mt/yr for TN.
- **Local Water Quality Projects.** One local water quality project has load reductions included in the long-term phase, which is estimated to provide minimal TP and TN load reduction.

- **Regional/Sub-Regional Projects.** All SLRWPP CERP IRL-S features, the Ten Mile Creek WPA, and Lake Point Restoration are included in the long-term phase. Collectively, these large regional projects are estimated to provide reductions of 62.6 mt/yr for TP and 293.4 mt/yr for TN. It is apparent that the majority of load reductions is expected in the long-term and can be associated with these larger regional features.
- **DWM.** One potential site for long-term DWM, Cypress Creek Trail Ridge Natural Area (C-23), is estimated to provide ancillary load reductions of 0.34 mt/yr for TP.
- **Chemical Treatment.** Chemical treatment is only included as a long-term option as this technology is still in the early stages of development in the Northern Everglades. This involves implementing chemical treatment at the parcel level based on the Northern Everglades Chemical Treatment Pilot Project (SWET, 2010). The study identified one potential site in all but one of the St. Lucie River sub-watersheds (Basin 4-5-6 Sub-watershed), and this technology has the potential to be expanded further in the St. Lucie River Watershed. Chemical treatment is estimated to provide load reductions of 8.6 mt/yr for TP and 2.7 mt/yr for TN.

Table 22. Long-term nutrient reduction activities in the St. Lucie River Watershed with lead agencies and estimated TN and TP load reductions.

	Total Nitrogen (mt/yr)	Total Phosphorus (mt/yr)	Lead Agency
Load After Near-Term Phase	1038.28	230.01	–
Concentration After Near-Term Phase	*1.28 ppm*	*284.27 ppb*	–
Load Reductions from Long-Term Activities			
Urban BMPs	34.73	2.19	FDEP
Agricultural BMPs	26.89	5.10	FDACS
DWM Projects	0.00	0.34	SFWMD, FDACS
Local Water Quality Projects	0.03	0.01	SFWMD, local governments
Regional/Sub-regional Projects	293.48	62.65	SFWMD, USCAE
Chemical treatment at Parcel Level	2.70	8.56	SFWMD, FDEP, FDACS
Total Reductions from Long-Term Activities	357.83 (% reduction: 30.0%)	78.85 (% reduction: 29.6%)	–
Remaining Load	680.45	151.16	–
Remaining Concentration	*0.84 ppm*	*186.82 ppb*	–
Overall Total Reduction	510.86 (% reduction: 42.9%)	115.59 (% reduction: 43.3%)	

Nutrient Load Reduction Summary

A summary of the results of implementing each phase of the plan is provided in **Table 23**. Overall, the phases are estimated to collectively reduce load reductions from the watershed to the estuary by 115 mt/yr for TP (43 percent) and 511 mt/yr for TN (43 percent) and concentrations are expected to be reduced to 187 ppb for TP and 0.84 ppm for TN. BMPs, which are generally less expensive than other forms of nutrient removal technologies, provide the majority of load reductions associated with the current and near-term phases. It is apparent, however, that the majority of load reductions are associated with long-term regional features.

Table 23. Summary of TN and TP load reductions and remaining concentration [in parts per million (ppm) and parts per billion (ppb), respectively] for SLRWPP implementation phases.

	Load Reduction (mt/yr)	Remaining Load (mt/yr)	Percent Reduction	Remaining Concentration
Total Nitrogen				
Baseline	n/a	1,191.31	n/a	1.47 ppm
Current Activities (through 2011)	114.00	1,077.31	9.6%	1.33 ppm
Near-Term Activities (2012–2014)	39.03	1,038.28	3.3%	1.28 ppm
Long-Term Activities (2015–beyond)	357.83	680.45	30.0%	0.84 ppm
Total Reduction	510.86	–	42.9%	–
Estimated Values for SLRWPP at TMDL	868.69	582.57	72.9%	0.72 ppm
Total Phosphorus				
Baseline	n/a	266.75	n/a	330 ppb
Current Activities (through 2011)	29.42	237.33	11%	293 ppb
Near-Term Activities (2012–2014)	7.32	230.01	2.7%	284 ppb
Long-Term Activities (2015–beyond)	78.85	151.16	29.6%	187 ppb
Total Reduction	115.59	–	43.3%	–
Estimated Values for SLRWPP at TMDL	194.44	65.54	72.9%	81 ppb

The estimated watershed load at TMDL was calculated for TP (65.5 mt/yr), using the water quality spreadsheet, and compared to current loads and remaining loads after implementation of each phase (**Figure 35**). Current TP loading to the estuary is four times higher than the estimated load at TMDL. Although full plan implementation is anticipated to result in a TP load reduction of 115.6 mt/yr (43 percent) to the estuary, approximately 85.7 mt of additional TP load reductions need to be accomplished for total loading to be within range of the TMDL. Similarly, the expected final concentration is also much higher (2.3 times) than the TP TMDL (**Figure 36**).

The estimated watershed load at TMDL was also calculated for TN (582.6 mt/yr), and compared to current loads and remaining loads after implementation of each phase (**Figure 37**). The ratio of current TN loading to the estimated load at TMDL is not as large as it is for TP, but at two times higher it is still significant. The gap between the remaining load at full plan implementation (680.4 mt/yr) is only 97.8 mt/yr higher than the estimated target. The final concentrations are also close to the TMDL with a difference of 0.12 ppm (**Figure 38**).

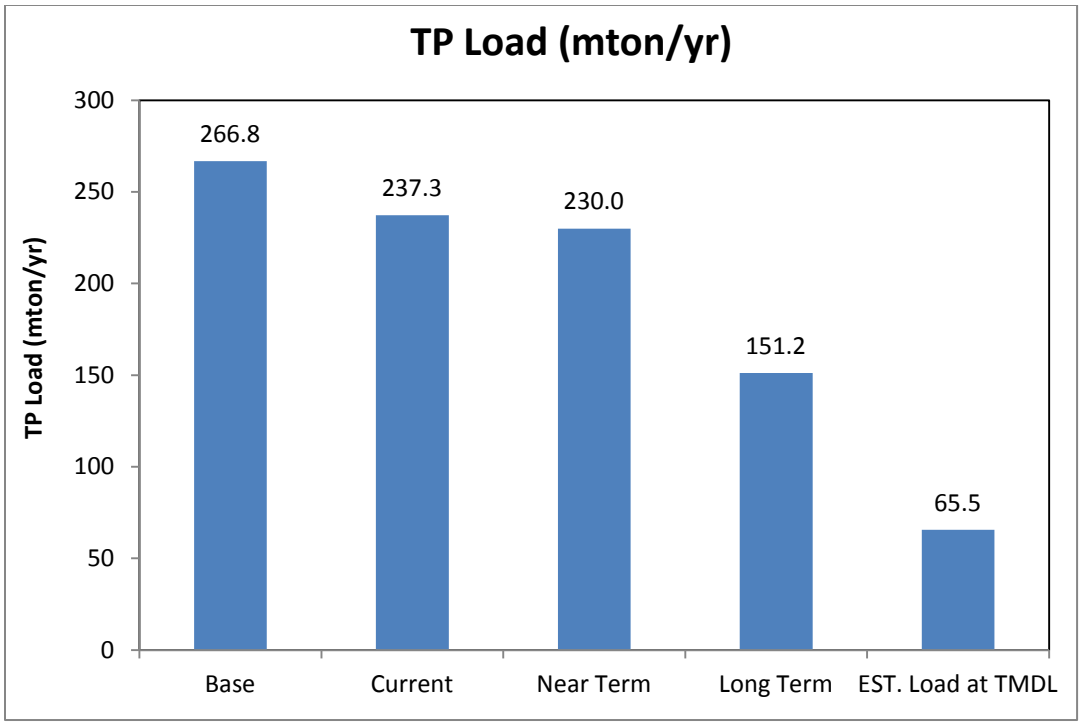


Figure 35. Comparison of TP base load [in metric tons per year (mton/yr)] and remaining loads after implementation of each phase to the estimated load at the TP TMDL of 81 parts per billion (ppb).

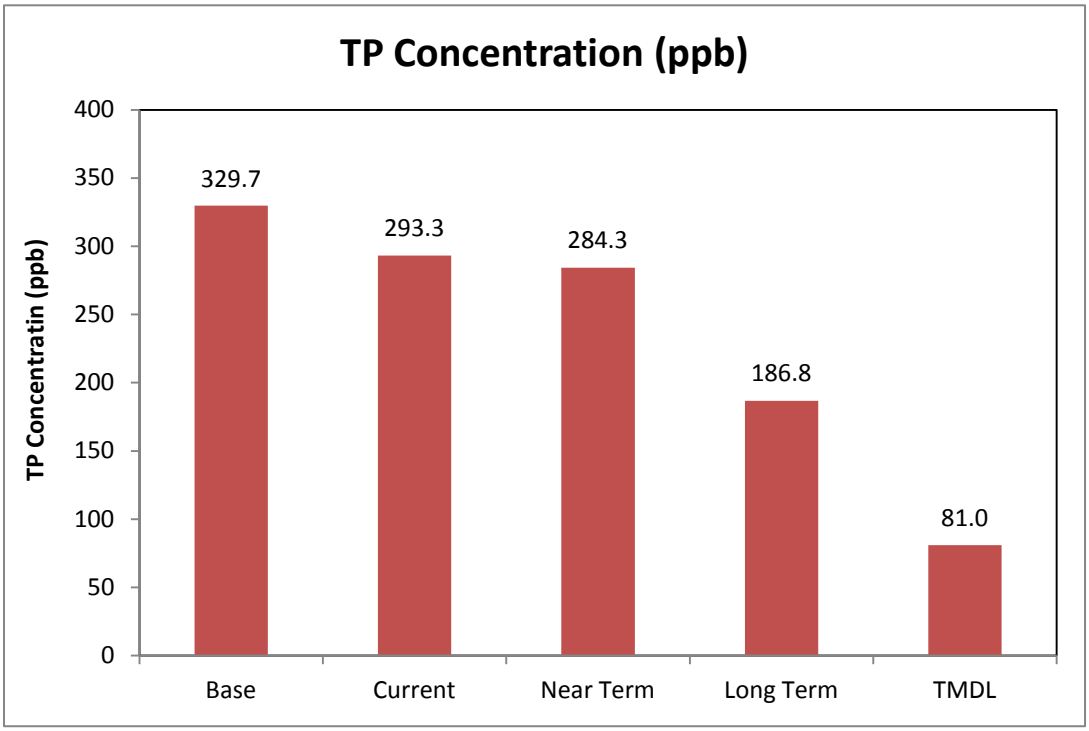


Figure 36. Comparison of TP base concentration and remaining concentration after implementation of each phase to the TP TMDL of 81 ppb.

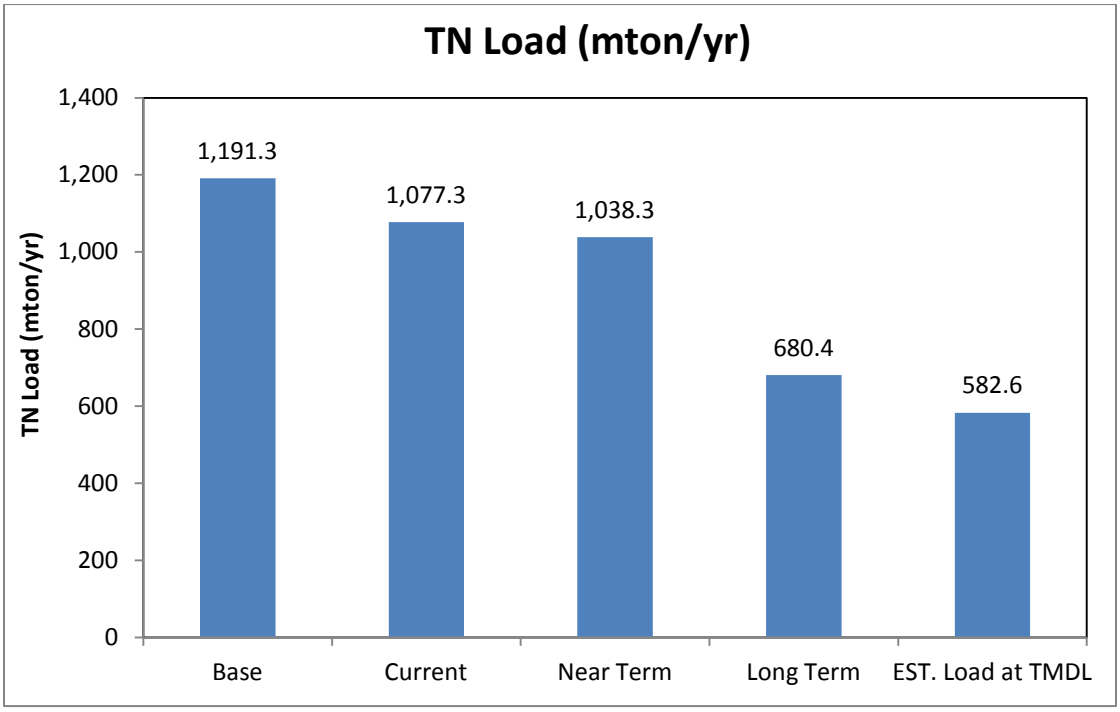


Figure 37. Comparison of TN base load [in metric tons per year (mton/yr)], remaining loads after implementation of each phase to the estimated load at the TN TMDL of 0.72 parts per million (ppm).

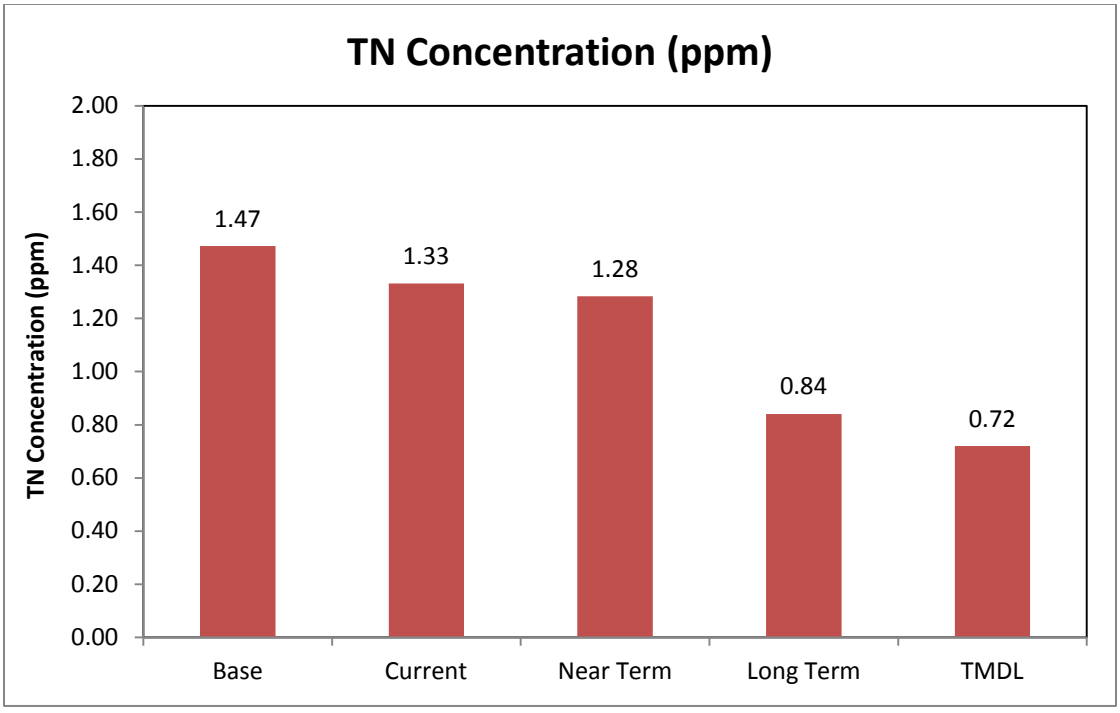


Figure 38. Comparison of TN base concentration, remaining concentration after implementation of each phase to the estimated load at the TN TMDL of 0.72 ppm.

Estimated Load Reductions by Sub-Watershed

The following section further analyzes the estimated load and concentration reductions for both TP and TN by each SLE sub-watershed. **Figures 39** and **40** show the TP loads and concentrations, respectively, for each planning phase: baseline, current, near-term, and long-term, and **Figures 41** and **42** show the same for TN. While loading and concentrations of both TP and TN from each sub-watershed decrease from each phase to the next, it is apparent that the majority of nutrient load reductions occur in the long-term plan implementation phase.

For the base condition and the three implementation phases, the highest TP loadings originate in the C-23 Sub-watershed, followed by the C-24 Sub-watershed. TN loading is highest in C-24, followed by the C-23 and the C-44/S-153 sub-watersheds. Loading from the C-23 and C-24 sub-watersheds are a function of disproportionally high concentrations (**Figure 40**), while disproportionally high discharge from the C-24 Sub-watershed also contributes to the high loading from this sub-watershed. The contribution from the Basin 4-5-6 Sub-watershed is relatively small because this sub-watershed comprises only three percent of the watershed. It is important to note, however, that load reductions from this sub-watershed only include BMPs and local water quality projects since there are no regional, sub-regional, DWM, or chemical treatment projects proposed in the Basin 4-5-6 Sub-watershed.

Most importantly, these graphs provide a comparison of the TP and TN concentrations from each sub-watershed with the nutrient TMDL targets, which, in the St. Lucie Watershed BMAP, are applied at each of the sub-watershed discharge points. At full SLRWPP implementation, the TP TMDL of 81 ppb is expected to be met in the C-44/S1-53 Sub-watershed. The TN TMDL of 0.72 ppm is expected to be met for the North Fork, C-23 and C-44/S-153 sub-watersheds. Overall, the plan is much closer to achieving the TN TMDL than the TP TMDL. This is primarily due to the fact that current TP concentrations from each sub-watershed are 2.7 to 5.9 times higher than the TMDL. It is recognized that opportunities for additional water quality treatment in the other sub-watersheds is needed to achieve the SLE TP and TN TMDLs.

Addressing Water Quantity: Strategies and Next Steps

Increasing water storage in the St. Lucie River Watershed will require a mix of regional and DWM projects. The coordinating agencies are aggressively pursuing DWM implementation and expansion in the Northern Everglades watersheds by working with other agencies, non-profit organizations, Florida Native American tribes, and public and private landowners. Creating another opportunity for businesses to participate in and help implement solutions, the NE-PES DWM Solicitation Program was initiated in 2011. This program offers eligible cattle ranchers the opportunity to compete for contracts for water and nutrient retention. It is widely acknowledged that the components of the DWM Program (easements, cost-share, and payment for services) are the most promising options in the near term to address a portion of the storage needs. Additional efforts have recently been initiated including implementation of water farming pilots, which will utilize fallow/out-of-production citrus lands to store water and attenuate nutrients allowing storm water to be used as an alternative water supply. The expected result of water farming will be reduced releases and improved water quality to the SLE. Currently, the District is discussing an agreement with Indian River Citrus League to assess the feasibility of water farming and potential implementation of a pilot project in FY2012. 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 near term.

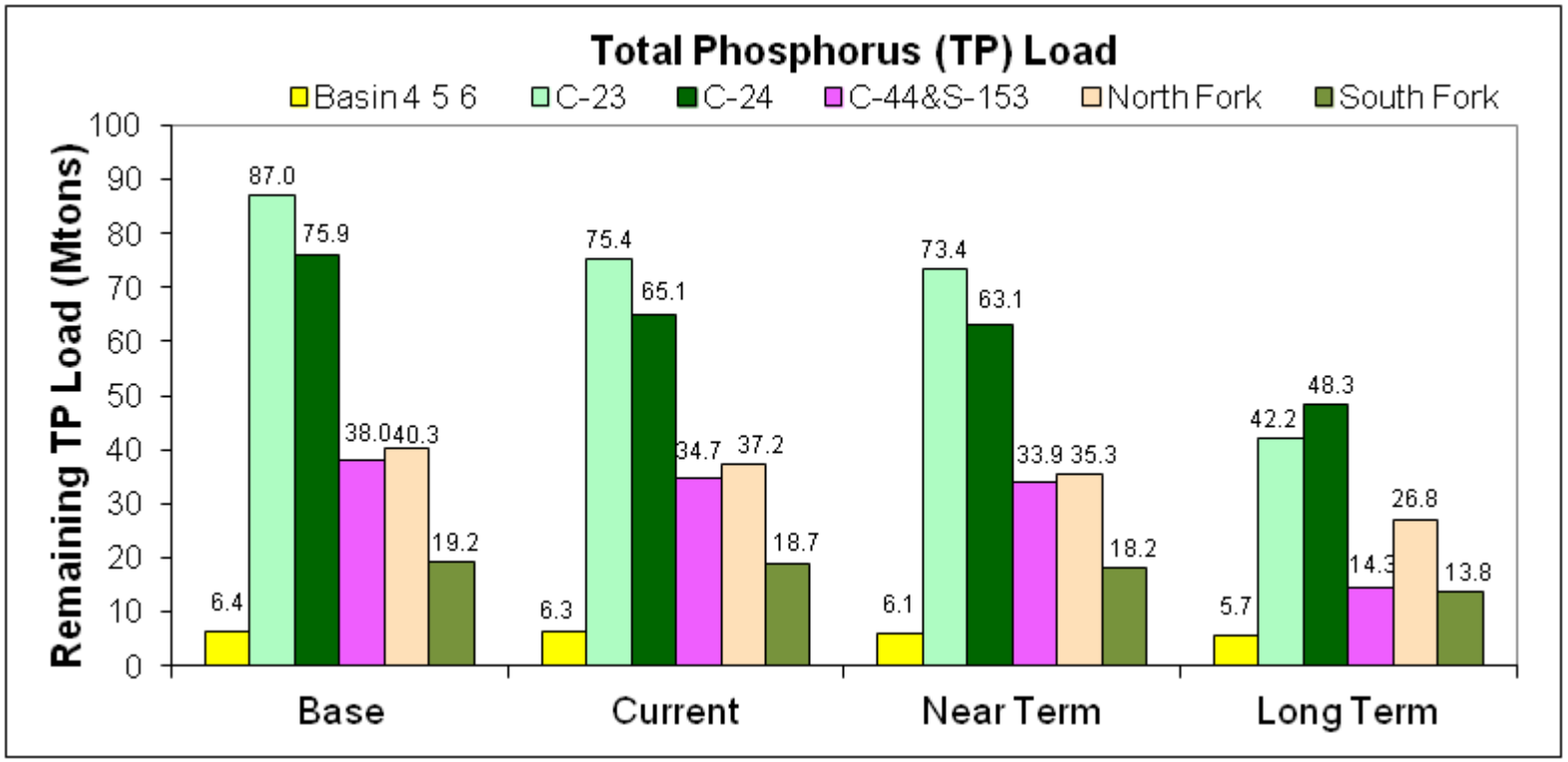


Figure 39. Estimated TP loads [in metric tons (Mtons)] by sub-watershed for each planning phase.

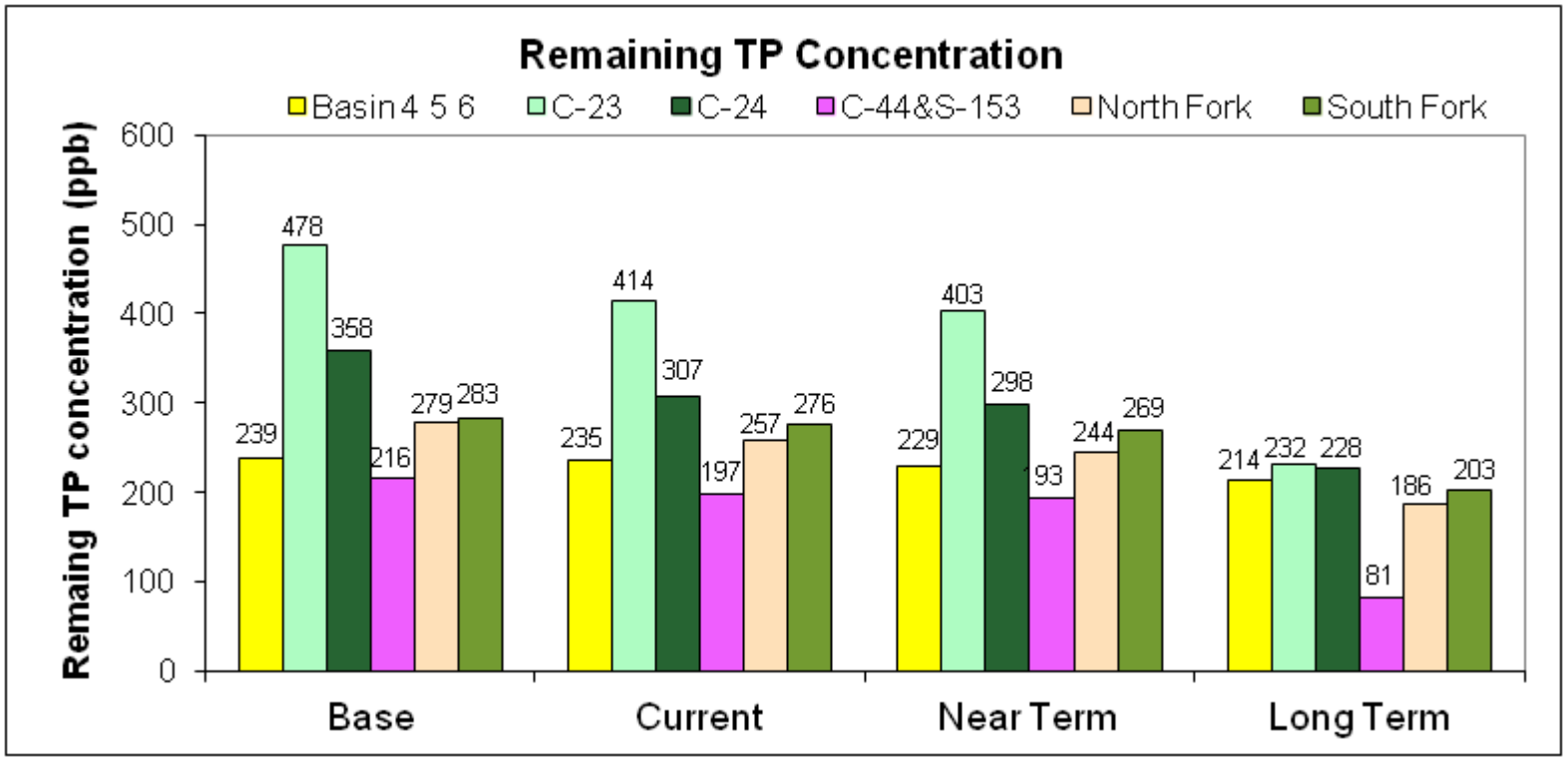


Figure 40. Estimated TP concentrations (µg/L or ppb) by sub-watershed for each planning phase.

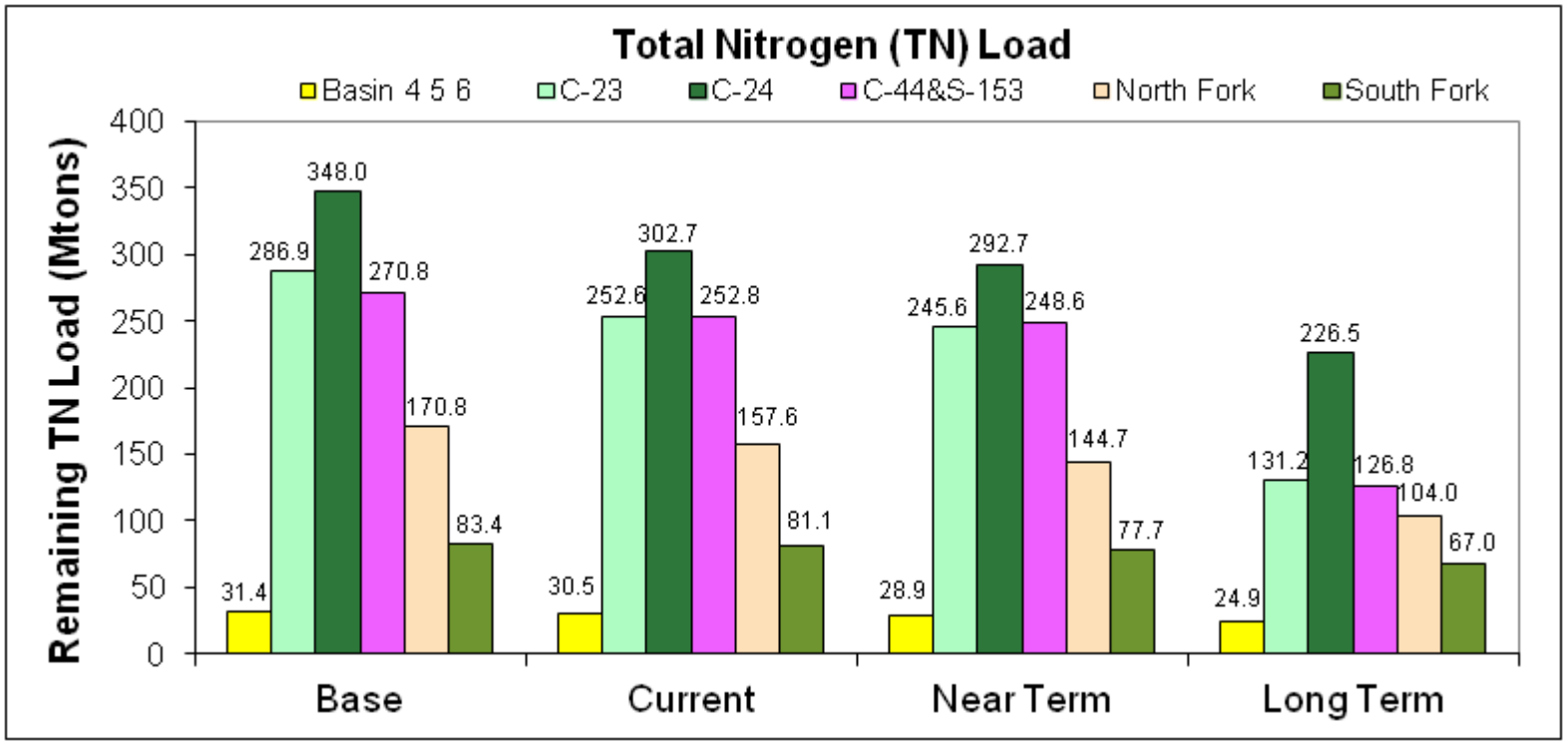


Figure 41. Estimated TN loads [in metric tons (Mtons)] by sub-watershed for each planning phase.

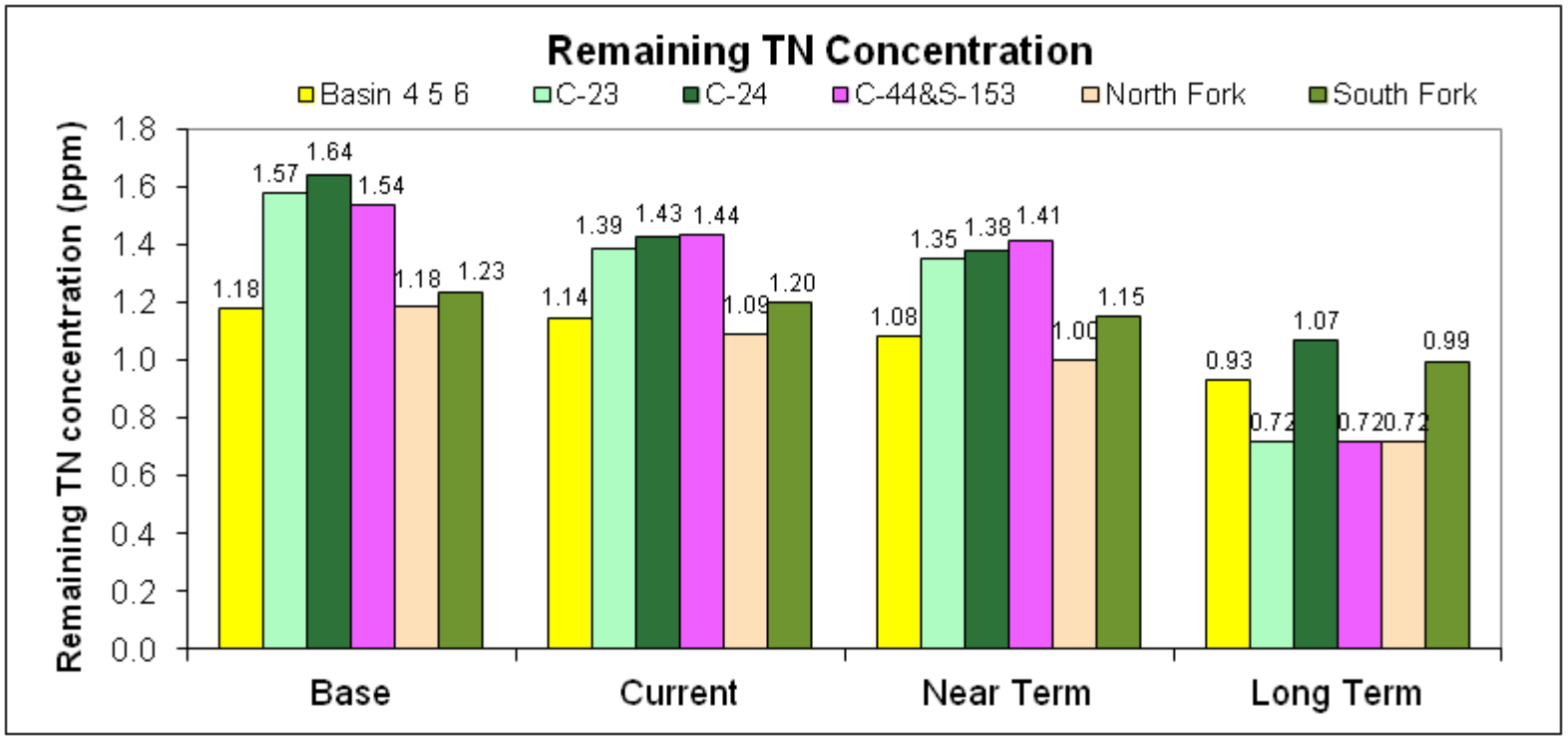


Figure 42. Estimated TN concentrations (mg/L or ppm) by sub-watershed for each planning phase.

Overall, the ultimate goal for the DWM Program is to provide 450,000 ac-ft of storage throughout the Northern Everglades watersheds (Lake Okeechobee, Caloosahatchee River, and St. Lucie River watersheds). However, regional projects also continue to be critical to reach the storage goals for the St. Lucie River Watershed, especially in the long term. Once implemented, SLRWPP CERP IRL-S PIR features are anticipated to provide the 200,000 ac-ft of storage estimated to be needed in the watershed. A total of 50,600 ac-ft of storage will be provided by the C-44 Reservoir/STA project which began construction in 2011. Implementation of other CERP IRL-S PIR features that will provide the remaining storage has been delayed due to lack of federal authorizations and funding constraints. DWM projects can help bridge the gap in storage needed until the larger regional projects are brought on line.

Plan Implementation

The SLRWPP Update will be implemented in multiple phases. The schedule and list of implementation measures take into account current fiscal challenges. The measures listed in **Table 24** are those that are most imminent and have the highest potential to be initiated or completed by the end of 2014. The entire list of implementation measures and their anticipated phase is provided in **Attachment A**, Table A-1. It is presumed the plan will be revisited and necessary adjustments will be made to the implementation measures and their phase in the next SLRWPP update.

Table 24. SLRWPP projects that are planned to be initiated or completed in the near-term (2012–2014).

Type	Project	Initiated	Completed
Source Control	Agricultural and Urban BMPs[1]	✓	✓
	SFWMD's Regulatory Source Control Program (Chapter 40E-61, F.A.C) for the St. Lucie River Watershed[2]	✓	
	FDEP St. Lucie BMAP	✓	✓
Construction Project and Other Related Efforts	Dispersed Water Management Projects-Planned[1]	✓	✓
	DWM-Interim Lands Allapattah Flats and C-23/C-24 Complex	✓	✓
	Northern Everglades Payment for Environmental Service Program Solicitation	✓	✓
	Water Farming Pilot Projects	✓	✓
	Lake Point Restoration	✓	
	C-44 Reservoir/STA IRL-S Project	✓	
	Alternative Nutrient Reduction Technologies (e.g., PRB technology and chemical treatment)	✓	✓
	Local Water Quality Projects	✓	✓
	Hybrid Wetland Treatment Technology	✓	✓
Research and Water Quality Monitoring	Watershed and Estuarine Nutrient Budget Refinement	✓	
	New Alternative Technology Assessment	✓	
	Continue Ecological and Water Quality Monitoring	✓	✓
	St. Lucie Estuary Water Quality Model Refinements and Watershed Model (WaSh) Calibration	✓	

[1]Completed partial implementation through a phased approach.
[2]The District will coordinate with the Office of Fiscal Accountability and Regulatory Reform prior to initiating rule development to amend Chapter 40E-61, F.A.C.

Plan Implementation Challenges and Cost Estimates

Since its inception in 2007, the NEEPP has faced many implementation challenges, the most significant being reduced funding. Federal, state, and local funds have drastically decreased within the last three years. The FDACS has also experienced a shortfall in expected BMP funding and the completion of cost-shared BMP programs has fallen behind schedule. Furthermore, ongoing litigation related to water quality in the Everglades Protection Area may result in additional legally mandated projects for the Southern Everglades. Construction of thousands of acres of additional water quality facilities within mandated deadlines will require funding commitments from the District that will have direct effects on implementation of the SLRWPP. Looking ahead, the coordinating agencies continue to work to overcome these challenges and remain committed to restoring and protecting the Northern Everglades and implementing the SLRWPP. If additional funding sources are identified, then expedited implementation of cost-share BMPs, local stormwater projects, DWM projects, Chemical Treatment, and development of a nutrient budget are the recommended priorities.

Total estimated costs for the current and near-term projects under the SLRWPP Update were calculated in 2011 dollars (**Table 25**). All project costs were obtained from projected values or actual costs where available. The coordinating agencies will continue to pursue alternative funding sources including federal matching funds, other non-state funding, and public-private partnerships, wherever possible, to expedite implementation of this plan. As noted earlier, economic downturn has had a substantial impact on the state's and District's funding capabilities, which will continue to affect the implementation of the projects and programs identified in the SLRWPP.

Table 25. Total cost estimates for near-term SLRWPP implementation.

Category of Cost	Cost Estimate
Watershed Source Control[1]	$3.0 M
Operations and Maintenance of Completed Projects [2]	$0.4 M
Near-term Construction Project[3]	$191.0 M
Dispersed Water Management[4]	$1.1 M
Research and Water Quality Monitoring[5]	$0.8 M
Total Cost	**$196.3 M**

[1]Includes FDACS Agricultural BMP cost-share dollars and programmatic costs for the South Florida Water Management District source control program. Urban BMP costs are not included.

[2]Includes O&M costs for the Ideal Groves HWTT project

[3]Includes federal contract and District costs anticipated through 2014 for the C-44 Reservoir/STA and costs for six local water quality projects expected to be completed in the near term.

[4]Includes the Alderman NE-PES project, Allapattah Flats and C-23/24 Interim Lands projects, and St. Lucie Water Farming Pilot Project. Does not include costs for future NE-PES solicitations.

[5] Includes costs for internal nutrient cycling and watershed nutrient budget studies and biological/water quality monitoring.

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Attachment A: St. Lucie River Watershed Protection Plan Updates and New Project/Activity Sheets

Table A-1 provides a summary of project updates since the publication of the 2009 St. Lucie River Watershed Protection Plan (SLRWPP) (SFWMD et al., 2009). Project description sheets (f/k/a management measure sheets) for new projects are provided in this attachment following the table. These projects are Eastern Watershed Improvement Project (SLE 60), Lake Point Restoration (SLE 62), Halpatiokee Regional Park Aquatic Habitat Enhancement (SLE 63), and Ideal Grove Hybrid Wetland Treatment Technology (SLE 63). Three other new projects are also listed in **Table A-1**, but project description sheets are not provided for these projects as they are described in detail in the *Dispersed Water Management Program* section of the report. These are Northern Everglades – Payment for Environmental Services (NE-PES) Solicitation (SE-59), Dispersed Water Management Water Farming Assessment (SE 61), and Dispersed Water Management Interim Lands (SE 64). See the 2009 SLRWPP (SFWMD et al., 2009) for project descriptions of the remaining projects.

Table A-1. St. Lucie River Watershed Protection Plan (SLRWPP) project updates from 2009 through 2011.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
LO 1	Agricultural Best Management Practices (BMPs) – Owner-Implemented and Cost-Shared (combined LO 1, 2, and 49)	Implements agricultural BMPs and water quality improvement projects to reduce the discharge of nutrients from the watershed.	Total agricultural acreage in the St. Lucie River Watershed is approximately 374,079 including the C-25 and C-25 East sub-watersheds. Approximately 52 percent of this acreage is enrolled in owner-implemented BMPs and have cost-share type BMPs in place.	Ongoing	Source Control	✓	✓
LO 3	Urban Turf Fertilizer Rule [Lake Okeechobee Estuary and Recovery (LOER)]	This is a Florida Department of Agriculture and Consumer Services (FDACS) rule that regulates the content of phosphorus and nitrogen in urban turf fertilizers to improve water quality.	No update	Ongoing	Source Control	✓	–
LO 4	Biosolids Rule	The Northern Everglades and Estuaries Protection Plan (NEEPP) [Section 373.4595(4)(b)2.e, Florida Statutes (F.S.)] requires that after December 31, 2007, the Florida Department of Environmental Protection (FDEP) may not authorize the disposal of domestic wastewater residuals within the St. Lucie River Watershed unless the applicant can affirmatively demonstrate that the nutrients in the residuals will not add to nutrient loadings in the watershed.	The biosolids rule, Chapter 62-640, Florida Administrative Code (F.A.C.), (August 2010) includes 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 a nutrient balance demonstration is completed by the applicant and approved by the FDEP. Current application of Class B biosolids is authorized under a facility's permit in the Caloosahatchee River Watershed until the permit expires; however, all application sites will have to be permitted by January 13, 2013, under the newly, revised biosolids rule. No authorizations for new residuals (Class B Biosolids) disposal sites have been issued since 2008.	Ongoing	Source Control	✓	—
LO 5	Florida Yards and Neighborhoods Program	This program provides education to citizens by promoting land use designs to minimize pesticides, fertilizers, and irrigation water.	Since 2009, the University of Florida Institute of Agricultural Sciences (UF/IFAS) Florida Yards and Neighborhood Program has expanded from a homeowner approach to cover a broader audience (e.g., builders, developers, architects)	Ongoing	Source Control	✓	—
LO 7	Environmental Resource Permit (ERP) Program	The South Florida Water Management District (SFWMD or District) and FDEP are authorized to implement the ERP program. The ERP program requires that 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.	No update	Ongoing	Source Control	✓	✓

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
LO 08	National Pollutant Discharge Elimination System (NPDES) Stormwater Program	This program targets reducing stormwater pollutant loads discharged to surface waters, particularly from existing land uses and drainage systems. This applies to the master drainage systems owned and operated by cities, counties, the Florida Department of Transportation (FDOT), and Chapter 298 water control districts. This also helps reduce stormwater pollutant loads from existing industrial sites and new construction sites.	No update	Ongoing	Source Control	✓	✓
LO 09	Coastal and Estuarine Land Conservation Program (CELCP)	Established in 2002 by the National Oceanic and Atmospheric Administration, CELCP protects important coastal and estuarine areas that have significant conservation, recreation, ecological, historical, or aesthetic values, or that may be converted from their natural or recreational state to other uses (CELCP Final Guidelines, 2003). In Florida, CELCP is coordinated through FDEP's Coastal Management Program.	No update	Ongoing	Land Manage-ment and Restoration	✓	✓
LO 12f	Alternative Water Storage (AWS) – Indiantown Citrus Growers Association	Rehabilitating and relocating pump stations and stormwater detention within the existing ditch system provided 3,550 acre-feet (ac-ft) of water storage on 492 acres. The projects promote water conservation and reduce the volume of surface water discharge to the St. Lucie Estuary (SLE).	No update	Completed	Dispersed Water Manage-ment (DWM)	✓	✓
LO 12m	AWS – Waste Management St. Lucie Site	Plans are to enter into a partnership arrangement to change borrow areas into minor aboveground impoundments. Water quality/quantity benefits are included in the DWM program benefits.	A project feasibility study is under development.	Long-term	DWM	✓	✓
LO 14	Comprehensive Everglades Restoration Plan (CERP) – Indian River Lagoon – South Project Implementation Report (IRL-S PIR): C-44 Reservoir/Stormwater Treatment Area (STA)	This project, to be located directly north of the C-44 canal, includes construction of a 3,400-acre reservoir, which will provide 50,600 ac-ft of storage, and an adjacent 6,300-acre STA in southern Martin County. The objectives of the reservoir and STA are to capture, store, and treat runoff from the C-44 basin prior to discharge to the SLE. Load reduction benefits to the SLE for this project are estimated at 26 metric tons per year (mt/yr) for total phosphorus (TP) and 82 mt/yr for total nitrogen (TN).	Design for the project components was completed in July 2007 and further updated to reflect technology advancements in April 2008. The United States Army Corps of Engineers will be responsible for the construction of the C-44 project and will convert the District design to three contracts anticipated to be solicited and constructed over seven years.	Long-term	Regional	✓	✓
LO 15	Proposed St. Lucie River Watershed Regulatory Nutrient Source Control Program	This program implements a nutrient source control program utilizing BMPs for the St. Lucie River Watershed. Ongoing activities include revising Chapter 40E-61, F.A.C., and expanding the rule boundary to include the St. Lucie River Watershed to reflect NEEPP requirements.	In late 2009, the District initiated the activities and technical analyses necessary to develop these programs and to initiate consultation with stakeholders and coordinating agencies. The District will coordinate with the Office of Fiscal Accountability and Regulatory Reform prior to initiating rule development to amend Chapter 40E-61, F.A.C.	Ongoing	Source Control	✓	✓

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
LO 38	C-44 Littoral	The project creates a littoral zone of native vegetation to "treat" water entering the C-44 canal via the S-308 structure to benefit Lake Okeechobee and the SLE. The project will maintain boat navigation through the lake.	No update	Long-term	Regional	✓	—
LO 50	Chemical Treatment at the Parcel Level (formerly known as Agricultural BMPs – Additional Agricultural BMPs)	Project reduces the TP load by implementing chemical treatment at the parcel level across the Lake Okeechobee Watershed.	The Northern Everglades Chemical Treatment Pilot Project Phase I was completed in July 2009 and was conducted to (1) investigate available information on chemical treatment technologies that have been tested within other water bodies to reduce TP loads in stormwater runoff, and (2) identify technologies appropriate for use within the Lake Okeechobee Watershed. Results of the study concluded that various chemical treatment technologies are viable and represent effective options for reducing phosphorus loads to the lake (Bottcher et al., 2009). Phase II of this project, which included implementation costs and site identification analysis for chemical treatment technologies in the Northern Everglades, was completed in October 2010 (SWET, Inc., 2010). Five areas identified as potentially appropriate for chemical treatment are located within the St. Lucie River Watershed.	Long-term	Local	✓	—
LO 63	Wastewater and Stormwater Master Plans	Master plans outline implementing urban stormwater retrofit or wastewater projects to achieve additional nutrient reductions and water storage basin-wide by working with entities responsible for wastewater and stormwater programs in the service area.	See the SLRWPP Construction Project for the implementation status of urban stormwater retrofits and wastewater projects.	Ongoing	Source Control	✓	✓
LO 65	L-65 Culvert to L-8 Tieback	Project to install a high volume (1,000± cubic feet per second) inverted culvert under the C-44 canal from the L-65 canal to the L-8 tieback canal to facilitate the movement of low nutrient water from STAs north of Lake Okeechobee to the L-8 reservoir.	No update	Long-term	Regional	—	—
LO 68	Comprehensive Planning – Land Development Regulations	Basinwide work with state agencies, cities, and counties to review current plans and ensure promotion of low-impact design through coordinated comprehensive planning and growth management initiatives.	No update	Ongoing	Source Control	✓	✓
LO 87 Revised	Florida Ranchlands Environmental Services Project (FRESP) – Existing, Future, and Full Implementation	FRESP will design a program in which ranchers in the Northern Everglades sell environmental services of water retention, nutrient load reduction, and wetland habitat expansion to state agencies and other willing buyers. The pilot project program is under way.	The FRESP Alderman-Deloney Ranch Pilot Project, located in the St. Lucie River Watershed, was submitted for consideration in the Northern Estuaries Payment for Environmental Services (NE-PES) Solicitation.	Completed	DWM	✓	✓

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 02	White City Drainage Improvements (Canals B, C, D, E, F, G) (SLE 02a and 02b)	This project is expected to improve water quality of stormwater flows to the North Fork of the St. Lucie River by modifying canal stages and reducing the potential for pollutant runoff from pastures using modern storm systems and BMPs.	Canal D is complete. Canals A–C and E–G1 will be completed after 2014.	Some features completed Others long-term	Local	✓	—
SLE 03	White City Drainage Improvements (Citrus/Saeger)	This project is expected to capture, store, and treat runoff and provide controlled releases to the St. Lucie River by constructing a 4-acre stormwater detention pond with an associated outfall structure. The project is expected to reduce TP by 0.01 mt/yr and TN by 0.03 mt/yr.	Construction is expected to begin in fall 2014.	Near-term	Local	✓	—
SLE 06	Indian River Estates/ Savannas Ecosystem Management Project	This project is expected to improve flood control and treat storm water that currently discharges directly to the Indian River Lagoon (IRL) and North Fork of the St. Lucie River by constructing a pump station, infrastructure, and water detention cells within a 1,200-acre basin adjacent to the IRL and the North Fork. The project is expected to reduce TP by 0.76 mt/yr and TN by 0.83 mt/yr.	The alum enhancement project is complete. Construction plans are complete for Phase II; however it is being "value engineered" to align costs with anticipated funding. Construction is expected to start in early 2012. The addition of a Siemens Link-2-Site system allows alum dosing relative to the water turbidity. The facility can also be monitored continuously via computer and rainfall, turbidity, pH, temperature, stage level, and station alarms can be reported and recorded.	Phase I completed/ Phase II near-term	Local	✓	✓
SLE 07	Platt's Creek Wetland Restoration	Project to improve the performance of an existing stormwater treatment system by adding alum injection and modifying the current outfalls and discharge conveyance to be incorporated into the restoration of a prior citrus operation to floodplain forest, marsh, and flatwoods. The project is expected to reduce TP by 0.03 mt/yr and TN by 0.11 mt/yr.	The addition of a Siemens Link-2-Site system allows alum dosing relative to the water turbidity. The facility can also be monitored continuously via computer and rainfall, turbidity, pH, temperature, stage level, and station alarms can be reported and recorded.	Completed	Local	✓	—
SLE 09	Natural Lands in CERP IRL-S PIR Project	The recommended plan includes approximately 92,000 acres of natural storage areas that will be hydrologically restored to provide various benefits, including approximately 30,000 ac-ft of freshwater storage, nitrogen and phosphorus load reductions, increased wetland acreage, and aquifer recharge.	No update	Long-term	Regional	✓	✓
SLE 09a	CERP IRL-S PIR: Pal Mar Complex – Natural Storage and Water Quality Area	The Pal Mar Complex includes 17,143 acres of pasture in the C-44 basin that has been identified for use as alternative storage, nutrient removal, rehydration, and habitat restoration. The project will provide 5,700 ac-ft of water storage and is estimated to reduce TP by 3.43 mt/yr and TN by 13.39 mt/yr.	No update	Long-term	Regional	✓	✓

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 09b	CERP – IRL-S PIR: Allapattah Complex – Natural Storage and Water Quality Area	The Allapattah Complex – Natural Storage and Treatment Area includes approximately 42,348 acres of the C-23 basin in Martin County. This land has been identified for use as alternative storage, rehydration, habitat restoration, and incidental water quality treatment. The project will provide 13,800 ac-ft of water storage and is estimated to reduce TP by 8.47 mt/yr and TN by 32.73 mt/yr,.	Approximately 12,300 acres of this area is currently operational/enrolled in the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Wetland Reserve Program (WRP) program, which focuses on habitat restoration and maintaining the area as "open lands."	Long-term	Regional	✓	✓
SLE 09c	CERP – IRL-S PIR: Cypress Creek/Trail Ridge Complex – Natural Storage and Water Quality Area	The Cypress Creek/Trail Ridge Complex includes approximately 32,639 acres of primarily pastureland, along with some of the last remaining large tracts of forested wetland habitat in St. Lucie County. The area has been identified for alternative storage, rehydration, habitat restoration, and water quality improvements. The project will provide 10,500 ac-ft of water storage and reduce TP by 6.49 mt/yr and TN by 25.29 mt/yr.	No update	Long-term	Regional	✓	✓
SLE 11	Creation of Suitable Oyster Substrate in the SLE at Various Sites Identified in the IRL-S PIR (Artificial Habitat Creation)	This project will build upon existing efforts to create suitable oyster substrate in the SLE using natural or man-made materials (i.e., "oyster balls," limestone rocks, relict shell bags) placed under docks or on open slopes. The project is expected to reduce TP and TN from within the SLE; however, the magnitude of these benefits is undetermined.	Since 2008, a total of 23 acres of oyster reef has been created, mainly in the middle, but also in the upper portion of the SLE.	Ongoing	Local	✓	—
SLE 13	On-site Sewage Treatment and Disposal System Inspection and Pump-out Program	This project will provide financial assistance and technical expertise to help residents identify damaged or non-functioning septic systems (covering approximately 10,500 eligible systems) to reduce the water quality problems that result from failing systems. Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits is undetermined.	In June 2010, the legislature approved a bill directing the Florida Department of Health (FDOH) to create and administer a statewide five-year cycle septic tank evaluation program. In 2011, the legislature added language in the Budget Implementation Act requiring the FDOH to submit a plan for approval by the Legislature Budget Commission before expending funds in furtherance of the evaluation program; however, they did not repeal or modify the five-year septic tank evaluation program. In addition, FDOH will have to adopt a rule to implement the program, which will require ratification from the legislature.	Ongoing	Source Control	✓	—
SLE 18	Additional Reservoir Storage and Water Quality Treatment Areas	These projects include additional reservoirs and STAs to capture and treat undesired releases from Lake Okeechobee or the local watershed to the St. Lucie River and Estuary that are not addressed by proposed improvements north of the lake.	No update	Long-term	Regional	✓	✓
SLE 18a	Reservoir and Stormwater Treatment Area along the South Side of the C-44 Canal	This project will capture and treat undesired releases from Lake Okeechobee to the SLE.	No update	Long-term	Regional	✓	✓

Table A-1. Continued

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 18b	C-23/C-24 Water Quality Treatment Project	This project will provide additional reservoirs or STAs along the C-23 and C-24 canals to capture and treat any remaining undesired releases from Lake Okeechobee or the local watershed to the St. Lucie River and Estuary.	No update	Long-term	Regional	✓	✓
SLE 19	Conversion of Existing Canals into Linear Wetland Treatment Areas	Installed weir structures will convert existing canals into linear wetland/shallow lake treatment areas to provide additional treatment of storm water entering the North Fork and South Fork of the St. Lucie River. The longer residence time of water in these areas will result in nutrient assimilation and attenuation during times of base flow and low flow conditions. The project is still in a conceptual phase; therefore, water quality benefits have yet to be determined.	No update	Long-term	Local	✓	✓
SLE 22	North River Shores Vacuum Sewer System	This project includes a vacuum-assisted gravity sewer collection system to provide service to approximately 750 single and multifamily residential units presently disposing approximately 190,000 gallons per day of waste through septic tanks. Based on preliminary estimates, the project is expected to reduce TP by 2.18 mt/yr and TN by 8.57 mt/yr.	Phase I is complete with 435 sewer lateral connections in place. As of May 2011, 165 homes have been connected. Homeowners have until January 12, 2012, to connect to the new system. Plans to convert the remaining 315 homes (Phase II) are 60 percent complete and funding is being investigated.	Phase I completed, Phase II near-term	Local	✓	—
SLE 24	CERP – IRL-S PIR: C-23/C-24 Reservoir/STA	This project includes two reservoirs (C-23/C-24 North and South) totaling approximately 47,799 acres and a 2,568-acre STA to improve the quality, quantity, timing, and distribution of water discharged to the St. Lucie River and Estuary from the local watershed. The reservoirs and STA will provide 94,468 ac-ft of water storage and is estimated to reduce TP by 24.0 mt/yr and TN by 104.2 mt/yr.	No update	Long-term	Regional	✓	✓
SLE 26	CERP – IRL-S PIR: North Fork Natural Floodplain Restoration	This project includes acquisition and preservation of approximately 3,100 acres of floodplain and adjacent lands, which will provide significant environmental improvement in the health of this portion of the St. Lucie River by reducing stormwater runoff, turbidity, and influence of exotic plants and animals from the surrounding areas that are under significant development pressure. This project is estimated to reduce TP by 0.57 mt/yr and TN by 2.23 mt/yr.	No update	Long-term	Regional	✓	✓
SLE 27	CERP – IRL-S PIR: Muck Remediation	This project will remove accumulated muck from areas that are effectively “dead zones” in the SLE. Muck has covered substrate that once supported healthy submerged aquatic vegetation and oyster communities. Removing this sediment will greatly improve estuarine conditions by exposing the substrate and make it suitable for colonization by target species.	No update	Long-term	Regional	✓	—

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 28	Tropical Farms/ Roebuck Creek Stormwater Quality Retrofit	This Martin County Engineering Department stormwater project treats runoff from 1,900 acres of the Roebuck Creek Basin and provides additional storage. Improvements include construction of a pipe system to collect and convey stormwater runoff from a 468-acre basin to a 17-acre STA that provides 39 ac-ft of water quality treatment and flood attenuation. This project is estimated to reduce TP by 0.04 mt/yr and TN by 0.21 mt/yr.	The project was completed in 2011.	Completed	Local	✓	✓
SLE 29	Old Palm City Phase III Stormwater Quality Retrofit	Phase 3 of the Old Palm City Retrofit project will address water quality and flood attenuation problems within the southern portion of the basin. It includes construction of two STAs totaling 6.5 acres serving 106 acres of residential land to provide 8.5 ac-ft of water quality treatment and stormwater attenuation. The project is estimated to reduce TP by 0.03 mt/yr and TN by 0.07 mt/yr.	The project was constructed in 2011.	Completed	Local	✓	✓
SLE 30	Manatee Pocket Dredging Project	This local cost-share project will remove approximately 250,000 cubic yards of muck sediments over 47 acres within Manatee Pocket and its tributaries. It is anticipated that the project will reduce TP and TN from within the SLE; however, the magnitude of these benefits is undetermined.	Construction began in July 2010. The dredging is anticipated to be complete in January 2012.	Completed	Local	✓	—
SLE 31	Stormwater Baffle Box Retrofit – City of Stuart	This project includes installing baffle boxes in storm systems throughout the City of Stuart that remove sediment and floating debris before discharge to the St. Lucie River. Expected water quality benefits include reducing total suspended solids (TSS), TP, and TN.	The city has retrofit baffle boxes to all 34 outfall pipes that convey storm water from within the city jurisdiction to tidal waters.	Completed	Local	✓	—
SLE 32	Danforth Creek Stormwater Quality Retrofit	This retrofit includes two projects. The first is located 0.25 mile west of Leighton Farms Road and 0.5 mile south of County Road 714 on an 11.4-acre parcel adjacent to Danforth Creek. The project will redirect flows from the creek into a deep lake with littoral shelves and an STA, and construct a weir for detaining water prior to discharging back into Danforth Creek. The second is south of and adjacent to Southwest Sunset Trail and 0.25 mile west of Danforth Creek in Palm City. This project will serve approximately a 90-acre sub-basin and provide about 5.5 ac-ft of treatment. The contract scope includes land acquisition, engineering design, permitting, and construction. Preliminary load reduction estimates are 0.01 mt/yr for TP and 0.03 mt/yr for TN.	At present the 11.4-acre parcel has been purchased and engineering design and permitting are under way. Negotiations fell through with the land owner along Southwest Sunset Trail and Martin County is looking at other parcels.	Near-term (11.4-acre parcel)/long-term (second parcel)	Local	✓	✓

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 33	North St. Lucie River Water Control District Stormwater Retrofit; Structures 81-1-2 and 85-1-2	This project involves retrofitting four water control structures within the North St. Lucie River Water Control District. The retrofits will improve the efficiency of structure operations and better control flows to Ten Mile Creek during storm events, while also controlling sediments released downstream. Water quality/ quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits is undetermined.	Four structures (81-1-2, 85-1-2, 83-2-2, and 82-2-2) were completed in May 2009. They primarily serve a water control function for the North St. Lucie River Water Control District, but also provide water quantity and quality benefits as the District has improved control over canal operations with the use of these structures.	Completed	Local	✓	✓
SLE 38	Urban BMPs Program (Extension of the Florida Yards and Neighborhoods Program)	The Florida Yards and Neighborhoods Program is an environmental education program designed to improve the water quality of the IRL and SLE by reducing nonpoint sources of pollution from properties throughout the watershed.	Since 2009, the UF/IFAS Florida Yards and Neighborhood Program has expanded from a homeowner approach to cover a broader audience (e.g., builders, developers, architects).	Ongoing	Source Control	✓	—
SLE 39	Aquifer Storage and Recovery (ASR)	ASR involves injecting water into an aquifer through wells and then pumping it from the same aquifer when needed. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water is needed, typically during a dry period.	No update	Long-term	Regional	—	✓
SLE 40	CERP – IRL-S PIR: Southern Diversion C-23 to C-44 Interconnect	The project will direct excess water from the C-23–C-24–C-25 canal system through the C-44 STA and into the St. Lucie Canal (C-44) where it can be diverted to Lake Okeechobee when the lake is below 14.5 feet mean sea level to meet local irrigation demands, or sent to tide at a point less damaging than the C-23 canal outlet. In an average year, 31,000 ac-ft could be gravity discharged to Lake Okeechobee via S-308 and 22,000 ac-ft could be sent to tide through the S-80 structure. Final water quality/quantity benefits have yet to be determined.	No update	Long-term	Regional	—	—
SLE 41	Martin County Baffle Boxes	Martin County has identified and prioritized nearly 30 locations for potential baffle box installations to provide sediment and debris traps to prevent discharges directly into either the IRL or the St. Lucie River. Expected water quality benefits include reducing TSS, TP, and TN.	Eight baffle boxes were installed along Indian River Drive in Jensen Beach. The future of this effort depends on further county funding.	Installation of 8 baffle boxes completed, remaining installation is long-term	Local	✓	—
SLE 42	Jensen Beach Retrofit	This project proposes to detain or retain stormwater runoff in vaults or infiltration for an older developed area in downtown Jensen Beach. Load reduction estimates are 0.01 mt/yr for TP and 0.03 mt/yr for TN.	No update	Long term	Local	✓	—

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 43	Leilani Heights/ Warner Creek Retrofit – Phases 1, 2, and 3	Approximately 1,600 acres drain to Warner Creek between the Savannas State Reserve and the St. Lucie River. This Martin County Engineering Department retrofit is a multiphase project. Phase I is complete and consisted of installing 1,600 linear feet of exfiltration trench, installing a second generation nutrient separating baffle box, and creating 900 linear feet of swales. Phase 2 is construction of a wet detention facility on the site of the decommissioned, 5-acre Beacon 21 Waste Water Treatment Plant. Phase 3 involves sediment removal, channel widening, and increased creek depth upstream of an existing weir in Warner Creek and replacing undersized culverts in Warner Creek. Load reduction estimates are 0.16 mt/yr for TP and 0.41 mt/yr for TN.	Construction of Phase 2 improvements in Beacon 21 were completed in April 2011. Construction began on Phase 3 improvements in April 2011.	Completed	Local	✓	✓
SLE 44	Manatee Creek Stormwater Retrofit, Phases I, II, and III; New Monrovia, Dixie Park	Phase I included creation a 12-acre STA marsh, creation of a dry detention facility, and infrastructure improvements to convey runoff to treatment facilities for water quality and reduce flooding. Phases II and III included converting a decommissioned 7-acre Dixie Park Wastewater Treatment Plant to an STA/wet detention system with a prototype denitrification bed to treat runoff from 200+ acres and creating a 5-acre STA in the adjacent sub-basin serving 40 acres of older residential development to improve water quality and reduce flooding in the New Monrovia subdivision. Load reduction estimates are 0.08 mt/yr for TP and 0.2 mt/yr for TN.	The project was completed in 2011.	Completed	Local	✓	✓
SLE 45	Ten Mile Creek Reservoir and STA	The Ten Mile Creek Water Preserve Area will capture and store stormwater flows that originate in the Ten Mile Creek Basin prior to discharge into the North Fork of the St. Lucie River. The sedimentation of suspended solids in the storage reservoir will reduce sediment loads delivered to the estuary. In addition, the captured stormwater is intended to pass through a polishing cell for additional water quality treatment before release. Estimated load reductions based on the facility as designed are 4.45 mt/yr for TP and 18.5 mt/yr for TN (applied in the long-term phase of the water quality evaluation).	Initial construction of the project is complete and modifications and improvements to the design are under development and review.	Completed	Regional	✓	✓
SLE 46	Small Acreage Manure Management	This project will reduce the amount of nutrients released into the regional watershed from landowner storage of manure on the banks of creeks. A centrally located and properly managed facility for collecting or composting manure waste will be developed. Water quality benefits are anticipated as a result of this project; however, the magnitude of these benefits is undetermined.	No update	Long-term	Local	✓	—

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 47	Deep Well Injection – C-44/ St. Lucie Canal	This project will construct deep, high-capacity injection wells for water disposal. Wells will be constructed in "clusters" along the C-44 canal right-of-way	No update	Long-term	Regional	✓	✓
SLE 48	Danforth Creek Muck Removal Dredging Project	The project will remove approximately 20,000 cubic yards of accumulated muck from Danforth Creek to improve estuarine habitat and water quality. It is expected that the project will reduce TP and TN within the SLE; however, the magnitude of these benefits is undetermined. This project will partially implement SLE 27.	No update	Long-term	Local	✓	—
SLE 49	Warner Creek Muck Removal Dredging Project	The project will remove approximately 16,000 cubic yards of accumulated muck from Warner Creek to improve estuarine habitat and water quality. It is expected that the project will reduce TP and TN within the SLE; however, the magnitude of these benefits is undetermined. This project will partially implement SLE 27.	No update	Long-term	Local	✓	—
SLE 50	Hidden River Muck Removal Dredging Project	This project will remove accumulated muck from Hidden River (exact volume to be determined) to improve estuarine habitat and water quality. It is expected that the project will reduce TP and TN within the SLE; however, the magnitude of these benefits is undetermined. This project will partially implement SLE 27.	No update	Long-term	Local	✓	—
SLE 51	Residential Canal Weirs along North and South Forks	This project will provide detention storage for existing residential areas presently draining directly into the North and South Forks of the St. Lucie River via uncontrolled canals. Weirs will be installed with a crest elevation of one foot above the existing mean wet season water level in the canals at the weir location. A bleeder in the weir will be included to allow detention volumes to be restored after runoff events.	No update	Long-term	Regional	✓	—
SLE 52	City of Port St. Lucie – E-8 Canal Stormwater Retrofit	The treatment area will reduce sediment and nutrient loading to the North Fork of the St. Lucie River by reducing the flow rate and implementing bioremediation. Retrofit improvements included constructing a marsh flow-way STA, removing nuisance/exotic vegetation, regrading the channel to repair erosion and remove shoaling, and replacing or upgrading outfall structures.	The City of Port St. Lucie constructed the E-8 Canal Stormwater Retrofit project with funding assistance from the District, FDEP, and USDA-NRCS. The Phase I and II portions were completed in 2008 and 2009 and Phase III was completed in May 2011.	Complete	Local	✓	—
SLE 53	Frazier Creek Water Quality – City of Stuart	This 3.6-ac-ft detention pond is south of the Roosevelt Bridge in the northwest quadrant of Stuart within the Frazier Creek drainage basin (approximately 500 acres). The detention pond serves approximately 75 acres of single family residential and light commercial property. Load reduction estimates are 0.02 mt/yr for TN.	No update	Complete	Local	✓	—

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 54	Haney Creek Wetland Restoration	This City of Stuart project includes restoring wetlands within the approximately 1,200-acre Haney Creek Watershed that serves approximately 436 acres of upstream development. The project will provide conservation and water quality enhancement within the watershed. Reductions in TP and TN are negligible.	Construction is complete. The "Heart of Haney Creek" purchase of 113 acres for conservation and passive recreation area north of NW Wright Boulevard, east of US 1 between Baker and Savannah roads, is planned to begin in 2011–2012.	Wetland restoration – completed Heart of Haney Creek purchase – near-term	Local	✓	✓
SLE 55	Poppleton Creek	This project involves a regional detention basin (30 ac-ft) providing storage and treatment for approximately 170 acres within the Poppleton Creek drainage basin. Load reduction estimates are 0.09 mt/yr for TP and 0.16 mt/yr for TN.	No update	Completed	Local	✓	—
SLE 56	Farm and Ranchland Partnerships	There are two USDA-NRCS programs to help farmers and ranchers keep their land in agriculture, the Farm and Ranchlands Protection Program and the WRP. Both programs provide funds to purchase conservation easements.	The District executed a Memorandum of Understanding in October 2010 to provide technical assistance to the USDA-NRCS in implementing their WRP projects. Additionally, in August 2011, the USDA-NRCS announced additional resources ($100 million) for the WRP in the Northern Everglades. Additional lands will be acquired with permanent conservation easements and hydrology restored to altered wetlands.	Ongoing	Source Control	✓	✓
SLE 57	Septage Disposal Requirements	Entities disposing of septage within the watershed must develop and submit to the FDOH an agricultural use plan that limits applications based upon nutrient loading.	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.	Ongoing	Source Control	✓	—
SLE 58	Animal Manure Application Rule	Landowners who apply more than 1 ton per acre of manure must develop conservation plans, approved by the USDA-NRCS, which specifically address the application of animal waste and include soil testing to demonstrate the need for manure application.	The animal manure application rule (Chapter 5M-3, F.A.C.) became effective in the Caloosahatchee River Watershed in February 2009.	Ongoing	Source Control	✓	—
SLE 59 (new)[3]	Northern Everglades – Payment for Environmental Services (NE-PES) Solicitation	The NE-PES solicitation establishes relationships via contracts with private landowners to retain water to reduce flows and nutrient loads to the Lake Okeechobee, St. Lucie River, and Caloosahatchee River watersheds.	Fourteen projects were proposed in response to the NE-PES solicitation released in January 2011. The District and FDEP evaluated and ranked the proposals and, in July 2011, the District's Governing Board approved entering into negotiations with the respondents. Successful NE-PES contracts were presented to the October 2011 Governing Board meeting for approval and contained provisions for data collection and monitoring to document that the services are being provided.	Near-term	DWM	✓	✓

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 60 (new)[4]	Eastern Watershed Improvement Project (EWIP)	EWIP is a City of Port St. Lucie water quality and flood protection retrofit of the Eastern Watershed drainage basins that address severe flooding observed during Tropical Storm Fay in 2008, Hurricane Wilma in 2005, and Hurricanes Frances and Jeanne in 2004. This combination of nine stormwater retrofit and habitat restoration projects will increase water quality treatment, provide peak discharge attenuation, improve flood protection, increase wildlife habitat (particularly wood stork habitat), and provide passive recreation opportunities. Load reduction estimates include Howard Creek, Cane Slough, Loutus and four park sites at 0.09 mt/yr for TP and 0.82 mt/yr for TN.	There are seven individual sub-projects under EWIP that are in varying stages of development. The East Port Basin/Patio STA construction is complete and construction of the Howard's Creek STAs is 75 percent complete. Other EWIP sub-projects are either permitted or out to bid.	Near-term	Local	✓	—
SLE 61 (new)[3]	Dispersed Water Management Water Farming Assessment	This project utilizes fallow/out-of-production citrus lands to store water and attenuate nutrients so storm water can be used as an alternative water supply. To determine the overall feasibility of the water farming concept, information with respect to environmental benefits gained compared to the cost estimates associated with on-site construction, infrastructure improvements, environmental assessments, and facility maintenance needs to be evaluated.	The District entered into a cooperative agreement with the Indian River Citrus League and Gulf Citrus Growers Association to assess the feasibility of water farming. If successful, water farming will continue to Phase II – Project Implementation.	Near-term	DWM	✓	✓
SLE 62 (new)[4]	Lake Point Restoration	Lake Point Restoration is a public-private partnership intended to promote Everglades conservation and improve water quality for various natural habitats, while providing essential raw materials for infrastructure and restoration projects. It is a long-term project to construct water storage lakes and stormwater treatment cells for treatment of water from the C-44 canal for nutrient reduction. Load reduction benefits to the SLE for this project are estimated at 3 mt/yr for TP and 25 mt/yr for TN.	In May 2009, both the Martin County Board of County Commissioners and the District approved the project.	Long-term	Regional	✓	✓
SLE 63 (new)[4]	Halpatiokee Regional Park Aquatic Habitat Enhancement	This environmental restoration project includes creating littoral zones and wetlands within the existing lake system. The littoral zones and wetlands will increase aquatic habitat within the lakes for fish and various wildlife.	Operational	Completed	Local Restoration	—	—

Table A-1. Continued.

ID	Project/Activity	Description	2012 Project/Activity Update	Phase[1]	Category	Benefits[2]	
						Water Quality	Water Quantity
SLE 64 (new)[3]	Dispersed Water Management Interim Lands	Parcels scheduled to become regional restoration projects present an opportunity to provide water retention through interim, low cost alterations to the existing surface water management systems. These parcels would then provide an interim role of contributing to the watershed restoration effort while the final designs are completed and approved. If the public lands are being leased, water management strategies will be jointly developed with the lessees to reduce discharges while not adversely affecting flood protection (including adjacent properties) and water quality.	Interim lands in the St. Lucie Watershed include Allapattah Flats and the C-23/C-24 Complex.	Near-term	DWM	✓	✓
SLE 65 (new)	Ideal Grove Hybrid Wetland Technology Treatment (HWTT) System	The 0.7-acre Ideal Grove HWTT System is located in the C-24 sub-watershed. It is a continuous-flow system (subject to water flow availability) that uses water pumped from citrus grove canals.	Continuous-flow systems show promising results. TP concentration reductions range between 92 and 94 percent for the Ideal 2 Grove system and between 87 and 95 percent for all the systems.	Complete	Local/ Sub-regional	✓	—

[1] Projects denoted as "ongoing" have activity for all three phases: completed, near-term, and long-term.
[2] Larger checkmarks indicate a stronger benefit.
[3] Refer to the *Dispersed Water Management Program* section of this report for additional details.
[4] A project description sheet is provided in this attachment for this new project.

PROJECT DESCRIPTION SHEET: EASTERN WATERSHED IMPROVEMENT PROJECT (SLE 60)

Description: The Eastern Watershed is a highly urbanized residential and commercial area developed by General Development Corporation in the 1980s. The existing drainage systems were designed and constructed to the permit criteria of that time and some existing facilities cannot reasonably be adjusted to meet current regulatory criteria. For example, the roadway and the adjoining properties were designed to store significant amounts of stormwater. It would be unreasonable to assume the roads and the adjoining properties can be raised to avoid stormwater storage for a large rainfall event. In addition, the historic peak discharge rates cannot be increased.

The Eastern Watershed Improvement Project (EWIP) is a water quality and flood protection stormwater retrofit improvement of the Eastern Watershed drainage basins that address severe flooding observed during Tropical Storm Fay in 2008, Hurricane Wilma in 2005, and Hurricanes Frances and Jeanne in 2004. This is a stormwater retrofit and habitat restoration project to increase water quality treatment, provide peak discharge attenuation, improve flood protection, increase wildlife habitat, especially wood stork (*Mycteria americana*) habitat, and provide passive recreation opportunities. The proposed improvements will provide additional detention storage, secondary basin outfalls for redundancy, modifications to existing pump facilities, one new back-up pump system and modifications of existing primary drainage canals and culverts of the basins. The EWIP components were selected to reduce stormwater flooding by reducing the flood stages and providing reliable recovery of the primary canals. The drainage basin study modeling was limited to the city's primary drainage canals as described in the Drainage Report. The secondary and tertiary stormwater facilities such as roadside swales/pipes, smaller canals and local business parking lots were not analyzed. Therefore, additional improvements may be necessary to minimize future localized flooding.

Parts of the EWIP include the following, which are shown in **Figure A-1**:

a. Howard Creek Channel Cleaning Improvement consists of nuisance and exotic vegetation removal, and shoaling removal from the existing natural creek channel from the Westmoreland Bridge to the open water area just north of Ballantrae Bridge. The United States Army Corps of Engineers and the Florida Department of Environmental Protection (FDEP) permitting for this improvement is complete, the channel cleaning north of Westmoreland Bridge is complete, and the balance of this work is currently in progress. No additional discharge is proposed with this improvement.

b. Howard Creek Stormwater Treatment Area (STA) Improvement consists of the construction of a 19-acre STA (marsh flow-way designed as wood stork habitat) on city-owned property and realignment of the existing Howard Creek channel to the center of the platted drainage right-of-way for the area immediately downstream from the STA. This improvement is required to attenuate EWIP discharges to Howard Creek and provide additional stormwater treatment. No additional discharge is proposed with this improvement.

c. Bur Street STA Improvement requires installation of a supplemental outfall for the Howard Creek Basin consisting of culvert/ditch installations for the Giffen Avenue neighborhood, the installation of larger culverts and inlets under Westmoreland Boulevard and Pyramid Road for the B-34 canal, and construction of a 3.7-acre STA designed as wood stork habitat east of Bur Street to provide additional stormwater storage. These improvements are required to reduce the flooding along Giffen Avenue.

d. Blackwell Pump Station and Calais Street Pipe Improvement consists of adding a fourth pump to provide back-up capacity for the existing Blackwell Reservoir Pump Station, and removal of the culvert interconnect between the Eastport Phase 1/Tiffany and the Eastport Phase 2/Blackwell Drainage Basins. This culvert is to be removed and

the canal plugged at Calais Street within the existing County Line ditch. This improvement is required to provide redundant pumping capacity for the Blackwell Pump Station and to remove a problematic basin interconnect. No additional discharge is proposed with this improvement.

e. Tiffany Pump Station Improvement consists of adding a fourth pump to provide back-up capacity for the existing Tiffany Pump Station, regrading/widening of the existing 13-acre pump station entrance channel, and replacement of existing culverts crossing Grand Drive with a concrete box culvert and headwalls. These improvements are required to provide redundant pumping capacity for the Tiffany Pump Station and to increase drainage capacity, storage, and efficiency. No additional discharge is proposed with this improvement.

f. Village Green Drive at City Center Improvement consists of the replacement and upsizing of the Midport Drainage Basin (M-D050) primary outfall structure and associated culverts under Village Green Drive. This improvement is required to increase drainage capacity and to provide improved system bleed-down/storage recovery. No additional discharge is proposed with this improvement.

g. Loutus STA and Interconnect Improvement consists of construction of a STA detention pond, installation of a new pump system between the Eastport Phase 1 and 2 drainage basins, and installation of a pressurized storm main from the new pump system to the Blackwell Reservoir. Although the majority of the Eastport Phase 1/Tiffany Basin drainage flow will outfall through the Tiffany Pump Station, this improvement is required to provide an emergency redundant (back-up) outfall back into the Blackwell Reservoir to recycle overland flows back to the Blackwell Reservoir drainage basin. The discharge to the reservoir will be limited to the existing system allowable discharge to avoid downstream impacts.

h. Azzi STA and Lennard Road Bypass Improvement consists of construction of a STA detention pond, retrofit of the existing diversion box outfall structure in Lennard Road, installation of additional storm structures, piping to direct drainage flow into the existing County Line ditch, and regrading of the County Line ditch to improve outfall hydraulic efficiency to the existing US 1 box culverts south of the Lennard Road/US 1 intersection. This improvement is required to supplement the outfall to Howard Creek with additional stormwater storage, to improve drainage of the Lennard Road/US 1 intersection and to provide wood stork habitat.

i. Cane Slough/Elks STA Improvement consists of the construction of one large STA detention pond (Cane Slough/Elks parcels) and three smaller STA detention ponds (Mary, Patio, and Leithgow parcels) to provide additional storage north of the intersection of Cane Slough Road and Lennard Road, and additional culverts to improve the drainage characteristics of this area. This improvement is required to provide additional storage volume to lower flood stages and to enhance the existing drainage network. All of these STA ponds are designed to provide wood stork habitat and these improvements do not increase discharge.

Purpose: The EWIP is a water quality and flood protection stormwater retrofit improvement of the Eastern Watershed drainage basins that addresses severe flooding observed during Tropical Storm Fay in 2008, Hurricane Wilma in 2005, and Hurricanes Frances and Jeanne in 2004. These improvements will provide enhanced flood protection for the existing residential and commercial developments to resolve recurring drainage and flood control problems in the Eastern Watershed. Project components include construction of STAs consisting of marsh flow-ways to remove pollutants and sediments and improve flood protection; installation of outfall structures to control drainage discharges; and construction of storm sewer and pump station improvements to provide drainage system redundancy. These improvements will restore hydraulic capacity, improve water quality, and attenuate stormwater flows discharging to the North Fork of the St. Lucie River.

Location/Size/Capacity: The City of Port St. Lucie's Eastern Watershed is located on the east side of the city, east of the North Fork of the St. Lucie River; west of the Savannahs State Preserve; south of the Spanish Lakes planned unit development mobile home park (in unincorporated St. Lucie County); and north and west of the St. Lucie-Martin county line. The Eastern Watershed includes the Howard Creek Drainage Basin, the Midport Drainage Basin, the Eastport Phase 1/Tiffany Drainage Basin and the Eastport Phase 2/Blackwell Drainage Basin.

Initiative Status:

- EWIP - East Port Basin (Patio STA) – complete
- EWIP - Azzi STA and Lennard Road Bypass Improvements – permitted
- EWIP - Cane Slough/Elks STA – permitted
- EWIP - East Port Basin (Mary and Leithgow STAS) – construction contract awarded
- EWIP - Howard's Creek STAs – construction 75 percent complete
- EWIP - Lennard Square Stormwater Retrofit – bids received
- EWIP - Loutus STA and Blackwell Interconnect – out to bid
- EWIP - Tiffany Pump Station Channel Widening – permitted

Cost: The EWIP is funded by City of Port St. Lucie Stormwater Utility Revenue Bonds Series 2009. The bonds were issued in January 2010 and the project must be completed within two years. The project was also awarded a St. Lucie River Issue Team Grant for the Howard Creek STA and the city is currently pursuing FDEP Fiscal Year 2011 319h Grant funding.

Drainage Area (acres that will be treated):

Estimate of Water Quality Benefits: Load reduction estimates were provided by the City of Port St. Lucie for Howard Creek, Cane Slough, Loutus and four park sites and were estimated at 0.09 metric tons per year (mt/yr) for total phosphorus and 0.82 mt/yr for total nitrogen (per e-mail from Dale Majewski on July 22, 2011).

Estimate of Water Quantity Benefits (increased storage): Not applicable

Contact Information: City of Port St. Lucie

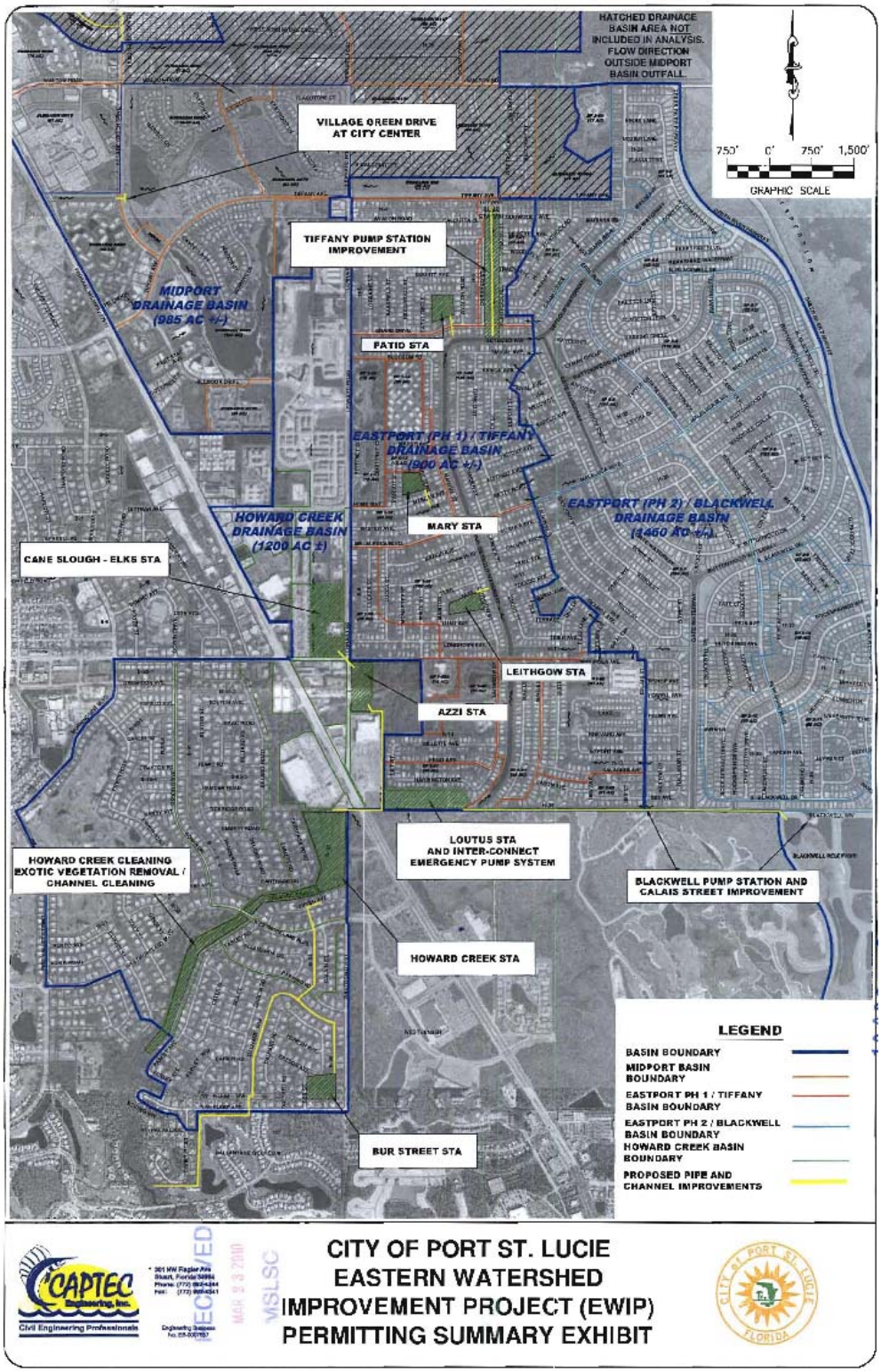

Figure A-1. Location of Eastern Watershed Improvement Project (EWIP) components.

PROJECT DESCRIPTION SHEET: LAKE POINT RESTORATION (SLE 62)

Description: The 2,260-acre Lake Point site is in Martin County, with its northern boundary fronting the C-44/St. Lucie Canal and its eastern boundary adjacent to DuPuis Management Area. Approximately 2,000 acres of the property was donated to the South Florida Water Management District (SFWMD and District) for use as a stormwater management and treatment project, particularly for the benefit of the St. Lucie River Watershed Protection Plan with retention by Lake Point of the rock mining and farming rights for about 1,000 acres for the next 20 years.

Purpose: The Lake Point Restoration Project is a public-private partnership intended to promote Everglades conservation and improve water quality, while providing essential raw materials for infrastructure and restoration projects. It is a long-term project to construct water storage lakes and stormwater treatment cells for reducing nutrients in water from the C-44 canal. Given the project's strategic location, one mile from Lake Okeechobee (and the Herbert Hoover Dike), the Florida Department of Transportation (FDOT)-certified materials being excavated from the facility will provide significant transportation savings to the (1) United States Army Corps of Engineer's repair work on the Herbert Hoover Dike, (2) District in their continuing Everglades restoration projects, (3) Florida Fish and Wildlife Conservation Commission on their Three Lakes Wildlife Management Area maintenance, and (4) FDOT/Martin County as they build the Indiantown and Indian Street Bridge.

Location/Size/Capacity: The site is located east of Interstate 95, south of State Road 76, and west of the South Fork of the St. Lucie River in the South Fork Sub-watershed. The proposed environmental restoration project is located south of the existing Martin County Halpatiokee Regional Park. This project does not increase the capacity or discharge of the existing lakes.

Initiative Status: In May 2009, both the District and Martin County Board of County Commissioners approved the project.

Estimate of Water Quality Benefits: 3 metric tons per year (mt/yr) for TP and 33 mt/yr for TN.

Estimate of Water Quantity Benefits (increased storage):

Contact Information: District and Martin County

PROJECT DESCRIPTION SHEET: HALPATIOKEE REGIONAL PARK AQUATIC HABITAT ENHANCEMENT (SLE 63)

Description: This is an environmental restoration project that includes creating littoral zones and wetlands within the existing lake system. The littoral zones and wetlands will increase aquatic habitat within the lakes for fish and a variety of wildlife.

Purpose: Restoration

Location/Size/Capacity: The site is located east of Interstate 95, south of State Road 76, and west of the South Fork of the St. Lucie River in the South Fork Sub-watershed. The proposed environmental restoration project is located south of the existing Martin County Halpatiokee Regional Park. This project does not increase the capacity or discharge of the existing lakes.

Initiative Status: The overall 247.3-acre site is owned by the South Florida Water Management District (SFWMD or District) and the Board of Trustees of the Internal Improvement Trust Fund of the State of Florida (each an undivided 50 percent interest) and is managed by Martin County through a lease agreement (SFWMD No. C-13636) and an adopted management plan.

Cost:

Drainage Area (acres that will be treated):

Estimate of Water Quality Benefits (TP load reductions): Not applicable

Estimate of Water Quantity Benefits (increased storage): Not applicable

Level of Certainty: Level 1 – Already constructed or implemented, or construction or implementation is imminent.

Contact Information: Martin County

PROJECT DESCRIPTION SHEET: IDEAL GROVE HYBRID WETLAND TREATMENT TECHNOLOGY (SLE 65)

Description: Six Hybrid Wetland Treatment Technology (HWTT) systems were constructed in the Northern Everglades. One site, the 0.7-acre Ideal Grove system, is located in the C-24 sub-watershed of the St. Lucie River Watershed. It is a continuous-flow system (subject to water flow availability) that uses water pumped from citrus grove canals. Continuous-flow systems show promising results.

Purpose: Restoration

Location/Size/Capacity: C-24 sub-watershed

Initiative Status: HWTT is a combination of wetland and chemical treatment technologies to remove phosphorus at the sub-basin and parcel scales. Chemical coagulants are added, either continuously or intermittently, to the front end of the wetland treatment system, which contain one or more deepwater zones to capture the resulting floc material. Recycling techniques are employed for additional phosphorus sorption. The HWTT system was developed to maximize nutrient removal per unit of chemical coagulant by incorporating novel design and multiple operational strategies. In addition to passive and active recycling/reuse of chemical floc, other optimization includes the sequencing and configuring of wetland unit processes to provide desirable nitrogen and phosphorus species transformations.

Estimate of Water Quality Benefits (TP load reductions): TP concentration reductions range between 92 and 94 percent for the Ideal 2 Grove system and between 87 and 95 percent for all the systems.

Estimate of Water Quantity Benefits (increased storage): Not applicable

Level of Certainty: Level 1 – Already constructed or implemented, or construction or implementation is imminent

Contact Information:
South Florida Water Management District
3301 Gun Club Road, West Palm Beach, FL 33406
561-686-8800

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SFWMD, FDEP, and FDACS. 2009. St. Lucie River Watershed Protection Plan. South Florida Water Management District, West Palm Beach, FL., Florida Department of Environmental Protection, Tallahassee, FL., and Florida Department of Agriculture and Consumer Services, Tallahasee, FL. January 2009. Available on-line at http://www.sfwmd.gov/northerneverglades.

SWET. 2010. Implementation Costs and Site Identification Analysis for Chemical Treatment Technologies in the Northern Everglades. Final report prepared by Soil and Water Engineering Technology, Inc., under P.O. 4500047932 for the South Florida Water Management District, West Palm Beach, FL.

Attachment B: Revised Nutrient Loading Rates and Reduction Factors Associated with Best Management Practices and Technologies

Del Bottcher[3] and Joyce Zhang

The 2004 land use data for the St. Lucie River Watershed were used in the recalibration effort discussed in this attachment (**Table B-1)**. There are no changes to the land use, except the drainage boundary changes. Specifically, 508 acres were deducted from the C-23 basin and added to Basin 4-5-6 (**Table B-2**).

The most recent estimates of the average annual discharge, total phosphorus (TP) and total nitrogen (TN) loads from each sub-watershed for the updated baseline period of 1996–2005 were obtained and are presented in **Table B-2**. In general, the annual discharge and TN load are about five and 10 percent lower, respectively, than the values used in the 2008 study (SWET, 2008), mainly due to the baseline period change. There is high variability for the annual runoff in terms of inches per year among the sub-watersheds in the St. Lucie River Watershed. For example, the runoff value for the C-24 Sub-watershed is 23.5 inches per year (in/yr), while the runoff values for the C-24 and C-44/S-153 sub-watersheds are 15.8 and 16.9 in/yr, respectively (**Table B-2**). The higher runoff value for the C-24 Sub-watershed may result from inter-basin transfers. Therefore, the cross sub-watershed comparisons focused more on matching the concentrations because they would be less influenced by any flow errors. The runoff coefficients for various land uses were established based on the calibration for the entire watershed (**Table B-3**).

In the 2008 study (SWET, 2008), the initial estimates of the unit nutrient loads were developed from the Lake Okeechobee Watershed provided in a letter report prepared by Soil and Water Engineering Technology, Inc. (SWET, 2006), estimates for Florida by Harper and Baker (2003; 2007), and data collected within the watershed by Graves et al. (2004). The final TP and TN unit loads for the St. Lucie River Watershed presented in **Table B-4** were developed as an iterative process. This process included initial unit loads estimates linked to a basin spreadsheet where the accumulative TP and TN loads from each sub-watershed could be calculated by multiplying the land use acreage by the unit loads. The net TP and TN loads were then compared to the measured basin loads to verify if the net loads were somewhat accurate and how the calculated and measured TP and TN loads for each of the basins compared (**Tables B-5** and **B-6**, respectively). In this update, the TN unit loads were adjusted by changing a global multiplier factor to obtain reasonable matches to observed data. The reduction factors under various Best Management Practices remained the same (**Tables B-7** and **B-8**, respectively). As previously described in the *Introduction* section of this report, the Florida Department of Environmental

[3] Soil and Water Engineering and Technology, Inc., Gainesville, FL

Protection and South Florida Water Management District both will be utilizing this revised set of unit loads.

Table B-1. 2004 land use distribution for each Florida Land Use and Cover Classification System (FLUCCS) category for the St. Lucie River Watershed.

Land Use Category	Land Use Description	FLUCCS	Area (acres)	Percent	Sum Area (acres)	Percent
Residential Low Density	Residential Low Density	1100	22,050	4.29%	22,050	4.30%
Residential Medium Density	Residential Medium Density	1200	38,206	7.43%	38,206	7.40%
Residential High Density	Residential High Density	1300	7,698	1.50%	7,698	1.50%
Other Urban	Commercial and Services	1400	5,090	0.99%	15,907	3.10%
	Industrial	1500	2,034	0.40%		
	Extractive	1600	640	0.12%		
	Institutional	1700	2,977	0.58%		
	Recreational	1800	5,167	1.00%		
Improved Pastures	Improved Pastures	2110	106,321	20.67%	106,321	20.70%
Unimproved Pastures	Unimproved Pastures	2120	15,033	2.92%	15,033	2.90%
Woodland Pastures/ Rangeland	Woodland Pastures	2130	25,205	4.90%	39,351	7.70%
	Rangeland	3000	14,147	2.75%		
Row Crops	Row Crops	2140	7,881	1.53%	7,881	1.50%
Sugar Cane	Sugar Cane	2156	5,562	1.08%	5,562	1.10%
Citrus	Citrus	2210	116,442	22.64%	116,442	22.60%
Sod Farms	Sod Farms	2420	294	0.06%	294	0.10%
Ornamentals	Ornamentals	2430	1,246	0.24%	1,246	0.20%
Horse Farms	Horse Farms	2510	784	0.15%	784	0.20%
Dairies	Dairies	2520	419	0.08%	419	0.10%
Other Areas	Field Crops	2150	2,800	0.54%	4,108	0.80%
	Other Groves	2230	48	0.01%		
	Cattle Feeding Operations	2310	105	0.02%		
	Poultry Feeding Operations	2320	107	0.02%		
	Tree Nurseries	2410	463	0.09%		
	Specialty Farms	2500	133	0.03%		
	Aquaculture	2540	204	0.04%		
	Fallow Crop Land	2610	248	0.05%		
Tree Plantations	Tree Plantations	4400	0	0.00%	0	0.00%
Water	Water	5000	11,411	2.22%	11,411	2.20%
Natural Areas	Upland Forests	4000	37,608	7.31%	105,380	20.50%
	Wetlands	6000	61,052	11.87%		
	Barren Land	7000	2,613	0.51%		
	Open Land	1900	4,108	0.80%		
Transportation	Transportation	8100	5,665	1.10%	5,665	1.10%
Communication/ Utilities	Communication	8200	91	0.02%	10,529	2.00%
	Utilities	8300	10,438	2.03%		
		Total	**514,287**	**100.00%**	**514,287**	**100.00%**

Table B-2. Summary of measured[1] or modeled[2] baseline data (1996–2005) for average annual discharge [in acre-feet (ac-ft)], runoff (in inches per year (in/yr)], total nitrogen (TN) load [in metric tons per year (mt/yr)] and concentration [in parts per billion (ppb)], and total phosphorus (TP) load (in mt/yr) and concentration (in ppb) for each of the sub-watersheds used in this St. Lucie River Watershed Protection Plan (SLRWPP) Update.

Sub-watershed	Area (acres)	Average Annual Discharge (1996– 2005 (ac-ft)	Runoff (in/yr)	Average Annual TN Load (1996–2005) (mt/yr)	TN Concen-tration (ppb)	Average Annual TP Load (1996–2005) (mt/yr)	TP Concen-tration (ppb)
Basin 4-5-6[3]	15,563	21,666	16.7	31	1,177	6.4	239
C-23[3]	112,167	147,689	15.8	287	1,574	87	478
C-24	87,706	171,856	23.5	349	1,647	76	358
C-44/S-153[4]	129,719	182,617	16.9	356	1,579	50	220
North Fork[5]	119,168	117,123	11.8	171	1,183	40	279
Tidal St. Lucie[6]	49,965	54,821	13.2	83	1,234	19	283
Lake Okeechobee		359,834		807	1,819	89	202
Total	**514,288**	**1,055,605**	**16.2**	**2,084**	**1,601**	**368**	**283**

[1]Measured baseline data are used for the C-23, C-24, C-44/S-153, and Lake Okeechobee sub-watersheds.

[2]Modeled baseline data are used for the Basin 4-5-6, North Fork, and Tidal St. Lucie sub-watersheds.

[3]Due to drainage boundary changes, 508 acres were deducted from the C-23 Sub-watershed and added to the Basin 4-5-6 Sub-watershed.

[4]During this baseline period, about 24 percent of the TN and TP loads from the C-44/S-153 Sub-watershed were discharged into Lake Okeechobee and the remaining loads were discharged to the St. Lucie Estuary (SLE).

[5]The North Fork Sub-watershed includes the North Fork of the St. Lucie River and the north Middle Estuary of the SLE.

[6]The Tidal St. Lucie Sub-watershed includes the South Fork of the St. Lucie River and the south Middle Estuary of the SLE.

Table B-3. Runoff [in acre-feet per year (ac-ft/yr)] for each sub-watershed within the St. Lucie River Watershed by land use category.

FLUCCS	Basin 4-5-6	C-23	C-24	C-44/S-153	North Fork[1]	Tidal St. Lucie[2]	Total
1100	6,318	2,795	1,810	2,655	13,827	4,875	32,280
1200	2,139	525	4,336	545	52,689	5,869	66,102
1300	1,403	0	589	371	9,551	3,454	15,367
1400	475	19	85	435	7,355	2,470	10,838
1500	301	109	126	174	3,512	380	4,601
1600	2	821	0	0	184	270	1,277
1700	220	1,321	43	195	3,128	1,035	5,942
1800	1001	373	974	307	3,379	1,530	7,565
1900	147	13	99	198	4,381	628	5,467
2110	1,608	53,706	54,219	37,028	7,983	15,256	169,799
2120	115	6,737	8,071	2,885	743	1,456	20,007
2130	499	11,575	9,170	8,595	1,426	2,280	33,544
2140	291	3,160	2,889	1,588	2,173	4,583	14,684
2150	0	2,096	1,111	520	0	0	3,727
2156	0	0	0	8,369	0	514	8,882
2210	48	51,850	27,929	68,281	33,024	4,832	185,964
2220	0	0	0	0	0	0	0
2230	8	27	0	0	42	0	77
2310	0	167	0	0	0	0	167
2320	0	0	71	100	0	0	171
2410	133	205	74	114	91	0	616
2420	0	0	0	470	0	0	470
2430	337	0	40	427	380	806	1,990
2500	0	0	0	38	32	106	176
2510	71	72	19	787	0	95	1,044
2520	0	558	0	0	0	0	558
2540	40	47	16	0	6	27	136
2610	0	346	0	0	50	0	396
3000	525	2,134	293	8,496	4,650	2,730	18,827
4000	3,209	3,263	1,515	13,818	14,410	8,832	45,046
5000	102	482	324	503	1,149	477	3,037
6000	168	2,167	1,630	2,012	1,262	887	8,125
7000	0	2,212	595	1,875	470	66	5,217
8100	673	1,030	1,179	1,383	5,935	2,617	12,818
8200	15	14	0	7	86	0	121
8300	570	1,219	136	10,392	1,463	111	13,891
Total ac-ft/year	**20,417**	**149,043**	**117,341**	**172,566**	**173,382**	**66,183**	**698,932**
in/yr	**16**	**16**	**16**	**16**	**17**	**16**	**16**

[1]North Fork Sub-watershed includes the North Fork of the St. Lucie River and the north Middle Estuary of the St. Lucie Estuary (SLE)

[2]The Tidal St. Lucie Sub-watershed includes the South Fork of the St. Lucie Estuary and the south Middle Estuary of the SLE.

Verification:		
	Lake Okeechobee	359,834
	Calculated Total	1,058,766
	Measured Total	1,055,605

Table B-4. Estimated runoff and TN and TP loads [in pounds per acre per year (lbs/ac/yr)] and concentrations [in milligrams per liter (mg/L)] for 2004 land use categories in the St. Lucie River Watershed.

Land Use Category	Land Use Description	FLUCCS	Runoff (in/yr)	Unit TN Load (lbs/ ac/yr)	TN Concen- tration (mg/L)	Unit TP Load (lbs/ ac/yr)	TP Concen- tration (mg/L)
Residential Low Density	Residential Low Density[1]	1100	17.5676	4.29	1.08	0.49	0.12
Residential Medium Density	Residential Medium Density[2]	1200	20.7617	6.24	1.33	1.40	0.30
Residential High Density	Residential High Density[2]	1300	23.9558	9.36	1.73	3.00	0.55
Other Urban	Commercial and Services[2]	1400	25.5528	8.58	1.48	1.40	0.24
	Industrial[2]	1500	27.1499	7.80	1.27	2.40	0.39
	Extractive[2]	1600	23.9558	5.46	1.01	0.66	0.12
	Institutional[2]	1700	23.9558	5.46	1.01	2.40	0.44
	Recreational[2]	1800	17.5676	5.46	1.37	0.96	0.24
Improved Pastures	Improved Pastures	2110	19.1646	8.66	2.00	1.90	0.44
Unimproved Pastures	Unimproved Pastures	2120	15.9705	4.29	1.19	0.92	0.25
Woodland Pastures/Rangeland	Woodland Pastures	2130	15.9705	3.20	0.89	0.88	0.24
	Rangeland	3000	15.9705	3.20	0.89	0.28	0.08
Row Crops	Row Crops	2140	22.3587	11.70	2.31	4.50	0.89
Sugar Cane	Sugar Cane	2156	19.1646	6.24	1.44	0.63	0.15
Citrus	Citrus	2210	19.1646	6.63	1.53	1.80	0.42
Sod Farms	Sod Farms	2420	19.1646	7.02	1.62	2.52	0.58
Ornamentals	Ornamentals	2430	19.1646	9.36	2.16	2.90	0.67
Horse Farms	Horse Farms	2510	15.9705	12.48	3.45	1.82	0.50
Dairies	Dairies	2520	15.9705	15.60	4.32	9.38	2.60
Other Areas	Field Crops	2150	15.9705	5.17	1.43	2.96	0.82
	Mixed Crops	2160	19.1646	8.58	1.98	3.50	0.81
	Fruit Orchards	2220	19.1646	7.02	1.62	2.30	0.53
	Other Groves	2230	19.1646	7.02	1.62	2.30	0.53
	Cattle Feeding Operations	2310	19.1646	42.16	9.72	8.96	2.07
	Poultry Feeding Operations	2320	19.1646	7.80	1.80	1.50	0.35
	Tree Nurseries	2410	15.9705	9.36	2.59	2.90	0.80
	Specialty Farms	2500	15.9705	6.24	1.73	1.82	0.50
	Aquaculture	2540	7.98525	7.80	4.32	0.70	0.39
	Fallow Crop Land	2610	19.1646	5.46	1.26	0.70	0.16
Tree Plantations	Tree Plantations	4400	15.9705	2.42	0.67	0.18	0.05
Water	Water	5000	3.1941	0.70	0.97	0.05	0.07
Natural Areas	Upland Forests (not including 4400s)	4000	14.3735	1.95	0.60	0.28	0.09
	Wetlands	6000	1.59705	1.17	3.24	0.01	0.03
	Barren Land	7000	23.9558	5.46	1.01	0.75	0.14
	Open Land	1900	15.9705	3.12	0.86	0.28	0.08
Transportation	Transportation	8100	27.1499	7.18	1.17	1.65	0.27
Communication/Utilities	Communications	8200	15.9705	4.68	1.30	0.48	0.13
	Utilities	8300	15.9705	4.68	1.30	0.48	0.13

[1]Assumed to be on septic systems.

[2]Assumed discharge from wastewater treatment outside of the watershed.

Table B-5. Net TP loads [in pounds per year (lbs/yr)] for each sub-watershed within the St. Lucie River Watershed by land use category.

FLUCCS	Basin 4-5-6	C-23	C-24	C-44/ S-153	North Fork[1]	Tidal St. Lucie[2]	Total
1100	2,115	936	606	889	4,628	1,632	10,804
1200	1,731	425	3,508	441	42,635	4,749	53,489
1300	2,108	0	885	557	14,353	5,191	23,093
1400	312	13	56	286	4,835	1,624	7,126
1500	320	116	133	184	3,726	403	4,881
1600	1	272	0	0	61	89	422
1700	265	1,588	52	234	3,761	1,244	7,144
1800	656	245	639	201	2,216	1,003	4,961
1900	31	3	21	42	922	132	1,150
2110	1,913	63,893	64,504	44,052	9,498	18,150	202,009
2120	79	4,657	5,579	1,994	514	1,007	13,830
2130	330	7,654	6,063	5,683	943	1,507	22,180
2140	702	7,633	6,976	3,836	5,248	11,070	35,465
2150	0	4,668	2,475	1,159	0	0	8,301
2156	0	0	0	3,301	0	203	3,504
2210	54	58,439	31,478	76,958	37,221	5,446	209,596
2220	0	0	0	0	0	0	0
2230	12	39	0	0	60	0	111
2310	0	938	0	0	0	0	938
2320	0	0	66	94	0	0	160
2410	291	446	161	247	198	0	1,343
2420	0	0	0	741	0	0	741
2430	612	0	73	776	690	1,463	3,613
2500	0	0	0	52	43	145	241
2510	98	98	26	1,077	0	129	1,428
2520	0	3,931	0	0	0	0	3,931
2540	42	49	16	0	7	29	143
2610	0	152	0	0	22	0	174
3000	110	449	62	1,787	978	574	3,961
4000	750	763	354	3,230	3,369	2,065	10,530
5000	19	91	61	95	216	90	571
6000	13	163	122	151	95	67	611
7000	0	831	223	704	176	25	1,960
8100	491	751	860	1,008	4,329	1,908	9,348
8200	5	5	0	3	31	0	44
8300	206	440	49	3,748	528	40	5,010
Grand Total	**13,264**	**159,686**	**125,049**	**153,531**	**141,301**	**59,983**	**652,814**
Concentration (ppb)	**233**	**384**	**382**	**319**	**292**	**325**	**335**
Measured Concentration (ppb)	**239**	**478**	**358**	**220**	**279**	**283**	
Lake Okeechobee (pounds)							**196,723**
Calculated (mt/yr)	**6**	**73**	**57**	**70**	**64**	**27**	**386**
Measured (mt/yr)	**6**	**87**	**76**	**50**	**40**	**19**	**368**

[1]The North Fork Sub-watershed includes the North Fork of the St. Lucie River and the north Middle Estuary of the St. Lucie Estuary (SLE).

[2]The Tidal St. Lucie Sub-watershed includes the South Fork of the St. Lucie River and the south Middle Estuary of the SLE.

Table B-6. Net TN loads (in lbs/yr) for each sub-watershed within the St. Lucie River watershed by land use category.

FLUCCS	Basin 4-5-6	C-23	C-24	C-44/ S-153	North Fork[1]	Tidal St. Lucie[2]	Total
1100	18,514	8,191	5,303	7,781	40,519	14,285	94,593
1200	7,713	1,895	15,637	1,965	190,029	21,168	238,407
1300	6,576	0	2,761	1,738	44,780	16,196	72,051
1400	1,912	77	341	1,754	29,634	9,951	43,670
1500	1,039	377	433	598	12,108	1,309	15,863
1600	4	2,247	0	0	504	738	3,493
1700	602	3,613	118	533	8,556	2,830	16,253
1800	3,734	1,391	3,634	1,144	12,604	5,707	28,213
1900	346	31	233	464	10,269	1,473	12,815
2110	8,716	291,151	293,937	200,736	43,280	82,705	920,524
2120	371	21,716	26,016	9,300	2,396	4,694	64,492
2130	1,198	27,814	22,035	20,652	3,428	5,478	80,605
2140	1,826	19,846	18,139	9,974	13,645	28,781	92,209
2150	0	8,133	4,311	2,019	0	0	14,464
2156	0	0	0	32,698	0	2,007	34,706
2210	200	215,250	115,944	283,462	137,096	20,058	772,012
2220	0	0	0	0	0	0	0
2230	35	120	0	0	184	0	339
2310	0	4,414	0	0	0	0	4,414
2320	0	0	346	488	0	0	833
2410	938	1,440	519	798	639	1	4,335
2420	0	0	0	2,065	0	0	2,065
2430	1,975	0	235	2,505	2,227	4,721	11,663
2500	0	0	0	179	149	499	827
2510	670	674	176	7,383	0	887	9,789
2520	0	6,538	0	0	0	0	6,538
2540	469	549	182	0	74	318	1,593
2610	0	1,183	0	0	171	0	1,354
3000	1,262	5,128	704	20,414	11,174	6,559	45,241
4000	5,224	5,311	2,466	22,495	23,460	14,379	73,335
5000	269	1,271	855	1,327	3,031	1,257	8,010
6000	1,477	19,046	14,330	17,684	11,098	7,795	71,430
7000	0	6,050	1,626	5,127	1,284	181	14,269
8100	2,136	3,268	3,739	4,386	18,826	8,300	40,654
8200	51	48	0	26	301	0	426
8300	2,004	4,287	479	36,544	5,144	389	48,848
Grand Total	**69,261**	**661,060**	**534,500**	**696,241**	**626,609**	**262,665**	**2,850,334**
Concentration (ppb)	**1,217**	**1,591**	**1,634**	**1,447**	**1,296**	**1,424**	**1,463**
Measured Concentration (ppb)	**1,177**	**1,574**	**1,647**	**1,579**	**1,183**	**1,234**	
Lake Okeechobee (pounds)							**1,775,254**
Calculated (mt/yr)	**31**	**300**	**243**	**316**	**285**	**119**	**2,103**
Measured (mt/yr)	**31**	**287**	**349**	**356**	**171**	**83**	**2,084**

[1]The North Fork Sub-watershed includes the North Fork of the St. Lucie River and the north Middle Estuary of the St. Lucie Estuary (SLE).

[2]The Tidal St. Lucie sub-watershed includes the South Fork of the St. Lucie River and the south Middle Estuary of the SLE.

Table B-7. 2004 land use categories, unit TP load factors, and percent TP reduction factors for Best Management Practices (BMPs) and alternative practices for the St. Lucie River Watershed.

Land Use Category	Land Use Description	FLUCCS	Unit TP Load (lbs/ac/yr)	Estimated Percent TP Reduction		
				Owner-Implemented BMPs	Typical Cost-Shared BMPs	Alternative Practices
Residential Low Density	Residential Low Density[1]	1100	0.49	5%	5%	70%
Residential Medium Density	Residential Medium Density[2]	1200	1.40	5%	5%	70%
Residential High Density	Residential High Density[2]	1300	3.00	5%	5%	70%
Other Urban	Commercial/Industrial[2]	1400–1800	1.54	5%	5%	70%
Improved Pastures	Improved Pastures	2110	1.90	11%	19%	49%
Unimproved Pastures	Unimproved Pastures	2120	0.92	7%	13%	44%
Woodland Pastures/Rangeland	Woodland/Range Pastures	2130/3000	0.66	4%	6%	35%
Row Crops	Row Crops	2140	4.50	30%	30%	50%
Sugar Cane	Sugar Cane	2156	0.63	10%	23%	52%
Citrus	Citrus	2210	1.80	12%	20%	42%
Sod Farms	Sod Farms	2420	2.52	20%	27%	50%
Ornamentals	Ornamentals	2430	2.90	32%	35%	50%
Horse Farms	Horse Farms	2510	1.82	20%	22%	49%
Dairies	Dairies	2520	9.38	9%	28%	48%
Other Areas	Other Areas	2150–2610	2.78	15%	25%	36%
Tree Plantations	Tree Plantations	4400	0.18	1%	10%	50%
Water	Water	5000	0.05	0%	0%	0%
Natural Areas	Forests/Wetlands/Open	4000/6000	0.14	0%	0%	0%
Transportation	Transportation	8100	1.65	10%	23%	52%
Communication/Utilities	Communication/Utilities	8200/8300	0.48	5%	5%	50%

[1]Assumed to be on septic systems.
[2]Assumed discharge from wastewater treatment outside of the watershed.

Table B-8. 2004 land use categories, unit TN load factors, and percent TN reduction factors for BMPs and alternative practices for the St. Lucie River Watershed.

Land Use Category	Land Use Description	FLUCCS	Unit TN Load (lbs/ac/yr)	Estimated Percent TN Reduction		
				Owner-Implemented BMPs	Typical Incentive BMPs	Alternative Practices
Residential Low Density	Residential Low Density[1]	1100	4.29	15%	15%	15%
Residential Medium Density	Residential Medium Density[2]	1200	6.24	25%	25%	15%
Residential High Density	Residential High Density[2]	1300	9.36	30%	25%	15%
Other Urban	Commercial/Industrial[2]	1400–1800	6.76	25%	25%	15%
Improved Pastures	Improved Pastures	2110	8.66	17%	10%	30%
Unimproved Pastures	Unimproved Pastures	2120	4.29	11%	8%	30%
Woodland Pastures/Rangeland	Woodland/Range Pastures	2130/3000	3.20	4%	6%	20%
Row Crops	Row Crops	2140	11.70	30%	30%	50%
Sugar Cane	Sugar Cane	2156	6.24	10%	23%	52%
Citrus	Citrus	2210	6.63	10%	20%	42%
Sod Farms	Sod Farms	2420	7.02	20%	27%	50%
Ornamentals	Ornamentals	2430	9.36	25%	25%	25%
Horse Farms	Horse Farms	2510	12.48	30%	22%	30%
Dairies	Dairies	2520	15.60	20%	40%	48%
Other Areas	Other Areas	2150–2610	6.86	15%	25%	36%
Tree Plantations	Tree Plantations	4400	2.42	5%	10%	25%
Water	Water	5000	0.70	0%	0%	0%
Natural Areas	Forests/Wetlands/Open	4000/6000	1.63	0%	0%	0%
Transportation	Transportation	8100	7.18	20%	23%	25%
Communication/Utilities	Communication/Utilities	8200/8300	4.68	5%	5%	50%

[1]Assumed to be on septic systems.
[2]Assumed discharge from wastewater treatment outside of the watershed.

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Attachment C: St. Lucie River Watershed Best Management Practices Assumptions

AGRICULTURAL BEST MANAGEMENT PRACTICES ASSUMPTIONS

Implementation rates for agricultural Best Management Practices (BMPs), determined on a sub-watershed basis, were provided by the Florida Department of Agriculture and Consumer Services (FDACS) (**Table C-1**). Applicable practices under the "owner-implemented" category are non-structural in nature. Typical BMPs in this category are nutrient and irrigation management, maintenance of vegetative buffers to protect water features from sediment runoff, and location of livestock feeding/mineral stations away from water features. Generally, this type of practice is already being implemented or is easily implemented in the first year. Applicable practices under the "cost-shared" category are structural in nature. Typical BMPs in this category are surface water control structures, detention/retention structures, alternative watering facilities for livestock, and tailwater recovery ponds. Generally, these practices require significant investment by the landowner and require long-term planning and cost-share assistance for installation and maintenance.

Cost-share funding provided by the FDACS, United States Department of Agriculture Natural Resources Conservation Service, and South Florida Water Management District (SFWMD or District) has been available to agricultural producers in the watershed on a limited basis, and some agricultural producers have used those funds along with their own to install BMPs that help maintain or improve water quality. However, in the St. Lucie River Watershed some BMPs that fall under the cost-shared category have been implemented without funding assistance. This is due to several factors. Agricultural land uses in South Florida such as citrus, vegetable, sugarcane, and sod production typically need surface water control systems for both irrigation and flood control. These systems also may be required by permit. Therefore, in some cases agricultural producers must, by necessity or regulation, install them regardless of whether cost sharing is available. Other agricultural land uses, such as cattle production, have installed surface water control structures over time to improve forage production.

Current implementation rates for owner-implemented BMPs, as of July 2011, were derived by taking estimates of current owner-implemented Notice of Intent enrollment (acres) in each sub-watershed divided by the total estimated agricultural acres in the sub-watershed. On the other hand, current implementation rates for cost-share BMPs were derived from cost-share BMP enrollment data and further investigations conducted by FDACS staff through Geographic Information System analyses and local knowledge of the area. These analyses indicated that landowners have been implementing cost-shared type of BMPs (water control structures, retention/detention systems, etc.) at the same rates as the owner-implemented BMPs by necessity or regulation, as described above. The near-term implementation rates are estimates of what is expected as reasonable to accomplish in the next three years (2012–2014). Long-term owner-

implemented BMPs were estimated at 100 percent with the assumption that the District's Regulatory Nutrient Source Control Program is expanded to encompass the St. Lucie River Watershed. There was no additional cost-shared implementation rates applied for the long-term phase.

Table C-1. St. Lucie River Watershed agricultural Best Management Practice (BMP) implementation rates.

Sub-Watershed	Current	Near-Term	Long-Term
Owner-Implemented Agricultural BMPs			
Basin 4-5-6	3.2%	30%	100%
C-23	66.4%	80%	100%
C-24	65.7%	80%	100%
C-44/S-153	44.8%	60%	100%
North Fork	27.1%	60%	100%
South Fork	6.9%	30%	100%
Cost-Share Agricultural BMPs			
Basin 4-5-6	3.2%	10%	not applicable
C-23	66.4%	75%	not applicable
C-24	65.7%	75%	not applicable
C-44/S-153	44.8%	55%	not applicable
North Fork	27.1%	35%	not applicable
South Fork	6.9%	10%	not applicable

URBAN BEST MANAGEMENT PRACTICES ASSUMPTIONS

Urban BMP implementation rates were determined on a sub-watershed basis and applied to pervious areas. Additionally, cost-shared urban BMPs were only applied to land that was not yet developed when stormwater permitting rules went into effect (post-1988). Cumulative implementation rates of 10 percent for current, 35 percent for near-term, and 100 percent for long-term were applied for owner-implemented urban BMPs. For cost-share urban BMPs in the St. Lucie River Watershed, cumulative implementation rates of 20 percent for current, 40 percent for near-term, and 100 percent for long-term were applied.

Attachment D: St. Lucie River Watershed and St. Lucie Estuary Monitoring Efforts

This attachment provides inventories of the monitoring efforts being conducted within the St. Lucie River Water Protection Plan study area, which includes the St. Lucie River Watershed and the St. Lucie Estuary, as of June 2011. **Table D-1** contains a water quality monitoring inventory. **Table D-2** contains an aquatic program inventory.

Table D-1. Water quality monitoring inventory for the St. Lucie River Watershed Protection Plan (SLRWPP) study area (current as of June 2011).

Organization	Type	Number of Stations	Location	Frequency	Period	Analytes
South Florida Water Management District (SFWMD) / Water Quality Monitoring – North	Water quality	5 grab	St. Lucie Estuary (SLE) and watershed district structures	Monthly	1982–present	Alkalinity, calcium (Ca), chloride (Cl), color, magnesium (Mg), ammonia (NH_4), nitrate + nitrite (NOx), ortho-phosphate (O-PO_4), total Kjehldahl nitrogen (TKN), total arsenic (Tot-As), total chromium (Tot-Cr), total copper (Tot-Cu), total phosphate (Tot-PO_4), total suspended solids (TSS), turbidity, dissolved oxygen (DO), specific conductance, temperature, pH.
				Quarterly		Includes all monthly parameters plus sodium (Na), potassium (K), silicone (SiO_2), sulfate (SO_4), total iron (Tot-Fe).
		5 auto-sampler		Weekly		NOx, TKN, Tot-PO_4
	Flow	5 auto-sampler		Weekly		
SFWMD / SE	Water quality	13 grab	SLE	Monthly	1991–present	Color, chlorophyll *a* (Chl*a*), NH_4, NO_x, nitrite (NO_2), O-PO_4, pheophytin, total organic carbon (TOC), TKN, total phosphorus (TP), turbidity, TSS, volatile suspended solids (VSS), DO, conductivity, temperature, pH, photosynthetic active radiation (PAR), Secci depth, total depth
SFWMD / SE Releases	Water quality	7 grab	SLE	Sampled on request	1991–2009	Chl*a*, chlorophyll 2 , color, pheophytin, TSS, turbidity, DO, conductivity, temperature, pH, PAR, salinity, Secci depth, total depth at sites SE02, SE03, HR1, SE06, SE08B, IRL11B, IRL17
SFWMD / St. Lucie Tributary Monitoring Network	Water quality	19 grab	SLE tributaries including North Fork, South Fork, Bessey Creek, and Danforth Creek basins	Biweekly when water is flowing	2001–2011	Chl*a*, chlorophyll b, pheophytin, O-PO_4, TKN, T-PO_4, TSS, turbidity, NH_4, NOx, DO, specific conductance, temperature, pH.
				Monthly		Includes all biweekly parameters plus Ca, Mg, Tot-As, Tot-Cu, Tot-Cr
	Flow and rainfall	12 flow 8 rainfall		Continuous		
SFWMD: Salinity Monitoring	Salinity	7 in situ	SLE	15 minutes	1997–2009 (7 sites) 1997–present (3 sites)	Near surface and bottom conductivity/salinity and temperature with water level, velocity, and DO at some sites (HR-1)
Blue-green Algae Interagency Coordination Committee	Chlorophyll	As required by the Blue-Green Algae Interagency Coordination Committee	SLE when blue-green algae is present	As required by the Blue-Green Algae Interagency Coordination Committee	2005–2006	Chl*a*

Table D-1. Continued.

Organization	Type	Number of Stations	Location	Frequency	Period	Analytes
St. Lucie County Health Department	Water quality	14 grab	SLE and tributary	Monthly	2005–present	Fecal coliform, enterococci, salinity
St. Lucie County Public Works Department	Water quality	2 auto-sampler composite time 2 grab	North Fork tributary	Tri-weekly	2008–present	TP, total nitrogen (TN), biochemical oxygen demand, field parameters
SFWMD / Allapattah Complex Restoration Area (ACRA)	Water quality	6 grab	Watershed (Allapattah Restoration Area)	Biweekly (2 sites)	2003–2010	NH_4, NOx, TKN, T-PO_4, DO, specific conductance, temperature, pH
				Monthly		Includes all biweekly parameters plus SO_4
		2 auto-sampler		Weekly		T-PO_4 at sites ACRA1, ACRA2
	Fish	4 fish		Quarterly (4 sites)		Total mercury and organochlorine pesticide compounds in mosquitofish at sites ACRA1, ACRA1B, ACRA7, and ACRA8
				Annually (2 sites)		Mercury and organochlorine compounds in large bodied fish [e.g., largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*)] at sites ACRA1, ACRA1B
Martin County Health Department		9 grab	SLE	Weekly	May 2004–present	Enterococci (site SP6 at Roosevelt Bridge; 8 other stations outside of SLE)
Martin County Office of Water Quality		7 at 2 stormwater treatment areas	Stormwater Facilities	Weekly	2008 (1–3 years)	pH, alkalinity, conductivity, NOx, TKN, particulate nitrogen, TN, NH_4, soluble reactive phosphorus , particulate phosphorus, TP, turbidity, TSS, copper, DO, bulk precipitation
SFWMD / St. Lucie Synoptic Monitoring		12 grab	C-23/C-24 sub-watershed	Event-driven	2010–present	NOx, NH_4, total dissolved Kjehldahl nitrogen, TKN, total dissolved PO_4, T-PO_4
SFWMD / Lake Okeechobee Inflows & Outflows		1 (S-308C) grab	C-44 and Lake Okeechobee S-308 lock	Biweekly	1973–present	Alkalinity, NH_4, NOx, O-PO_4, TKN, T-PO4, TSS, turbidity, DO, specific conductance, temperature, pH, Chl*a*, TOC
				Quarterly		Tot-Fe

Table D-2. Aquatic program inventory for the SLRWPP study area (current as of June 2011).

Organization	Number of Stations	Location	Frequency	Period	Analytes	Summary
Seagrass Mapping and Monitoring	80+	Transect locations represent all segments of the lagoon	Semiannually	1994–present	Species composition, epiphytes, coverage, abundance, drift algae, light extinction, salinity, temperature, dissolved oxygen (DO)	This is a lagoon-wide, multi-agency effort. Data are maintained and analyzed by the St. John's River Water Management District (SJRWMD). Parameters related to species composition, epiphytes, coverage, abundance, drift algae, light extinction, salinity, temperature, and DO.
Seagrass Mapping and Monitoring	Lagoon-wide maps	Entire lagoon including St. Lucie Estuary (SLE) upstream to Roosevelt Bridge (US 1)	Every 2–5 years	1986–present	Seagrass distribution and density	This monitoring is conducted lagoon-wide, in partnership with SJRWMD. Maps are created by interpreting seagrass signatures present on aerial imagery. Seagrass distribution and density are mapped. The data is used to evaluate long-term trends in seagrass distribution/density.
Seagrass Mapping and Monitoring	10	Southern Indian River Lagoon	Bi-monthly (3 sites near SLE are monitored monthly)	2008–present	Seagrass canopy height seagrass percent cover, macroalgae percent cover, spatial distribution of seagrass species, DO, pH, temperature, conductivity/salinity, photosynthetically active radiation, Secchi depth (to the nearest 10 centimeters)	The purpose of this monitoring it to establish pre-Comprehensive Everglades Restoration Plan (CERP) reference conditions and variability of seagrass; determine seagrass status and trends; detect unplanned ecosystem responses to stressors CERP activities may change; and support scientific understanding of ecosystem dynamics and cause-and-effect relationships. Monthly seagrass monitoring at three of the 10 locations is conducted to support decision making for operations.
American Recovery and Reinvestment Act (ARRA) Project Oyster Monitoring and Mapping: Florida Fish and Wildlife Conservation Commission (FWC)	2 natural sites 4 restoration reefs	SLE	Semiannually	summer 2009 – summer 2011	Oyster spat recruitment, oyster condition, reproduction, and disease monitoring. Water quality (salinity, temperature, pH, DO, Secchi depth) is monitored monthly.	Adult oysters are sampled twice per year from replicate stations within the SLE establishing an oyster baseline. Oyster monitoring includes reproduction, recruitment, and disease patterns.
CERP Oyster Monitoring and Mapping: FWC	9	SLE	Semiannually	2005–present	Oyster spat recruitment, oyster condition, reproductive, and disease monitoring. Water quality (salinity, temperature, pH, DO, Secchi depth) is monitored monthly. Juvenile growth and mortality was measured in 2005–2007 and added into the 2011 monitoring plan	Adult oysters are sampled twice per year from replicate stations within the SLE establishing an oyster baseline. Oyster monitoring includes reproduction, recruitment, and disease patterns.