Sarasota Bay

Water Quality Management Plan

Sarasota County

Southwest Florida Water Management District

Janicki Environmental, Inc.

Jones Edmunds

Sarasota Bay
Water Quality Management Plan

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Dear Friends of the Sarasota Bay Watershed,

You hold in your hands the key to the Sarasota Bay Watershed's future. This report is the product of an intensive collaboration between local citizens, county governments, and concerned agencies. The facts and recommendations in this report are based on the distillation of many hundreds of pages of scientific study and data gathering specific to the Sarasota Bay watershed and scientific analysis performed by this Project Team.

Representing our current understanding of Water Quality, Water Supply, Natural Systems, Flood Protection, Best Management Practices, and a host of other topics, this plan, along with its companion appendices, provides a framework for future action and work by the very same entities that collaborated to write it.

The watershed conditions will change with time and with it this Management Plan must evolve and adapt - but the goal will remain the same: protect the Sarasota Bay and its Watershed.

We must now put this plan to work - we must protect Sarasota Bay.

—The Sarasota Bay Water Quality Management Plan Project Team

ACKNOWLEDGEMENTS

The Sarasota Bay Water Quality Management Plan (WQMP) was funded through a cooperative partnership between Sarasota County and the Southwest Florida Water Management District (SWFWMD). Sarasota County and SWFWMD provided funds and in-kind services including project coordination and management, consultant contract administration, stakeholder input coordination, education and outreach plan, and staff input on plan development.

Several agencies and individuals provided significant contributions to this plan, including Sarasota Bay Watershed stakeholders, whose members include representatives from City of Sarasota, Manatee County, and Sarasota Bay Estuary Program. Of particular mention are Kelly Westover, Sarasota County – Sarasota Bay WQMP Project Manager/Environmental Specialist; John Ryan, Sarasota County/Water Quality Manager; Lizanne Garcia, SWFWMD – Sarasota Bay WQMP Project Manager/Senior Environmental Scientist; Jay Leverone, Senior Environmental Scientist, Sarasota Bay Estuary Program; County and District staff that contributed to this plan as technical experts and reviewers; and all watershed stakeholders whose interest in protecting, restoring, and enhancing the Sarasota Bay Watershed has been critical to the success of this plan.

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AOR	Area of Responsibility
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CCMP	Comprehensive Conservation and Management Plan
CIP	Capital Improvement Program
DO	Dissolved Oxygen
EPA	US Environmental Protection Agency
ET	Evapotranspiration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FPLOS	Flood Protection Level of Service
FWC	Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
gpcd	gallons per capita per day
HOA	Homeowners Associations
ICW	Intracoastal Waterway
IWR	Impaired Waters Rule
LDR	Land Development Regulations
LID	Low-Impact Development
LOS	Level of Service
MGD	Million Gallons Per Day
NNC	Numeric Nutrient Criteria
NPDES	National Pollutant Discharge Elimination System
OFW	Outstanding Florida Waterbody
SBEP	Sarasota Bay Estuary Program
SEU	Stormwater Environmental Utility
SIMPLE	Spatially Integrated Model for Pollutant Loading Estimates
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management Program
SWUCA	Southern Water Use Caution Area
TCCI	Tidal Creek Condition Index
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UAL	Unit Area Load
WBID	Waterbody Identification
WQMP	Water Quality Management Plan

EXECUTIVE SUMMARY

Sarasota County recognizes how important clean water resources, healthy streams, and safety from flooding are for residents, businesses, community leaders, and the local economy. The County has implemented the Comprehensive Watershed Management Program to address water quality, water quantity, flooding, and natural systems in a comprehensive manner within each of its watersheds. This program is consistent with the Sarasota County Comprehensive Plan (Chapter 4, Goal 2, Objective 2.2, Policy 2.2.1) and employs an approach consistent with the Southwest Florida Water Management District's (SWFWMD) four areas of responsibilities related to water resource management: Water Quality, Water Supply, Flood Protection, and Natural Systems. One component of this Comprehensive Watershed Management Program is to develop a Water Quality Management Plan (WQMP) for each of the County's watersheds. The County partnered with the Southwest Florida Water Management District and tasked the team of Jones Edmunds and Janicki Environmental with developing a Comprehensive Water Quality Management Plan for Sarasota Bay. This section is the Executive Summary of the Sarasota Bay Watershed WQMP. To view the full report, visit www.scgov.net (keyword = Sarasota Bay).

Watershed Management Plans balance the goals of restoring natural systems, enhancing water quality, ensuring the sustainability of the water supply, and protecting against floods while expanding recreational and educational opportunities

Water Quality
To protect, maintain, and improve water quality conditions in estuarine and freshwater environments

Water Supply
To provide reliable and safe water to meet existing and future demands

Natural Systems
To protect, enhance, and restore natural communities and habitats

Flood Protection
To minimize flood risk to the population and property in developed areas while protecting the natural and beneficial functions of the remaining floodplain

What's the GOAL?

The Sarasota Bay WQMP is a regional initiative to develop and implement a watershed management plan for Sarasota Bay and its watersheds to help achieve the following objectives:

- Improve water quality.
- Restore to the greatest extent possible the historical natural hydrologic regime.
- Protect, enhance, and restore natural communities and habitats.
- Identify potential sustainable surface water supply options.

The Sarasota Bay WQMP balances the goals of restoring natural systems, enhancing water quality, ensuring the sustainability of the water supply, and protecting against floods while expanding educational opportunities. This plan summarizes past, present, and future watershed conditions. The plan also contains recommendations for activities to help reach these goals and progress toward sustaining and enhancing the health of the watershed

The Sarasota Bay WQMP discusses factors that affect water quality in the bay and tributaries and the consequences of degraded water quality on natural resources. Specific activities completed in developing the WQMP included:

- Summarizing existing water quality characteristics of Sarasota Bay and its tributaries.
- Comparing existing water quality (nutrients and dissolved oxygen [DO]) to regulatory criteria and management targets.

- ❖ Estimating current and projected future pollutant loading levels to the bay and identifying "hot spots" in the bay and tributaries.
- ❖ Establishing Water Quality Levels of Service (LOS) standards for the bay and tributary tidal creeks.
- ❖ Presenting potential projects for the improvement and protection of water quality in the bay and tributaries.

The analysis and recommendations were applied to the Sarasota County portions of the Sarasota Bay Watershed, which consists of one bay segment and three subbasins (Figure ES-1). Approximately half of the Sarasota Bay Watershed is located north of the County boundary in Manatee County. For this WQMP, the Sarasota Bay Coastal (SBC) Basin has been subdivided into two portions: SBC-South, which includes the basin area in Sarasota County, and SBC-North, which includes lands outside the County. To assess Sarasota Bay as a whole, the entire watershed was evaluated for hydrologic and pollutant loadings; however, all management options address only areas within Sarasota County.

Bay Segments

- ❖ Sarasota Bay

Basins

- ❖ Sarasota Bay Coastal Basin-South
- ❖ Whitaker Bayou Basin
- ❖ Hudson Bayou Basin
- ❖ Manatee County Basins
  - ➢ Sarasota Bay Coastal Basin-North
  - ➢ Bowlees Creek
  - ➢ Cedar Hammock Creek
  - ➢ Palma Sola Drain – Bayshore
  - ➢ Canal Road Drain

Additionally, the plan promotes and furthers implementation of other regional plans, including the *Sarasota County Comprehensive Plan*, the Sarasota Bay Estuary Program's (SBEP) *Comprehensive Conservation and Management Plan* (CCMP), SWFWMD's *Southern Coastal Comprehensive Watershed Management Plan*, and SWFWMD's *Sarasota Bay Surface Water and Improvement* (SWIM) *Plan*.

Widespread alterations to the surface hydrology of the watershed have occurred over the past decades, resulting in significant changes to the volume and timing of freshwater inflows to the bay. However, Sarasota Bay is on a whole healthy, and water quality management programs overseen by the County and others (Section 3.7.1) will help maintain this health. Conversely, some of the bay's basins exhibit water quality problems, and while the County's programs will help improve water quality in these basins, construction projects focused on addressing water quality may be needed as well. This plan will present opportunities to implement stormwater treatment in already developed areas throughout the watershed. Advances in stormwater system technology can better help balance the needs of the environment with those of the community.

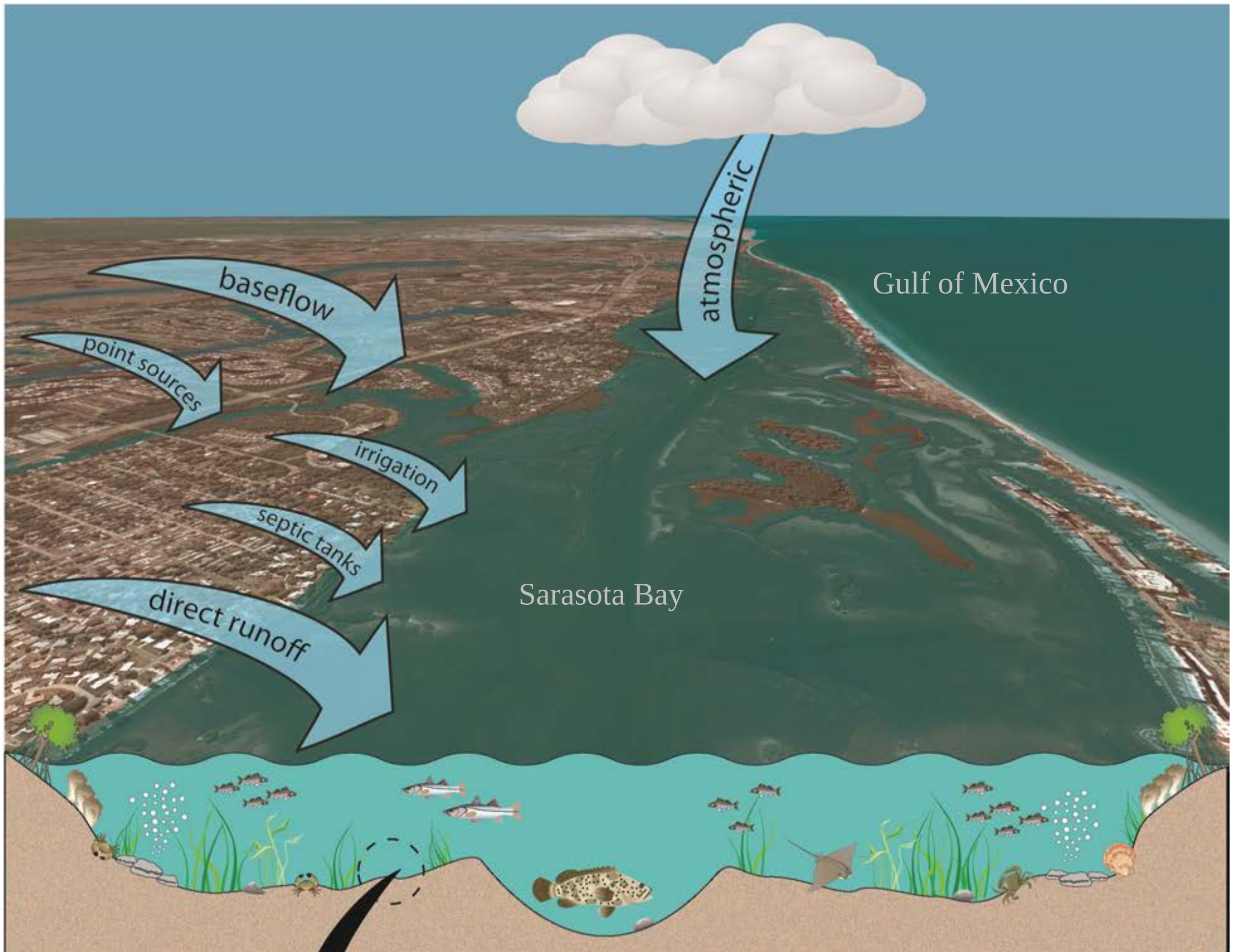
Figure ES-1 Sarasota Bay Watershed Basins

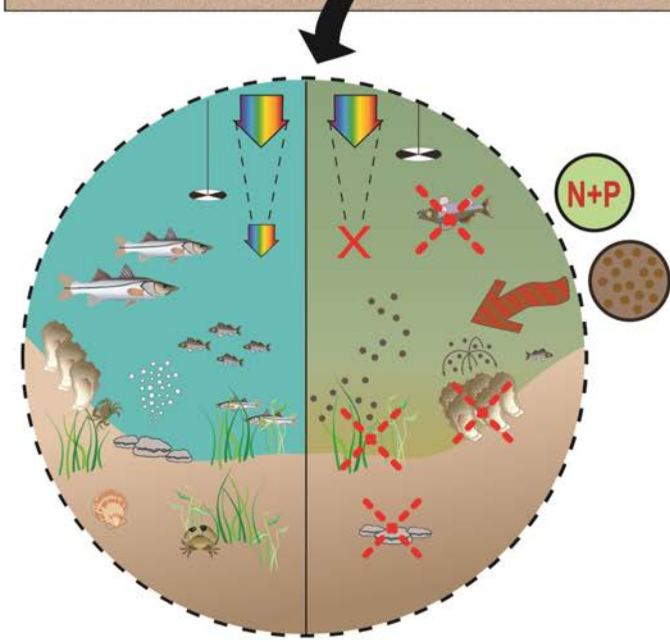
Additional major findings of this WQMP are presented by basin—SBC, Whitaker Bayou, Hudson Bayou, and basins outside the County.

Located on the west-central coast of Florida, the Sarasota Bay Watershed is famous for its sandy beaches, keys, sparkling blue water, and array of marine life such as dolphins, manatees, loggerhead turtles, fish, and crabs. The subtropical estuary is a vital resource for Sarasota County, providing economic, recreation, and aesthetic benefits. The bay is connected to the Gulf of Mexico via Big Pass and other inlets, as well as with the watershed through inputs of freshwater, chemicals, and mineral materials conveyed to the bay in tidal creeks. Understanding the relationship of the bay to these inputs is important to protecting and enhancing bay resources (Figure ES-2).

Sarasota Bay is classified as an Estuary of National Significance, SWFWMD Surface Water Improvement and Management (SWIM) Priority Waterbody, an Outstanding Florida Water (OFW) as designated by Florida Department of Environmental Protection (FDEP), and a Florida priority estuarine conservation area as designated by the Fish and Wildlife Conservation Commission (FWC).

The Sarasota Bay Watershed is relatively flat and has an average annual rainfall of 53 inches. The majority of the watershed has been altered, leaving only isolated natural and conservation areas for many threatened and endangered native species. Only about 10% of the watershed is undeveloped, which significantly affects water quality, water quantity (flow), habitat, and flooding risks. The highly urbanized watershed consists of a lot of older neighborhoods that provide only minimal stormwater retention or detention. The surface water runoff from the rainfall flows across the watershed terrain through ditches, storm drains, creeks, and wetlands and eventually into Sarasota Bay. The untreated runoff contributes sediment and associated pollutants to Sarasota Bay and its tributaries. Previous studies show some sediment in the Sarasota Bay tributaries contains substantial levels of contaminants including toxic metals, pesticides, petroleum, and other organic compounds. However, sediments in the bay proper have been reported to be uncontaminated.





Freshwater flow from atmospheric deposition (rainfall), direct runoff, baseflow, and to a lesser extent, point sources, irrigation, and septic tanks influences physical, chemical, and biological conditions in the watershed and Sarasota Bay. Unfortunately, our actions can negatively affect the quality and quantity of freshwater inflows and the bay. As water flows through the watershed and into Sarasota Bay, it picks up pollutants including sediment, nutrients, and chemicals and pathogens. Adverse impacts to the bay can occur if the loading rate exceeds the bay's ability to self purify, which can reduce water clarity, light penetration, dissolved oxygen, seagrasses, benthos, including oysters and scallops, and even crustaceans and fish, all of which are vital components of a healthy bay system.

Symbols courtesy of the Integration and Application Network (http://ian.umces.edu/imagelibrary), University of Maryland Center for Environmental Science.

Figure ES-2 Bay Processes

Freshwater inflows to Sarasota Bay originate from sources in nature and from human activities. Rainfall is the primary source of freshwater in the Sarasota Bay system. Atmospheric deposition (direct rainfall to the open water estuary) contributes the most freshwater to Sarasota Bay of any source (see Figure ES-3). This is because the relative size of the open water estuary is large with respect to the watershed land area.

Replacement of natural uplands and wetlands with urban land uses has a profound effect on the timing and volume of freshwater reaching the bay. The relative contributions of sources of freshwater for historical, current, and future conditions indicate that although freshwater inflows have increased since the historical period, future freshwater inflows should very much resemble current inflows. Stormwater runoff and shallow groundwater inflows to the bay have increased over the years and are expected to remain greater that historical levels into the future. Another change to inflows to the bay is wastewater effluent. The City of Sarasota's wastewater treatment plant, the only major discharge to the bay that remains, will stop discharging in the future. No adverse effects due to changes to freshwater inflows are expected.

One of the main challenges of protecting water quality in the watershed is to decrease the amount of stormwater runoff to limit the amount of freshwater, sediments, and nutrients entering the bay.

Water quality in the bay has been regularly monitored for salinity, nutrients (total nitrogen [TN] and total phosphorus [TP]), DO, total suspended solids (TSS), water clarity, and other parameters since 1998. A review of in-bay concentration data shows:

- Statistically significant decreasing trends in TP, TSS, and turbidity over the period of record.
- No statistically significant trends in chlorophyll *a*, TN, or water clarity.

These results indicate that current water quality conditions in the bay as a whole are good. Parameters that could indicate undesirable conditions (TN, chlorophyll) are stable. Additionally, targets for seagrass survival are being met or exceeded, signifying that existing water quality conditions are appropriate for seagrass growth and that current management efforts to protect bay resources are successful.

Seagrasses are a fundamental component of the ecological structure of most Florida estuaries. Seagrasses provide numerous benefits including stabilizing sediments, providing refuge for juvenile fishes and invertebrates, and serving as a food source for manatee and sea turtles.

Although the water quality indicators provide abundant evidence of a healthy estuary, some local areas of the bay or in tributaries have water quality issues. The entire bay currently meets State water quality standards; however, some of the watershed's stream segments have listed impairments (Table ES-1 and Figure ES-4). A defensible strategy for managing bay water quality is to maintain current conditions overall, but if isolated problem areas are identified then remedial action should be considered. Coastal areas and tidal portions of tributaries with limited circulation are especially vulnerable to water quality problems.

Potential project concepts were identified throughout the watershed to help meet the objectives for this plan. These projects incorporate strategies such as providing source control to reduce or remove nutrients, solids, and other pollutants in upland areas; implementing maintenance practices designed to reduce nutrient loading and sedimentation; improving eroding and sloughing banks for long-term stability; capturing excess runoff before it enters the streams; improving natural habitats; and providing buffers to capture nutrients. Implementing these projects will help the Sarasota Bay remain a healthy system.

A comparison of TN, TSS, and TP contributions by basin shows Whitaker Bayou as the largest contributor for all three constituents (Figure ES-5). The County should focus efforts to implement projects in this basin. If implemented, the Whitaker Bayou projects could reduce TN in the basin by as much as 1,000 pounds per year.

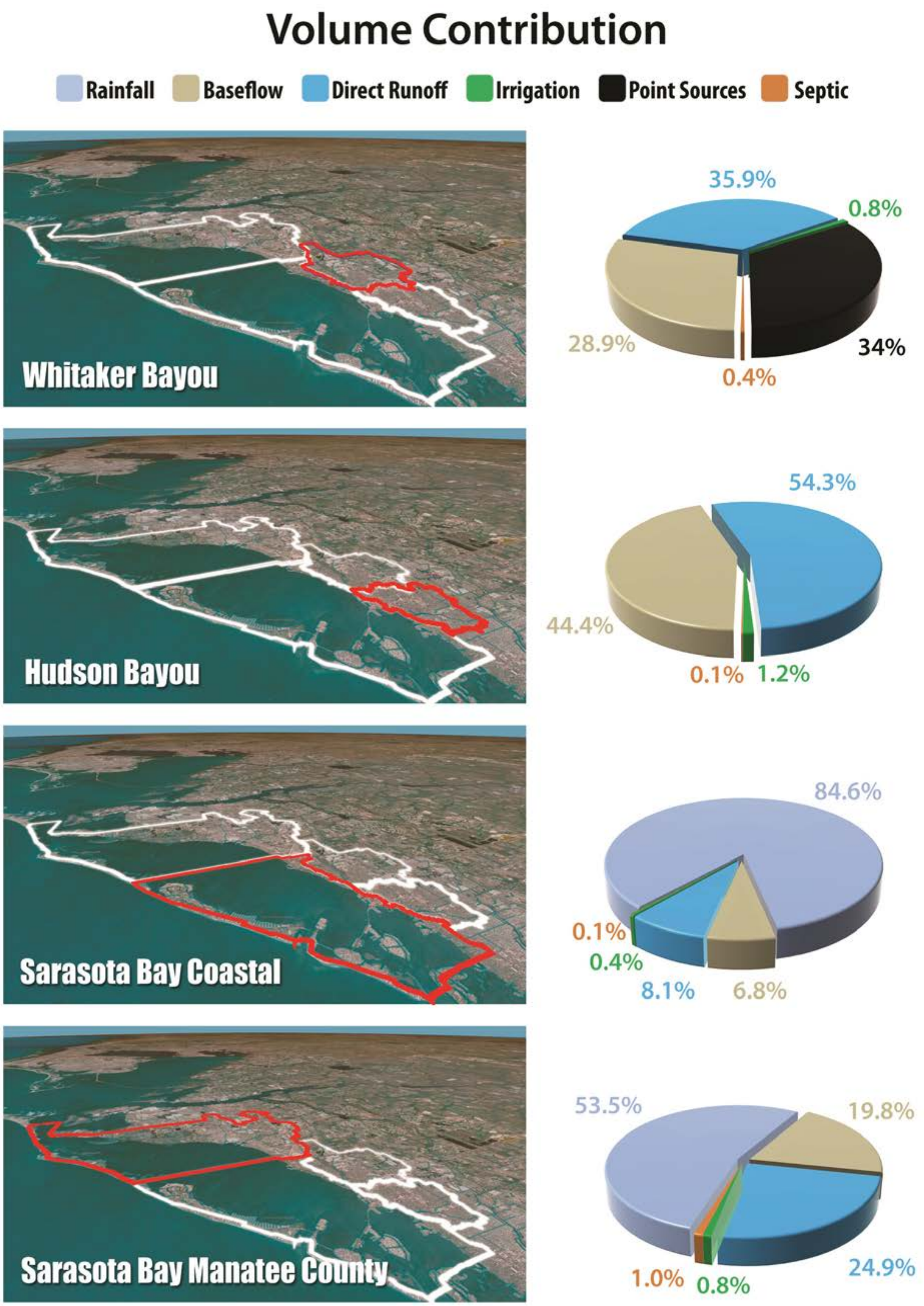


Figure ES-3 Volume Contribution by Source for each Basin

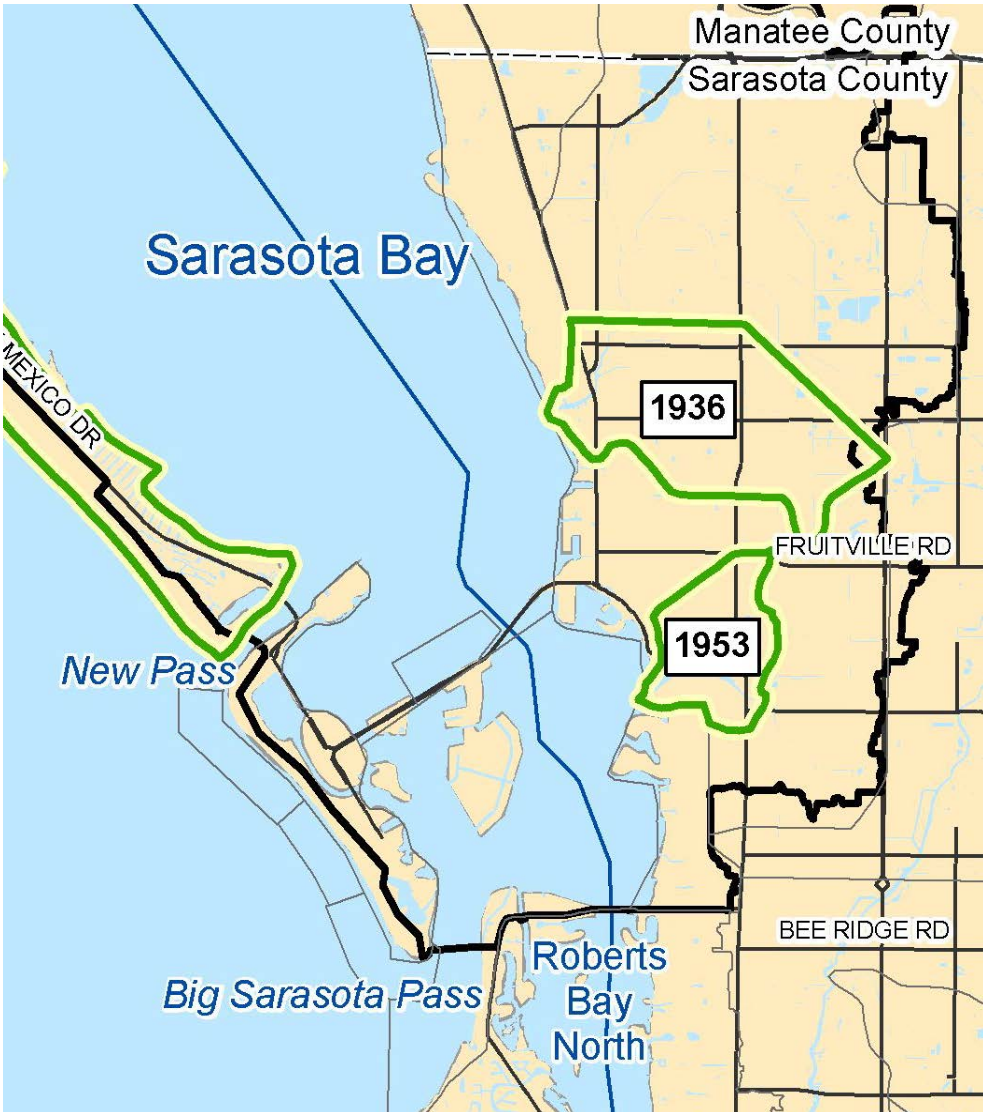


Figure ES-4 Impaired WBIDs within the Sarasota Bay Watershed – Whitaker Bayou (WBID 1936) and Hudson Bayou (WBID 1953).

Table ES-1 Summary of Water Quality LOS Targets for Sarasota Bay

Variable	Bay Targets	Bay Status	Whitaker Bayou Targets	Whitaker Bayou Status	Hudson Bayou Targets	Hudson Bayou Status
SBEP Targets						
Seagrass (acres)	7,269	Meets criterion	N/A	N/A	N/A	N/A
Chlorophyll *a* (µg/L)	5.2	Meets criterion	Marine: 11	Meets criterion	Marine: 11	Meets criterion
TN Concentration (mg/L)	0.38	Meets criterion	0.82	Meets criterion	0.79	Meets criterion
TN Load (tons/year)	215	Meets criterion	26.4	Meets criterion	13.9	Meets criterion
TP Concentration (mg/L)	0.15	Meets criterion	0.27	Meets criterion	0.47	Meets criterion
TP Load (tons/year)	31.8	Meets criterion	2.57	Meets criterion	2.46	Meets criterion
FDEP Targets						
Current DO Standards (mg/L)	DO>4	Meets criterion	Freshwater: DO > 5 Marine: DO>4	Meets criterion	Freshwater: DO > 5 Marine: DO>4	Meets criterion
Proposed DO Standards (% saturation)	Daily DO>41.7% 7 day > 51% 30 day > 56.5%	Meets criterion	Marine: Daily DO>41.7% 7 day > 51% 30 day > 56.5% Freshwater: DO >= 34%	Meets criterion	Marine: Daily DO>41.7% 7 day > 51% 30 day > 56.5% Freshwater: DO >= 34%	Meets criterion
Impaired Water Body (FDEP IWR)	Varies by Parameter	Not Impaired	Varies by Parameter	Marine portion impaired for low DO Marine portion impaired for TN	Varies by Parameter	Marine portion impaired for low DO

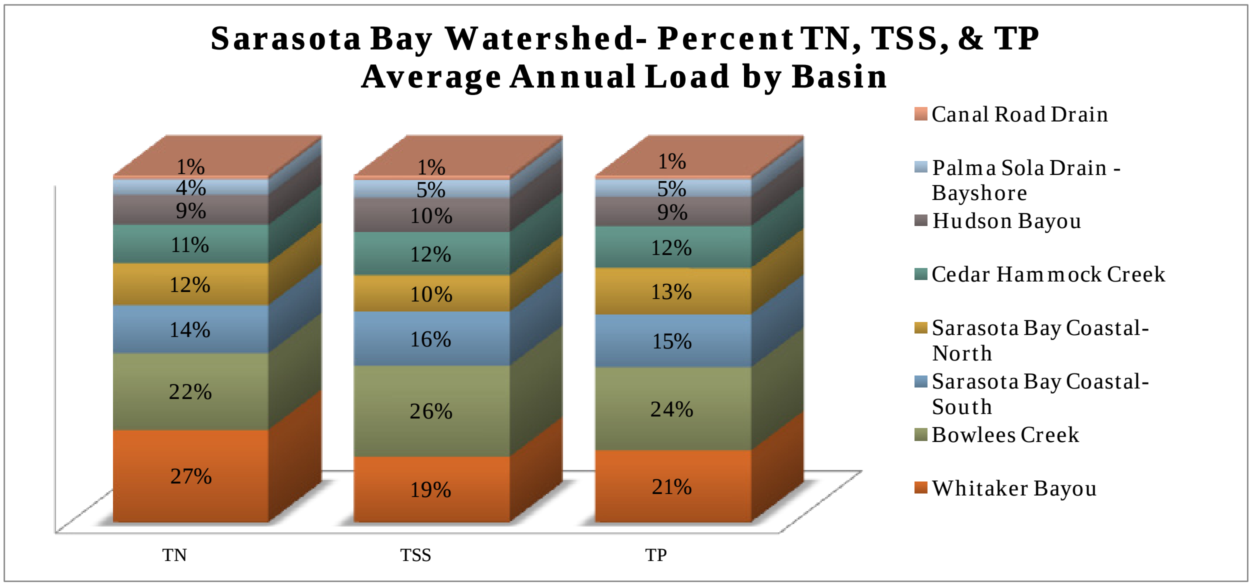


Figure ES-5 Average Annual Load Percent by Basin

Natural systems are self-sustaining living ecosystems such as wetlands, streams, seagrass beds, and upland vegetation communities that support a diversity of organisms and provide many valuable ecosystem-based services. Appendix D presents a summary and trends of the critical estuarine and freshwater natural systems found in Sarasota Bay. Six opportunities to enhance existing or create natural systems on public lands were identified and conceptual designs were developed.

Positive trends were observed in seagrass coverage in Sarasota Bay, and efforts by stakeholders to achieve this should be a model for other watersheds. No clear trends were observed for oysters. Large losses of mangrove acreage have occurred in Sarasota Bay since the 1940s and before wetland protection regulations were implemented. However, small (<0.25 acre) patches of mangroves are now widely distributed in Sarasota Bay in areas not present historically. The County's mangrove monitoring program provides valuable data to assess mangrove extent and trimming practices. With over 90% of the parcels adjacent to major watercourses developed before 1995 and lacking a naturally vegetated watercourse buffer, the emphasis should be on persuading homeowners to incorporate naturally vegetated setbacks into their landscape rather than deterring buffer impacts on undeveloped parcels. An abundance of opportunities exists to work with homeowners to convert waterward portions of their backyards dominated by turf grass to native, low-maintenance species. Approximately 50% of the total shoreline in Sarasota County portions of Sarasota Bay has been hardened. The goal for natural shoreline should be to maintain existing extents while working to increase extents over time, even at a parcel-by-parcel level. Appendix D presents LOS targets and recommendations for several of these important natural systems.

SARASOTA BAY WATERSHED BASINS

Sarasota Bay Coastal Basin

Medium-density residential and commercial land uses make up the great majority of the basin. The land consists of barrier islands and coastal mainland that drain directly to the bay.

Urban runoff reaching the bay can impact seagrass acreage, saltwater wetlands, fishing resources, and scallop population. Additionally, occasional closures of shellfish harvesting waters and no swim advisories for Bird Key Park occur (Sarasota County Comprehensive Plan Appendix B, page B-20).

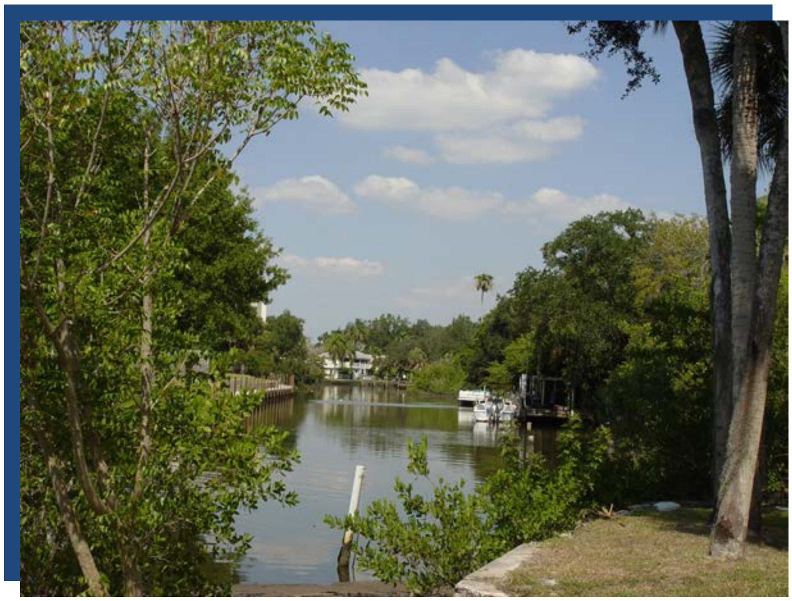
The Sarasota Bay Coastal Basin, as defined for this WQMP, includes both waterfront lands that drain directly to the bay and the downstream portions of several tidal creeks including Hudson Bayou and Whitaker Bayou in the County and Bowlees Creek and Cedar Hammock in Manatee County. Approximately 50% of naturally occurring shoreline in the Sarasota County portion of Sarasota Bay is hardened. Existing County, State, and Federal regulations should limit additional hardening. Where shoreline protection is warranted, the County should strongly promote soft, non-structural, or hybrid shoreline protection alternatives to dissuade the applicants from constructing bulkheads or armoring. These "living shorelines" use a suite of bank stabilization techniques to stabilize the shoreline, minimize future erosion, and maintain coastal processes.

Hudson Bayou, Whitaker Bayou, and Cedar Hammock Creek have been determined by FDEP to have impaired water quality under the Total Maximum Daily Load (TMDL) program as discussed in the WQMP Appendix B, Water Quality. Impairments include low DO caused by high biochemical oxygen demand (BOD), TN, and TP; the high TN is evidenced by high levels of chlorophyll *a*.

Baseflow and direct runoff are the dominant sources of loadings from the basin (Figure ES-3). However, the basin is already highly urbanized with little opportunity for additional urbanization in the future, which reduces the chances of increased pollutant-loading levels due to additional urbanization.

If implemented, nine recommended projects in the SBC Basin could reduce TN by approximately 490 pounds per year and prevent or remove approximately 2,900 cubic yards of sediment and 7 acre-feet of direct runoff from reaching the bay, in addition to providing habitat improvements worth 0.2 UMAM credits. Living shorelines and vegetated buffers will also help reduce runoff, thereby reducing the amount of pollutants reaching the waterbodies. The County should work with property owners to properly maintain mangroves and implement a 50-foot watercourse setback. Sarasota County should also look for opportunities to work with Manatee County through the SBEP or other facilitator if water quality problems arise.

<u>Whitaker Bayou Basin</u>



Whitaker Bayou is a highly urbanized basin that has changed in land use and hydrology since the mid-1900s. These changes have impacted flood control, water quality, and natural habitat.

With the extension of the bayou farther east, stormwater drains more quickly through the land. The lack of storage can cause widespread flooding throughout the basin. The Whitaker Bayou Basin Master Plan identified 154 habitable structures to be susceptible to flooding from the 100-year, 24-hour storm, and 275 roadway locations to have a Flood Protection Level of Service (FPLOS) deficiency. Seven alternative improvements were evaluated in the Whitaker Bayou Flood Attenuation Alternatives Analysis Report (Boyle Engineering, 2004). Flooding conditions under the seven alternatives reveal that less than a third of the parcels are eliminated from structural flooding during at 100-year, 24-hour storm. Hence, structural flooding may continue to be a concern in the Whitaker Bayou Basin.

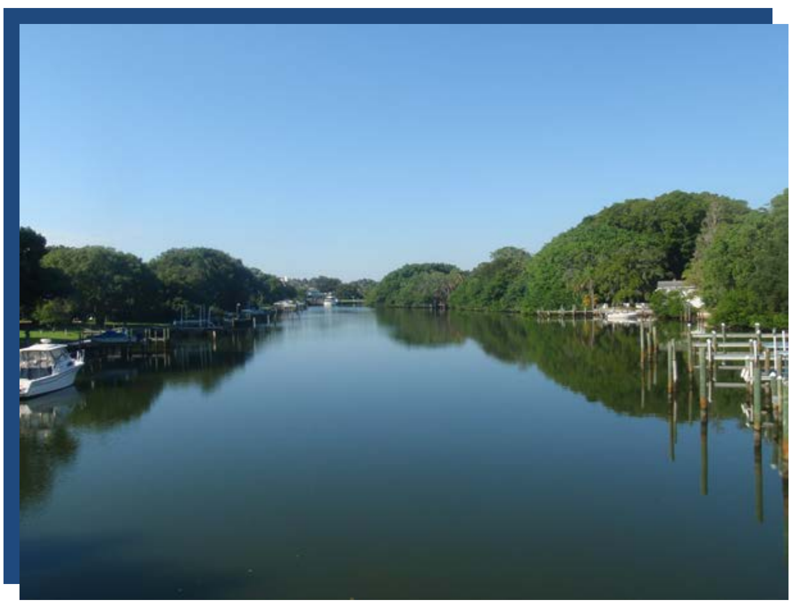
The spatial and temporal patterns of freshwater inflows in the Whitaker Bayou Basin are less similar to those of the watershed as a whole because of the large effect of the wastewater discharges under current conditions. Total freshwater inflows from the Whitaker Bayou Basin have increased from historical to current levels but, unlike other basins freshwater inflows from Whitaker Bayou, should be significantly reduced for future conditions because of the expected cessation of wastewater effluent discharges. Seasonal patterns in freshwater inflows have not changed significantly between historical, current, and future conditions, indicating that changes in land use do not alter the intra-annual pattern of inflows to the bay. Land use does, however, affect the magnitude of total inflow to the bay. Although inflows from individual sources (runoff, baseflow, irrigation, point sources) have been shown to change between scenarios, their relative contributions have not with the exception of the current conditions point source. The results of the water budget analysis suggest that no adverse effects due to changes to freshwater inflows in the future are expected. Four water supply projects identified in Whitaker Bayou could capture and beneficially use approximately 17 acre-feet of stormwater upstream in the basin.

As noted above, the Whitaker Bayou Basin has been determined by FDEP to have impaired water quality through their TMDL program. Impairments include low DO caused by high BOD, TN, and TP; the high TN is evidenced by high levels of chlorophyll *a*. However, insufficient data are available to determine if these water quality impairments are having an undesirable effect on aquatic communities. Additionally, Whitaker Bayou has met the State's Numeric Nutrient Criteria (NNC) for TN and TP as well as existing and proposed DO criteria.

The basin is highly urbanized, so little opportunity exists for increases in land use-based pollutant loadings. Water quality conditions are likely to improve in the future when point-source discharges are eliminated as projected. Additionally, if implemented one sediment project and one natural systems project recommended in this basin could prevent approximately 900 pounds of TN and 1,400 cubic yards of sediment from reaching the water bodies and would provide habitat benefits worth 1.3 UMAM credits.

Hudson Bayou Basin

Hudson Bayou is a highly urbanized basin that has changed in land use and hydrology since the mid-1900s. These changes have impacted flood control, water quality, and natural habitat.



Hudson Bayou has areas of polluted sediments. Studies reveal elevated lead concentrations in sediment throughout the bayou, including the tidal portion. Many areas throughout the basin exhibited higher TSS loadings, as estimated by Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE), than the average across the watershed. Additionally, many areas with erosion or sediment build-up were identified. If implemented, three sediment projects identified as part of this plan can in total prevent over 22,000 cubic yards of sediment from reaching the bay.

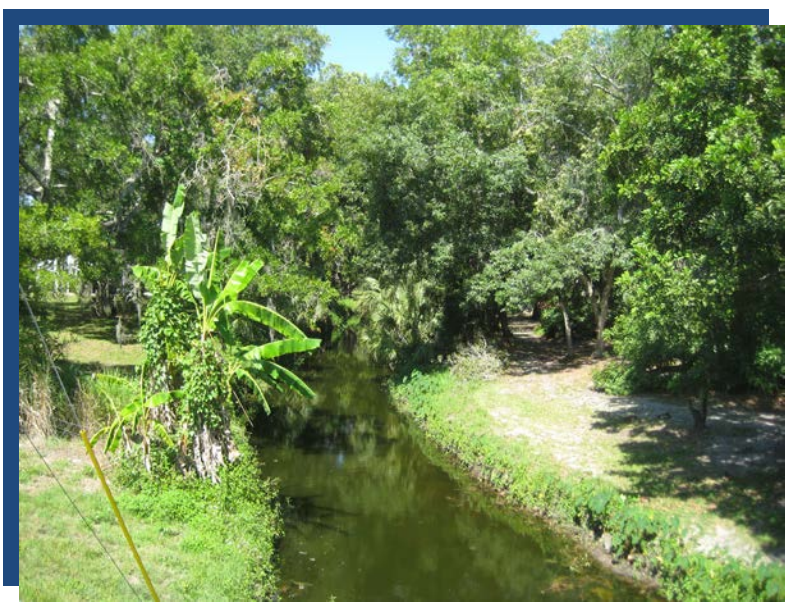
The basin also has moderate levels of total pollutant-loading rates with respect to other basins in the watershed and has among the highest unit area loads (UAL) of any basin. The basin is highly urbanized, so little opportunity exists for increases in land use-based pollutant loadings. Hudson Bayou has ongoing low DO levels and has been determined by FDEP to have impaired water quality (low DO) through their TMDL program. However, insufficient biological data exist to identify any negative effects to aquatic biota resulting from the low DO in Hudson Bayou. Additionally, Hudson Bayou has met the State's NNC for TN and TP as well as existing and proposed DO criteria.

The water body is bounded by concrete seawalls and surrounded by high-density development. Enhancing freshwater inflows and circulation to this water body could have a beneficial effect on DO; therefore, future investigations should explore means of enhancing DO levels in Hudson Bayou.

If implemented, twelve recommended projects in the Hudson Bayou Basin could reduce TN by approximately 400 pounds per year and prevent or remove approximately 22,200 cubic yards of sediment and 43 acre-feet of direct runoff from reaching the bay, in addition to providing habitat improvements worth 0.5 UMAM credits. Living shorelines and vegetated buffers will also help reduce runoff, thereby reducing the amount of pollutants reaching the water bodies and improving natural systems. The County should work with property owners to properly maintain mangroves and implement a 50-foot watercourse setback.

Manatee County Basins

The Manatee County Basins are approximately 40% urbanized, consisting of 25% residential and 11% commercial and light industrial land uses.



The spatial and temporal patterns of freshwater inflows in the Manatee County Basins are very similar to those of the watershed as a whole. Total freshwater inflows from the basins have increased from historical to current levels, but very little change exists between current and future inflows. This is a reflection of the current urban nature of the basin. Seasonal patterns in freshwater inflows have not changed significantly between historical, current, and future conditions, indicating that changes in land use do not alter the intra-annual pattern of inflows to the bay. Land use does, however, affect the magnitude of total inflow to the bay. Although inflows from individual sources (runoff, baseflow, irrigation, point sources) have been shown to change between scenarios, their relative contributions have not.

The results of the water budget analysis suggest that although inflows have increased since the historical period, future freshwater inflows should very much resemble current inflows. No adverse effects due to changes to inflows in the future are expected.

Cedar Hammock Creek has been determined by FDEP to have impaired water quality (low DO resulting from high levels of BOD, TN, and TP) through their TMDL program.

The SBC-North and Bowlees Creek Basins are not as highly urbanized as those within Sarasota County, so some opportunity exists for increases in land use-based pollutant loadings in the future. Opportunities also exist for traditional water quality improvement projects; however, none was analyzed as part of this plan.

Although a significant portion of the Sarasota Bay Watershed is outside the County, the watershed is most effectively managed as a whole. Cooperative efforts should be undertaken as feasible to address any large-scale water quality issues that may arise in the future.

IMPLEMENTATION

Effective implementation of the Sarasota Bay WQMP will depend on four elements:

1. Establishing LOS.
2. Monitoring to collect the essential data for compliance assessment.
3. Compliance assessment process that "rolls up" the individual LOS.
4. Conducting a comprehensive compliance assessment through a Decision Framework that scales the response to the number of LOS that may be exceeded.

The watershed condition for Sarasota Bay will change with time, and this WQMP must evolve and adapt. The goal will remain the same: to protect the ecological health of Sarasota Bay and its watershed.

1.0 INTRODUCTION/PROJECT BACKGROUND

Sarasota County has six major watersheds located wholly or partially within its limits: Sarasota Bay, Roberts Bay North, Little Sarasota Bay, Dona and Roberts Bay, Myakka River, and Lemon Bay. Sarasota County has implemented the Comprehensive Watershed Management Program to address water quality, water quantity, flood protection, and natural resources in a comprehensive manner within each watershed. This program is consistent with the Sarasota County Comprehensive Plan (Chapter 4, Goal 2, Objective 2.2, Policy 2.2.1) and employs an approach consistent with the Southwest Florida Water Management District's (SWFWMD) four areas of responsibilities related to water resource management: Water Quality, Water Supply, Flood Protection, and Natural Systems. One component of this Comprehensive Watershed Management Program is to develop a Water Quality Management Plan (WQMP) for each of the six watersheds.

The County and SWFWMD have partnered on cooperative funding projects to develop the WQMPs for Little Sarasota Bay, Sarasota Bay, Roberts Bay North, and Lemon Bay. The Roberts Bay North and Lemon Bay Plans were completed in 2010.

While cooperative funding is provided by SWFWMD, the inclusion of proposed projects, corrective actions, and best management practices (BMPs) in this plan does not confer any special status, approval, permitting standing, or funding from SWFWMD. Requests for funding assistance will have to meet the requirements of funding programs and be subject to SWFWMD's Governing Board appropriating funds.

Further, all projects are subject to County and SWFWMD regulatory review and permitting and are designed to be consistent with the Sarasota County Comprehensive Plan and the Sarasota County Code of Ordinances. Where applicable, all regulatory authorizations shall be obtained before a project can begin. To address these concerns, regulatory coordination will occur at the planning stages for each project discussed in this WQMP to ensure a streamlined permitting review process and address consistency with the Sarasota County Comprehensive Plan and Sarasota County Code of Ordinances before the project is designed.

The recommended management actions contained in this WQMP address the segment of Sarasota Bay that is within Sarasota County and the watershed area that drains to the Sarasota County portion of Sarasota Bay (Figure 1-1). The Manatee County portion of the watershed was analyzed in regard to its pollutant load contributions to the bay; however, project and programs for this area were not recommended.

Watershed management requires a holistic approach to protecting water resources, one that integrates all of the physical and biological components of the landscape.

This WQMP presents scientific and community-based watershed management actions and the approach used to formulate, evaluate, and prioritize them. These actions will be holistic in recognition of the relationships and interdependencies of watershed functions as well as the related goals of state, regional, and federal partners.

The Sarasota Bay WQMP balances the goals of restoring natural systems, enhancing water quality, ensuring the sustainability of the water supply, and protecting against floods while expanding educational opportunities. This plan summarizes past, present, and future watershed conditions. The plan also contains recommendations for activities to help reach these goals and progress toward sustaining and enhancing the health of the watershed.

The following tasks outline the work elements completed by Jones Edmunds and Janicki Environmental during the course of the WQMP development:

- *Watershed Field Trip:* Conducted an initial visual watershed assessment with stakeholders.
- *Literature Search and Creation of Watershed Bibliography:* Performed a literature search and developed an online bibliography.
- *Characterization:* Characterized the watershed.
- *Current, Historical, and Future Water Budgets:* Estimated the historical, current, and future targeted water budgets for the Sarasota Bay Watershed.
- *Flood Protection:* Summarized current County flood protection programs and practices.
- *Sediment Management Plan:* Evaluated sediment conditions in the watershed, developed a sediment management plan, and identified and field-investigated potential projects to reduce erosion and remove sediment and pollutants from drainage system.
- *Water Supply:* Evaluated the change in direct runoff from historical to current conditions and identified stormwater harvesting opportunities.
- *Natural Systems:* Evaluated critical estuarine and lotic natural resources, performed habitat assessment and potential improvement strategy, and established a Natural Systems Level of Service (LOS).
- *Water Quality:* Assessed status, trends, and targets; analyzed pollutant loads; set Water Quality LOS; and identified potential water quality improvement opportunities.
- *Project Analysis:* Developed conceptual plans and cost estimates for recommended programs and projects.
- *Watershed Report Card Coordination:* Provided the County with detailed information to develop the Watershed Report Card.
- *Water Quality Management Plan:* Summarized comprehensive WQMP efforts.

The analysis and recommendations were applied to the Sarasota County portion of the Sarasota Bay Watershed, which consists of one bay segment and three subbasins (Figure ES-1). Approximately half of the Sarasota Bay Watershed is located north of the County boundary in Manatee County. For this WQMP, the Sarasota Bay Coastal (SBC) Basin has been subdivided into two portions: SBC-South, which includes the basin area in Sarasota County, and SBC-North, which includes lands outside the County. To assess Sarasota Bay as a whole, the entire watershed was evaluated for hydrologic and pollutant loadings; however, all management options address only areas within Sarasota County.

Bay Segments
- Sarasota Bay

Basins
- Sarasota Bay Coastal Basin-South
- Whitaker Bayou Basin
- Hudson Bayou Basin
- Manatee County Basins
  - Sarasota Bay Coastal Basin-North
  - Bowlees Creek
  - Cedar Hammock Creek
  - Palma Sola Drain – Bayshore
  - Canal Road Drain

This report is organized into six sections, including this introduction. Following the goals and objectives (Section 2.0), the technical analyses and recommendations are presented by basin in Section 3.0 and Section 4.0. Each basin section provides a summary of the watershed study for the particular basin. Additional details concerning the study are provided in the Appendices. Each basin section includes a characterization and analyses. The analyses cover relevant information for each area of responsibility (AOR)—water supply, water quality, natural systems, and flood protection conditions. The analyses are followed by recommendations as well as a summary and conclusions for each basin.

Much of the background information for each AOR is provided in the Sarasota Bay Watershed section (Section 3.0) and is not repeated in subsequent basin sections. Section 3.0 describes the program recommendations directed at the entire basin. The analyses presented in Section 3.0 include the entire Sarasota Bay Watershed. The characterization, water quality, and natural systems information in Section 3.0 are focused on the bay itself.

To make this plan more relevant to the individual watersheds, the characterization, analysis, and project recommendations are broken out by basin. Section 4.0 is for the tributary basins draining directly to Sarasota Bay.

Plan implementation is described in Section 5.0, and Section 6.0 seeks to link goals with management actions.

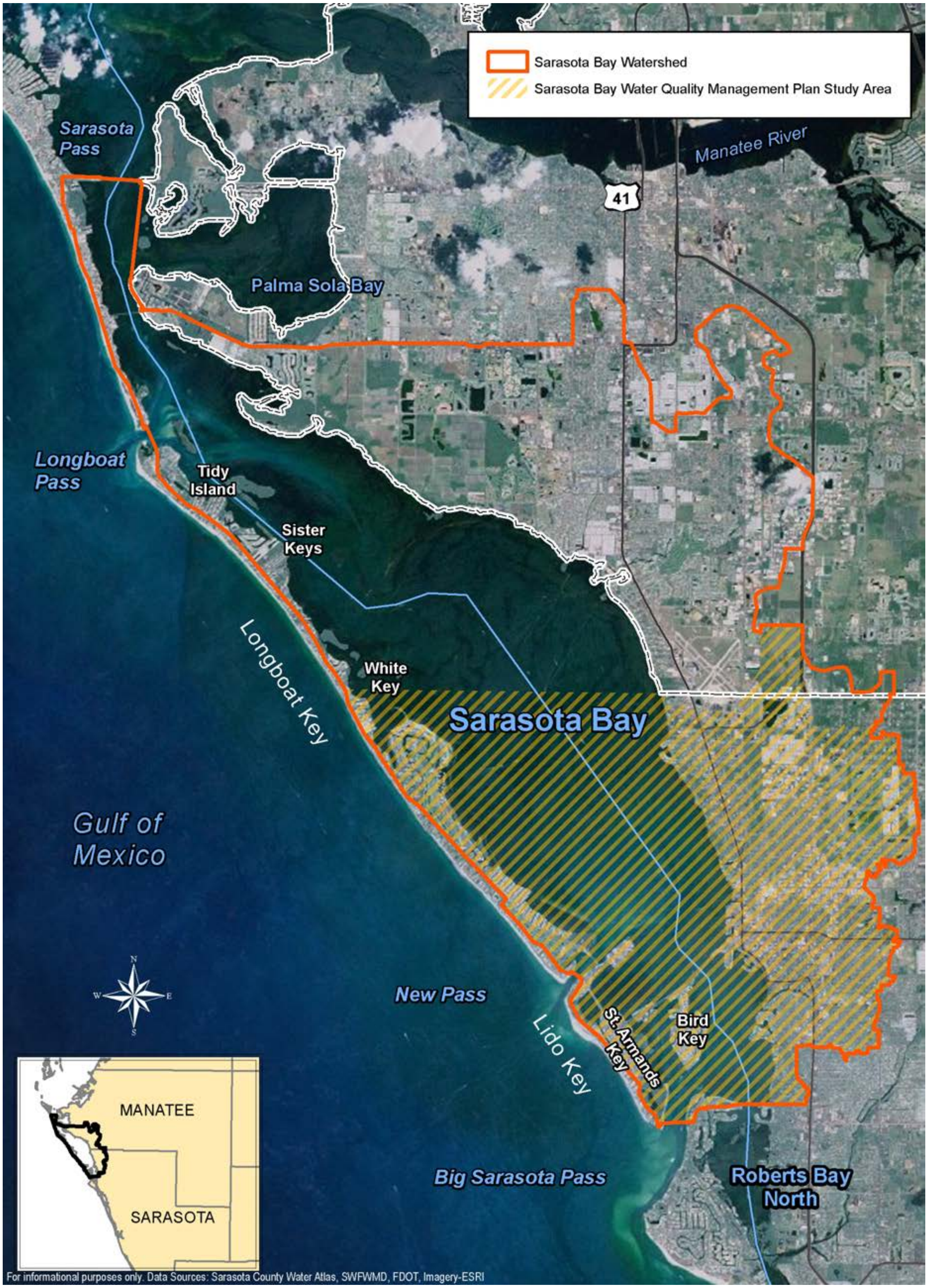


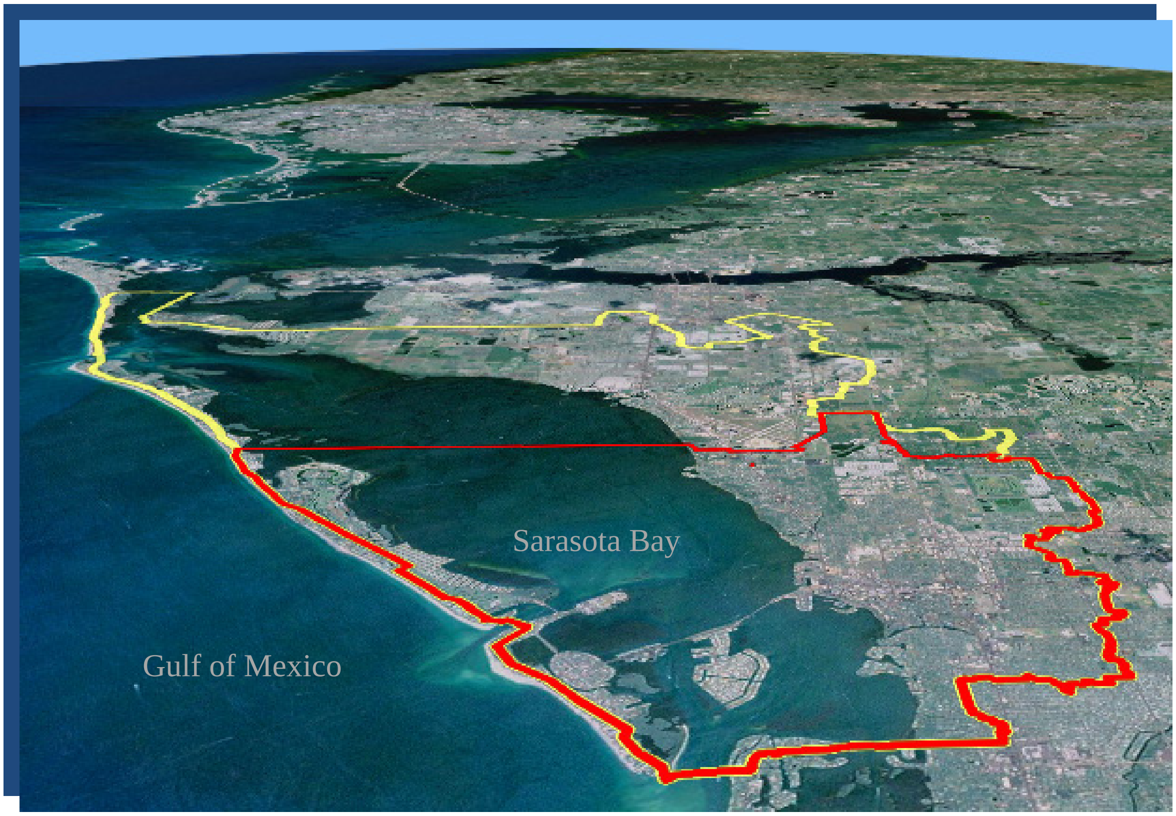
Figure 1-1 Sarasota Bay Water Quality Management Plan Study Area

2.0 GOALS AND OBJECTIVES

The Sarasota Bay WQMP is a regional initiative to develop and implement a water quality management plan for Sarasota Bay and its watershed to help achieve the following objectives:

- Improve water quality.
- Restore to the greatest extent possible the historic natural hydrologic regime.
- Protect property owners from flood damage.
- Protect, enhance, and restore natural communities and habitats.
- Identify potential sustainable surface water supply options.

The Sarasota Bay WQMP promotes and furthers implementation of other regional plans, including the *Sarasota County Comprehensive Plan*, the Sarasota Bay Estuary Program's (SBEP) *Comprehensive Conservation and Management Plan (CCMP)*, and the SWFWMD's *Southern Coastal Comprehensive Watershed Management Plan*, and SWFWMD's *Sarasota Bay Surface Water and Improvement (SWIM) Plan*.



3.0 SARASOTA BAY/WATERSHED

3.1 CHARACTERIZATION

Located on the west-central coast of Florida, the Sarasota Bay Watershed is famous for its sandy beaches, keys, sparkling blue water, and array of marine life, such as dolphins, manatees, loggerhead turtles, fish, and crabs. The watershed spans approximately 100 square miles from Anna Maria Sound in Manatee County, south to Roberts Bay North in Sarasota County, and includes the City of Sarasota to the east. Sarasota Bay is bound to the west by stretches of barrier islands, including Longboat Key and Lido Key, and to the east by the mainland of Manatee and Sarasota Counties. Sarasota Bay is a subtropical estuary with tidal tributaries and small creeks, coves, inlets, and passes. New Pass and Big Sarasota Pass connect the bay with the Gulf of Mexico and promote tidal mixing and circulation (Figure 3-1).

The Sarasota Bay Watershed once consisted of an expanse of pine flatwoods and other upland systems, numerous wetlands, and marshy tributaries that slowly drained into the bay. These native natural systems provided habitat, flood control, and improved water quality. Many of these natural systems were altered and degraded by urban and agricultural development over the past 100 years, resulting in major changes in the watershed.

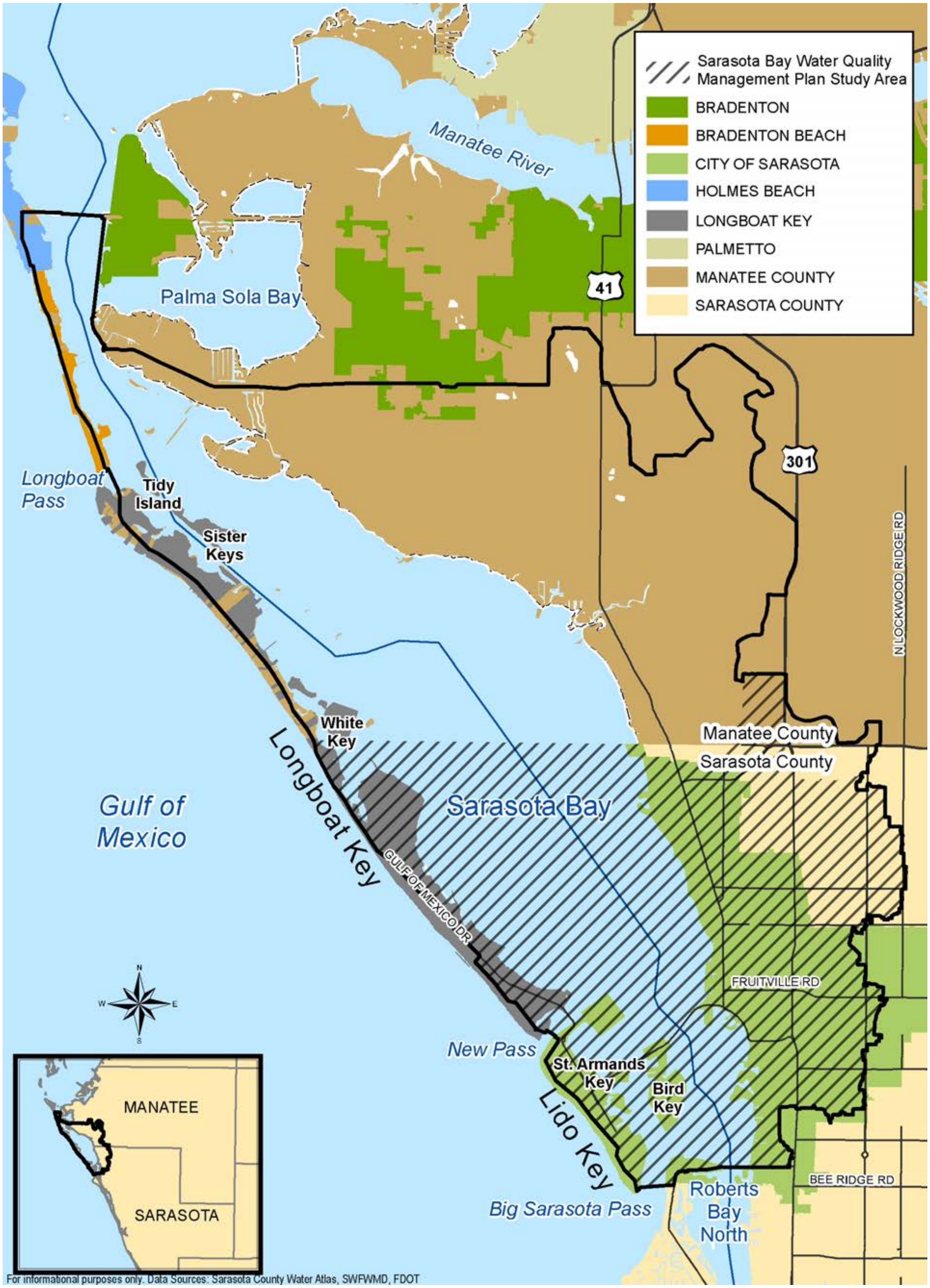


Figure 3-1 Location of the Sarasota Bay Watershed

Archaeological evidence suggests more than 10,000 years of occupation in the watershed by native peoples. The first records of the Sarasota Bay Watershed date back to the European explorers in the early 1500s (Figure 3-2). By the late 1800s, hotel resorts were built and Sarasota Bay was advertised as a place for recreation in the northern states as well as overseas. By the beginning of the 20th century, paved streets, sidewalks, an electric plant, water and sewer services, and the Florida West Shore Railway attracted even more settlers. The area experienced a period of rapid growth, mainly along the coast and tributaries, in the early 1920s, tripling the population.

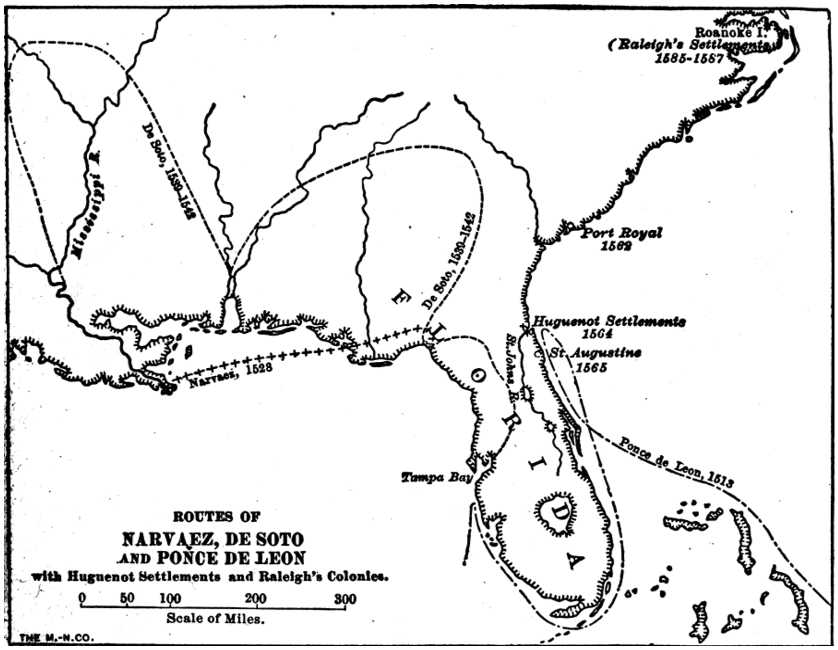


Figure 3-2 Routes of European Explorers (Courtesy of the private collection of Roy Winkelman)

As development continued, natural mangrove shoreline was replaced by concrete sea walls, reducing nursery areas essential to many marine species in Sarasota Bay (Figure 3-3). Ditches within tidal areas, a common mosquito control technique at the time, were constructed. Wetlands, and flatwoods that once provided habitat, flood control, and improved water quality were altered and degraded. Inland in the watershed, the natural tidal creeks of Hudson and Whitaker Bayous were dredged and extended and wetlands were filled to accommodate agriculture, businesses, and residences. By the mid-1950s, most of the coastal mainland was developed and growth persisted inland and across the barrier islands. Lido Key was formed from several small mangrove islands, and Bird Key was constructed of fill material taken from shallow grass beds. These two artificial uplands near Big Pass have both reduced the benefits of tidal interactions with the Gulf of Mexico and have replaced natural habitats with urban development. Dredging activities in the bay, including dredge-and-fill projects and channel excavation and maintenance, have resulted in deep holes that act as sediment traps, especially for fine-grained particles. This concentrates sediment that may otherwise cloud and contaminate the water column. The deeper areas also provide a refuge for fish during periods with colder than normal water temperature. Channel dredging has also created spoil islands, some of which have become vegetated with mangroves. These created habitats include Sister and Jewfish Keys south of Anna Maria Pass along the Intracoastal Waterway (ICW).

Figure 3-3 Sarasota Bayfront, looking southwest circa 1935 (Credit: George I. Pete Esthus) vs circa 2000 (Sarasota County Water Atlas)

Today, the watershed is almost entirely developed and lies within an area designated by SWFWMD as the Southern Water Use Caution Area (SWUCA), which is an area where water resources are or will become critical in the next 20 years. Additionally, Sarasota Bay is classified as an Estuary of National Significance, OFW, and SWFWMD SWIM Priority Waterbody and is designated as a Florida priority estuarine conservation area by the Fish and Wildlife Conservation Commission (FWC). Sarasota Bay west of the ICW is designated as Class II (suitable for shellfish propagation or harvesting), and the bay east of the ICW is Class III Marine (suitable for recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

The Sarasota Bay Watershed is currently regulated by the Florida Department of Environmental Protection (FDEP) and by extension the US Environmental Protection Agency (EPA), SWFWMD, two counties (Sarasota and Manatee), the City of Sarasota, and the Town of Longboat Key. Each regulatory agency is responsible for the health of the bay and can regulate specific activities throughout the watershed. In general, State regulations should be followed unless one of the counties has adopted a more stringent rule. The same policy applies to cities within a county boundary; the more stringent regulations always take precedence. This WQMP discusses the goals and objectives for Sarasota County and the measures the County is taking to meet these goals. This plan does not encompass the portion of the Sarasota Bay Watershed in Manatee County; however, Manatee County is also taking measures to meet similar goals for Sarasota Bay.

Historically, watershed management focused solely on flood control wherein the common practices of ditching, channelizing streams, and the use of structural measures hasten drainage. In addition, most of the development in the watershed occurred before stormwater regulations were implemented in 1982, so stormwater from most of the watershed’s developments flows into the bay without treatment. Drainage activities, flood-control projects, and the construction of impervious surfaces have changed the natural hydrology of the watershed, resulting in higher peaks in the natural flow and increases in the delivery of pollutants to the bay. Hydrologic alterations within the Sarasota Bay Watershed include:

- ❖ Reducing on-site rainfall storage by filling and ditching natural depressions and wetlands.
- ❖ Increasing stormwater runoff rates by channelizing natural streams and creating networks of interconnected ditches that flow to the bay.
- ❖ Reducing infiltration by introducing pavement and other impervious surfaces.
- ❖ Altering flow patterns by constructing water control weirs and increasing sedimentation in the channel from upland erosion.

Rainfall and surface water runoff are critical to maintaining the natural resources of any estuarine system and its supporting watershed. However, maintaining appropriate quantity and quality of runoff through effective resource management is essential to these beneficial properties. The Sarasota Bay Watershed is relatively flat and has an average annual rainfall of 53 inches.

The majority of the Sarasota Bay Watershed has been altered, leaving only isolated natural and conservation areas that provide infiltration and habitat for many threatened and endangered native species. Only about 10% of the watershed is undeveloped, which significantly affects water quality, water quantity (flow), habitat, and flooding risks. The highly urbanized watershed consists of a lot of older neighborhoods that provide only minimal stormwater retention or detention. The surface water runoff from the rainfall flows across the watershed terrain through ditches, storm drains, creeks, and wetlands, and eventually into Sarasota Bay. The untreated runoff contributes sediment and associated pollutants to Sarasota Bay and its tributaries. Previous studies show some sediment in the Sarasota Bay tributaries contains substantial levels of contaminants including toxic metals, pesticides, petroleum, and other organic compounds. However, sediments in the bay proper have been reported to be uncontaminated.

Widespread alterations to the surface hydrology of the watershed have occurred over the past decades, resulting in significant changes to the volume and timing of freshwater inflows to the bay.

The freshwater inflows result in a net outflow from the estuary, generally on a tide-driven basis. Tidal communication between the bay and the Gulf of Mexico via Anna Maria Pass, New Pass, and Big Sarasota influences circulation patterns in the bay. These narrow flow paths are relatively shallow except for the deeper ICW channel, which enhances circulation and flushing and reduces retention time of water in the bay, reducing the accumulation of pollutants.

One of the main challenges of protecting the water quality in the watershed is to decrease the amount of stormwater runoff to limit the amount of freshwater, sediments, and nutrients entering the streams and bay.

Sarasota Bay has three major tributaries that connect to the bay: Hudson Bayou and Whitaker Bayou in Sarasota County and Bowlees Creek in Manatee County. For this plan, the Sarasota Bay Watershed has been divided into four basins: the Whitaker Bayou Basin, the Hudson Bayou Basin, the Sarasota Bay Coastal (SBC) Basin, and the Manatee County Basin (Figure 3-4). The focus of this WQMP is the Whitaker Bayou, Hudson Bayou, and SBC Basins. The Whitaker Bayou Basin consists of Whitaker Bayou, one of three major tributaries to Sarasota Bay, and its drainage basin, which extends from Sarasota County slightly north into Manatee County. The Hudson Bayou Basin includes Hudson Bayou, another major tributary, and its drainage basin, which is entirely within the City of Sarasota city limits in Sarasota County. The SBC Basin includes the Sarasota County portion of the barrier islands, including Siesta Key, Lido Key, Bird Key, and south Longboat Key. This basin also includes the Sarasota County coastal mainland that drains directly to the bay and the Sarasota County portion of Sarasota Bay.

Clean water resources, healthy streams, and safety from flooding are important for residents, businesses, and the local economy. Managing water and other natural resources is necessary to sustain the economy and environmental health of the community. Because of proper management actions since the late 1980s, wastewater pollution in the watershed has decreased as a direct result of the development of reclaimed water in combination with removing aging sewage treatment facilities and replacing leaking septic tanks. As a result, water quality, seagrass beds, and habitat for birds and fish have improved in Sarasota Bay; improvements include decreases in nitrogen levels, fewer impaired areas, and thousands of acres of new or improved seagrass beds. Although the bay currently meets State water quality standards as a whole, the watershed still has numerous instances where standards have not been consistently met at a smaller scale such as in some tidal creeks, as discussed in following sections.

This plan will present opportunities to implement stormwater treatment in already developed areas throughout the watershed. Advances in stormwater system technology can better help balance the needs of the environment with those of the community.

For more information on the watershed attributes, such as land use, topography, and geology, see Section 3 of Appendix A – Watershed Characterization. Information on the public lands, recreational facilities, and threatened and endangered species within the watershed can be found in Sections 5 through 7 of Appendix A.

Figure 3-4 Sarasota Bay Watershed Basins

3.2 WATER QUANTITY AND WATER SUPPLY

Developing a sustainable water supply is a goal of Sarasota County. The County is committed to providing a sustainable water supply through protecting water resources from harm, optimizing the use of alternative water supplies such as reclaimed water and surface waters, providing reliable and cost-effective water supply to the County's residents, and reducing demands on water resources through conservation and Low-Impact Development (LID).

Sarasota County meets its water supply needs through several sources. The bulk of the County's annual average daily demand of 19.0 million gallons per day (MGD) is supplied by the Peace River Manasota Water Supply Authority and Manatee County. Demand on average is expected to increase nearly 6 MGD over the next 6 years with the majority of the new supply coming from existing contracts and its own wellfields. Additional details concerning Sarasota County's water supply and demand are provided in Section 2 of Appendix B.

Stormwater runoff is a potential water source for non-potable uses that have been traditionally supplied by groundwater or other potable water sources. Current surface water flows in Sarasota Bay are about 20% higher than historical flows, and future flows are expected to remain near current levels. Section 3.2.2 of this plan summarizes the flow analysis, or water budget, and results that are detailed in Section 3 of Appendix B.

Section 6 of Appendix G provides specific project and program recommendations to capture and use excess flow. The recommendations focus on stormwater-derived alternative water supplies for irrigation and programs aimed at reducing the potable water supply demand. Potable and reclaimed sources are covered under the County's Comprehensive Plan and water and wastewater master plans.

3.2.1 Water Supply and Demand

Water supply planning is the process by which an agency assesses the projected water demands for a period and the potential sources of water available to meet the demands. The Water Supply Plan helps the county manage one of its greatest resources, water. Water does not have boundaries; it is found in the sky and on, in, and under the ground. Water is seemingly abundant, with a continual supply falling from the sky and stored in the ground and in our bodies. However, recent droughts and the impacts of over pumping have shown us that water is not as abundant as Floridians once thought, and therefore a plan is needed to help neighboring communities share and protect this important resource.

Sarasota Bay Watershed is within SWFWMD's SWUCA, which is defined as an area where water resources are or will become critical in the next 20 years. Regulatory requirements stemming from this distinction are described in the SWUCA Recovery Strategy (SWFWMD, 2006). For detailed information on Water supply and demand in the Sarasota Bay Watershed see Section 2 of Appendix B.

3.2.1.1 Water Sources

Potable and reclaimed water within the Sarasota Bay Watershed are distributed by Sarasota County Utilities, which falls within SWFWMD's region for supply management.

3.2.1.2 Sarasota County Supply and Demand

Water demand projections were compiled as part of the County's *10 Year Water Supply Facilities Work Plan* (June 2012). Projected annual average water demands from Sarasota County are shown in Table 3-1.

Table 3-1 Annual Average Water Demands (WSMP, Carollo, 2011)

	2010	2015	2020	2025	2030
Sarasota County	17.54	21.15	23.51	25.51	27.19
City of Sarasota	7.712	7.924	7.959	7.994	8.108
Town of Longboat Key	2.021	2.021	2.021	2.021	2.021

Table 2-3 in Appendix B summarizes average annual and maximum month water demands, facility capacities, and permitted quantities for Sarasota County Utilities based on the upper band of the demand projection cone. New water supply will need to begin development soon after 2020. The County is working on several options for future supply including the Dona Bay wastewater treatment facility and expansions of existing County-owned facilities (Carollo, 2012).

3.2.1.3 Per Capita Consumption

The average gross per capita water consumption from 2003 through 2007 in Sarasota County was 87 gallons per capita per day (gpcd). This value accounts for water use by commercial and industrial users, as well as for lost and unaccounted-for water. Although the County water system provides approximately 87 gpcd to its customers on average, a demand factor of 100 gpcd was selected to use for planning. This value accounts for any potential changes in water use patterns or shifts in demand. Conservation activities have reduced per capita water use from approximately 110 gpcd in 1992 Carollo, 2012).

Picture yourself carrying 87 gallons of water in a bucket from a well or stream. Would you still use that much water?

3.2.2 Water Budget

Water follows numerous pathways in the atmosphere, on land, in freshwater water bodies, and in estuaries and the ocean. Water from the atmosphere falls to the land and the open water in liquid or solid form. Water that falls to land can either seep in the soil and become shallow or deep, confined groundwater, remain on the land surface and be transpired or evaporated back into the atmosphere (evapotranspiration – ET), or flow from the land to a freshwater or marine water body as runoff. Shallow groundwater can also re-enter a surface water body through baseflow and septic tank effluent seepage. Freshwater also enters the estuary as discharges from point sources such as wastewater treatment plants and industrial facilities.

Societal activities in the watershed affect the magnitude, timing, and distribution of freshwater inputs to the estuary. Land use changes alter how precipitation is partitioned when it reaches the ground. Urbanization reduces the area of open land that allows water to infiltrate from the ground surface to lower soil strata. Natural wetland and upland areas are also filled and cleared of vegetation, which reduces ET levels and on-site storage. Surface water management for drainage control often results in the channelization of natural streams which reduces aquatic and upland habitat, degrades water quality, and can increase erosion and sediment transport. However if ditching reaches a depth that intersects the water table, baseflow may be increased.

The volume, timing, and distribution of freshwater inflows significantly affects the balance of aquatic life in an estuary. Maintaining an appropriate range of freshwater inflows delivered from the watershed to the estuary is crucial to protecting the ecological health of the entire aquatic system. Freshwater plays diverse roles in supporting estuarine communities, including the following.

1) Freshwater inflows affect circulation in an estuary. Circulation can be enhanced during periods of high inflow—for example during the wet summer months. Increased circulation has several benefits including dispersing pollutants such as excess nutrients, increasing dissolved oxygen (DO) levels in the water, and transporting suspended organisms.

2) Freshwater inflows affect residence time of water in an estuary. If water is not circulated from nutrient-rich coastal areas excessive algal growth can occur that may result in high chlorophyll levels. Consequences of this may include lower water clarity and reduced DO levels, both of which are undesirable for aquatic biota. During periods with abundant rainfall, freshwater inflows to an estuary increase and residence time decreases. Conversely, during dry periods freshwater inflows are low and residence time increases.

3) Freshwater inflows affect salinity levels in an estuary. During dry periods the salinity concentration in Sarasota Bay is close or equal to that in the Gulf of Mexico. However, in the wet summer months freshwater inflows mix with the saline water to lower overall salinity, and to form a concentration gradient within

the estuary. Many commercially and recreationally important fish and benthic species rely on the lower salinity (oligohaline) conditions of estuaries for at least some portion of their life cycle.

The salinity gradient is especially important near the mouth and in the lower reaches of tidal creeks, or coastal streams as they are called in the Sarasota County Comprehensive Plan. Freshwater mixes with salt water to form a salinity gradient in the stream that ranges from marine to fresh water. The low salinity zones are important habitat, providing areas for feeding and nursery for a variety of fish and benthic organisms.

4) Freshwater inflows supply sediments and nutrients to an estuary. The delivery of watershed-based suspended and dissolved materials is important to the health of an estuary and provides many benefits. However, excessive loadings may cause detrimental effects to the receiving water body. High sediment loading may smother the bay bottom and degrade benthic habitat. Elevated nutrient loads can result in high algal growth, which can cause lower DO levels and reduce water clarity.

Many of the ecological problems that are manifested in estuaries are caused by activities in the watershed. Watershed-based actions that can adversely affect an estuary include alterations to the surface water and groundwater systems that deliver freshwater. Water can be diverted into or out of an estuary, changing the volume of freshwater delivered to the receiving water. Urbanization and channelization of natural streams also affects the magnitude, timing, and distribution of freshwater inflow to an estuary.

This relationship between the watershed and estuary is the focus of the water budget investigation. By understanding how altering freshwater inflows affects the health of the estuary, we can better manage watershed-based activities to protect and enhance Sarasota Bay's aquatic resources.

The objective of evaluating freshwater inflows to Sarasota Bay is to provide answers to the following questions:

1) Have historical land use changes or other watershed-based activities significantly altered freshwater inflows to the bay on an annual and seasonal basis?
2) Can we expect future land use changes or other watershed-based activities to affect freshwater inflows?
3) Have land use changes altered the relative contributions of the individual sources of freshwater inflows to the bay?
4) Can environmental problems in the estuary be linked to changes in freshwater inflows?

3.2.2.1 Methods and Assumptions

Water budgets for Sarasota Bay and its watershed under historical, current, and future conditions were developed using the Sarasota SIMPLE (Spatially Integrated Model for Pollutant Loading Estimates) model. The model integrates rainfall, land use, and soils data with algorithms using rate constants developed for local conditions to calculate the water budget using six components:

- Atmospheric deposition (direct rainfall to the open water estuary).
- Direct runoff (stormwater).
- Baseflow (shallow groundwater seepage).
- Irrigation (seepage and runoff from reclaimed water land application).
- Point sources (wastewater treatment plant and industrial discharges).
- Septic tanks.

The current conditions were provided by a SIMPLE model run for 1989 through 2008. The original modeling was completed for a project funded by SBEP (*Numeric Nutrient Criteria for Sarasota Bay*, prepared by Janicki Environmental [2010]).

The water budgets were developed using current conditions rainfall for all three scenarios and varying the other inputs to simulate historical and future conditions. The results provide a basis for comparing historical and current conditions, and for current and future conditions, due to anthropogenic activities, without having to account for changing rainfall patterns.

A Decision Memorandum was developed by the Project Team to specify assumptions, data, and approach be used to estimate inflows for historical and future conditions. The memorandum outlined changes regarding land use, wastewater treatment and septic tanks, and other elements that may result in changes to freshwater inflow patterns. A detailed description of the Decision Memorandum is provided in Appendix B – Water Quantity.

3.2.3 <u>Sarasota Bay Watershed Water Budget</u>

Historical, current, and future freshwater inflows to Sarasota Bay were estimated using the methods summarized above and detailed in Appendix B. Selected results are presented below. The analyses of these data included examining and comparing the spatial and temporal variation in freshwater inputs to Sarasota Bay. Spatial, annual, and seasonal variations in rainfall are described, followed by comparisons of historical\current and current\future inflows and sources. These analyses are essential to understanding the role of freshwater to the health of the bay for several reasons:

- An assessment of rainfall is critical to the analysis, as rainfall drives many natural processes in the bay.
- Examining historical conditions allows us to compare freshwater inflows from the past to current conditions. This helps identify to what extent changes in the watershed have affected freshwater inflows to date.

- Comparing current to future conditions is also important for effective resource management, as it helps identify potential future problems and facilitates developing pro-active, preventative actions.

3.2.3.1 Rainfall

Annual rainfall averaged approximately 48 inches per year across the watershed during 1989 through 2008 and ranged from about 33 inches per year in 2000 to approximately 66 inches in 1995. Only a 20-year period of rainfall was evaluated and may not apply to the long-term rainfall record. Annual rainfall totals for Sarasota Bay and the watershed are shown in Figure 3-5.

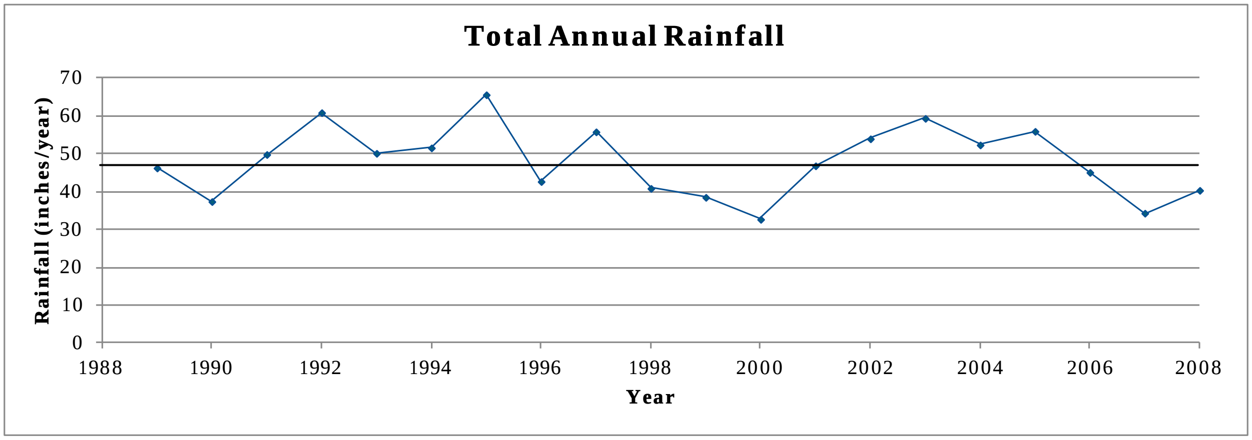


Figure 3-5 Total Annual Rainfall to Sarasota Bay and its Watershed

A distinct seasonal signal in precipitation occurs in the watershed. As is typical of peninsular Florida, June through September are significantly wetter than the other 8 months. The four wet season months have average rainfall of between 6 and 8 inches, while the eight dry season months average between 2 to 3 inches. Monthly rainfall for the Sarasota Bay Watershed is presented in Figure 3-6.

A spatial trend in precipitation for Sarasota Bay and its watershed is evident. For 1989 through 2008 significantly higher amounts of rain fell in the most inland portions of the watershed with lower precipitation along the coast. The precipitation gradient is striking—more than 10 inches per year difference over a distance of less than 10 miles, as shown in Figure 3-7.

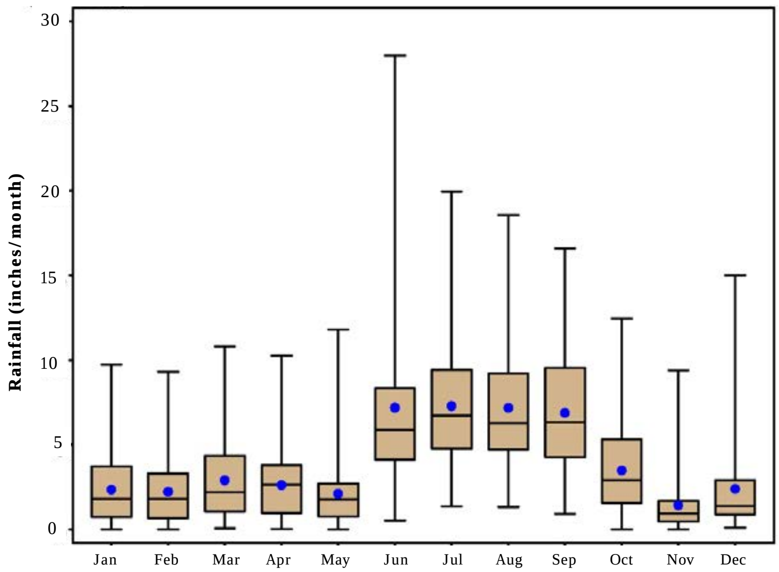


Figure 3-6 Variation in Total Monthly Rainfall within Sarasota Bay and its Watershed (1989–2008)

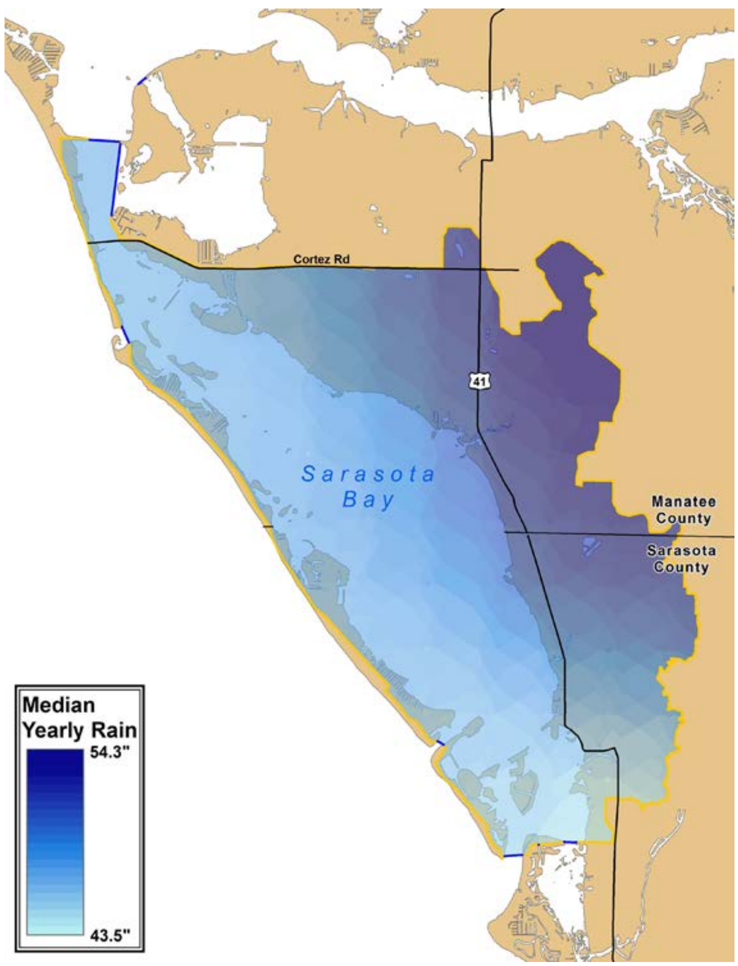


Figure 3-7 Median of Annual Rainfall (1989–2008) used in the SIMPLE Model to Estimate Freshwater Inflows to Sarasota Bay

Freshwater inflows to Sarasota Bay originate from sources in nature and from human activities. Rainfall is the primary source of freshwater in the Sarasota Bay system. Atmospheric deposition (direct rainfall to the open water estuary) contributes the most freshwater to Sarasota Bay of any source. This is because the relative size of the open water estuary is large with respect to the watershed land area.

Sources of freshwater inflows that are rainfall-dependent but are also influenced by human activities include direct runoff (stormwater) and baseflow (shallow groundwater seepage). These sources vary in direct response to rainfall patterns but are also influenced by alterations to the drainage system and land use changes. Replacement of natural uplands and wetlands with urban land uses has a profound effect on the timing and volume of freshwater reaching the bay. Although the seasonal patterns do not change, the rate of runoff from individual storms can be greatly altered as a result of land use changes.

Other sources of freshwater inflows are totally controlled. Irrigation (seepage and runoff from reclaimed water land application), point sources (wastewater treatment plant and industrial discharges), and septic tanks seepage all vary according to human activity and control. In general these sources contribute much less freshwater than rainfall, direct runoff, and baseflow, and their management is more important with respect to controlling pollutant-loading rates.

As stated above, the historical and current periods were both evaluated using current rainfall so that effects due to land use changes and other watershed-based activities could be better identified. The results of the analyses indicate that total freshwater inputs to the bay for the current period (1989 through 2008) were, on average, approximately 26% higher than during the historical period. Although this change is substantial, portions of the Sarasota Bay Watershed were already developed in the historical period (circa 1950). If urban land uses had not been developed to the extent they were, the increase would have been greater.

Both direct runoff and baseflow were higher during the current period. This is a result of land use changes, and alterations to the surface water drainage system including filling natural storage areas and channelizing natural streams. However, annual and within-year variability were similar for both periods, as shown in Figure 3-8 and Figure 3-9. The figures demonstrate that freshwater inflows for both periods mainly depend on rainfall, and that land use changes do not influence the seasonality of freshwater inflows to the bay

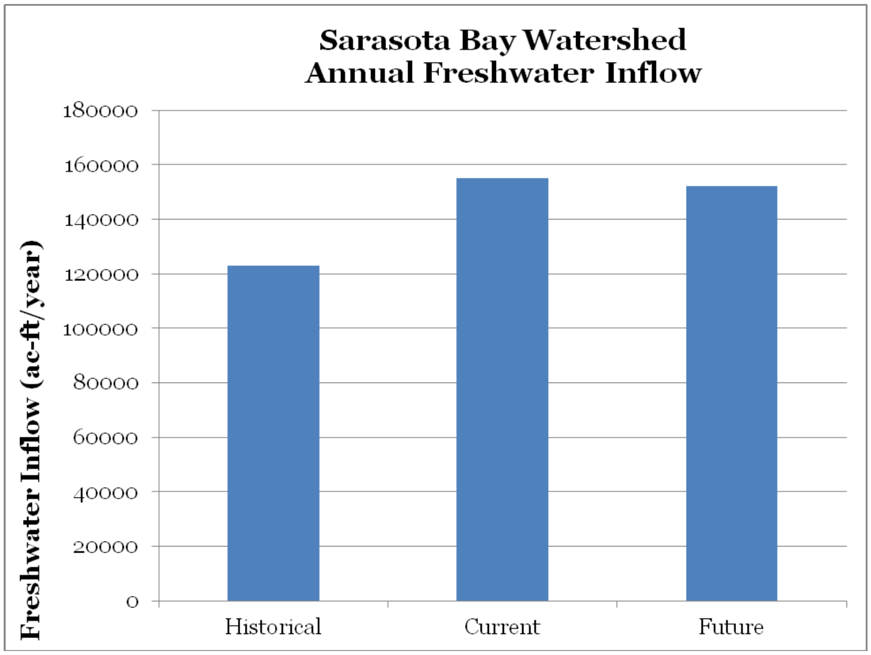


Figure 3-8 Annual Total Freshwater Inflows to Sarasota Bay for Historical, Current, and Future Conditions

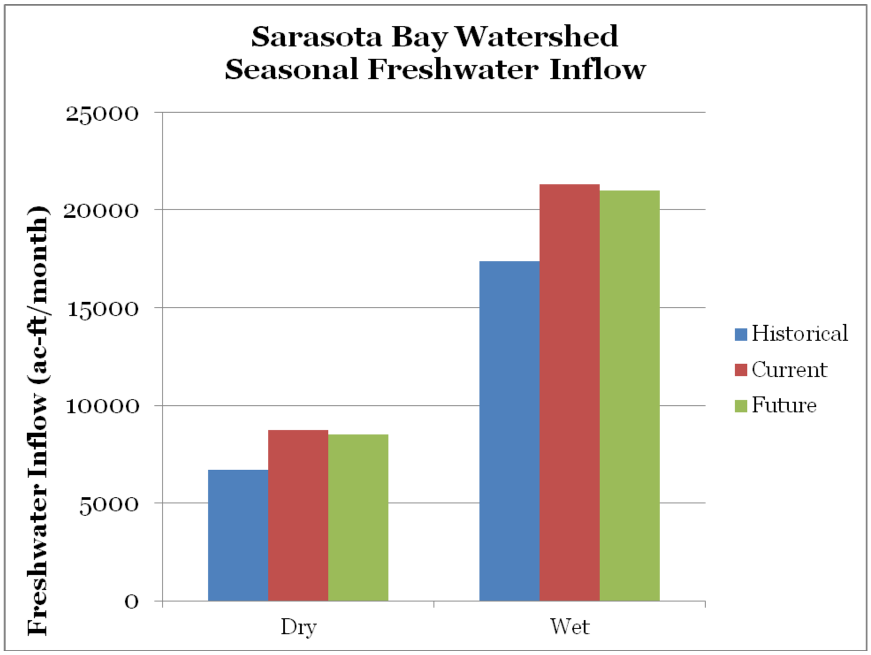


Figure 3-9 Seasonal Variability in Total Freshwater Inflows to Sarasota Bay for Historical, Current, and Future Conditions

The relative contributions of sources of freshwater for current and historical conditions were compared. The relative importance of all sources has remained constant for both periods. Atmospheric deposition was the main freshwater contributor for both periods and contributed over half of all freshwater entering the bay. Figure 3-10 shows the relative contributions of freshwater inflows by source for current and historical conditions. The results indicate that although the overall volume of freshwater inflows to the bay has changed, the relative importance of individual sources has not changed significantly.

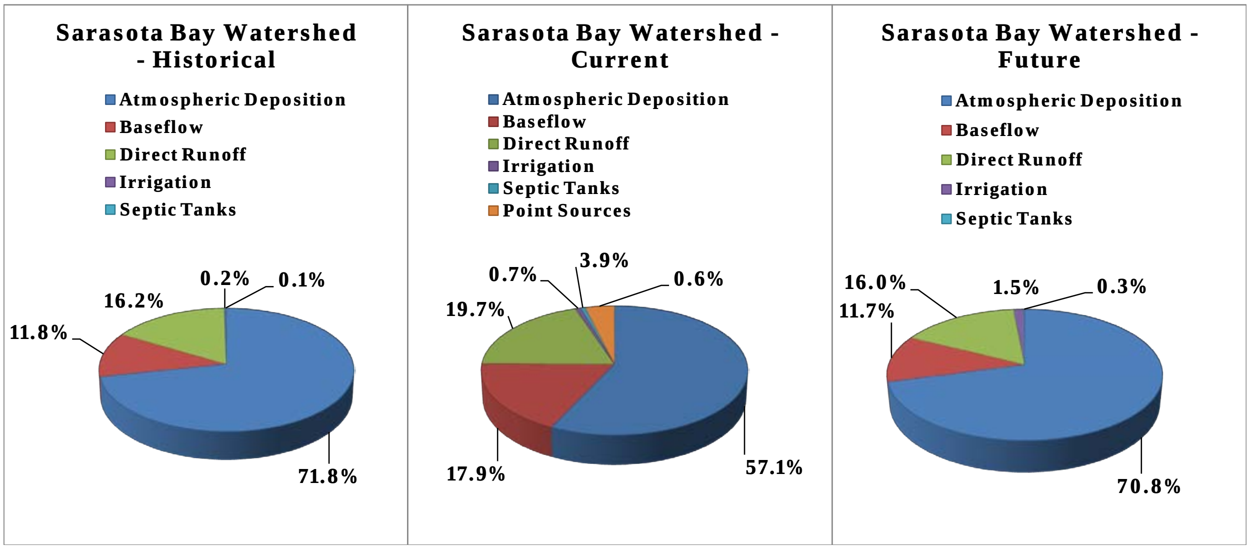


Figure 3-10 Relative Contributions of Freshwater Inflows to Sarasota Bay by Source for Historical, Current, and Future Conditions

The greatest change in any source is the point source contribution. There were no point sources during the historical period, but the City of Sarasota wastewater treatment plant now periodically releases treated effluent to the bay via Whitaker Bayou. The discharges account for only 4% of the total inflow to the bay.

As stated above, the freshwater inflow analysis was completed using the results of the SIMPLE computer model. The watershed was delineated into nine drainage areas for use in the SIMPLE model. These drainage areas are the basis of the analyses described in Appendix B. For the WQMP, the nine drainage areas were aggregated into four basins. The basins are shown in Figure 3-4 (Section 3.1) and Table 3-2.

Table 3-2 Sarasota Bay Watershed Plan Basins and SIMPLE Basin Names

Plan Basin Name	SIMPLE Drainage Area Name
SBC-South	SBC-South
	Longboat/Lido Key
Whitaker Bayou	Whitaker Bayou
Hudson Bayou	Hudson Bayou
Manatee County Basins	Canal Road Drain
	Longboat Key
	SBC-North
	Palma Sola Drain – Bayshore
	Cedar Hammock Creek
	Bowlees Creek

Additionally, the relative contribution of individual sources remains constant year-to-year, although the magnitudes of source-specific inflows change. Rainfall, direct runoff, and baseflow all vary much more than the controlled sources but always represent the bulk of the inflows. This is illustrated in Appendix B, Figure 3-8.

The current and future periods were also evaluated and compared. Current rainfall was used for both scenarios so that potential effects due to projected land use changes and other watershed-based activities could be better identified. The results of the analyses indicate that freshwater inputs for the future period were, on average, approximately 2% lower than during the current period. This change is small and reflects the current urban nature of most of the watershed. Because land use change is the major cause of changes in modeled freshwater inflows, the small change in future conditions is expected. The small increases in runoff and baseflow are offset by the larger reduction in point source contributions (see Table 9, Appendix B). The City of Sarasota wastewater treatment plant is expected to cease surface water discharges to the bay, so no point-source inflows are in the future period.

Annual and within-year variability were similar for both periods, as shown in Figure 3-9 and Figure 3-10. The figures demonstrate that freshwater inflows for both periods mainly depend on rainfall, and that land use changes do not influence the seasonality of freshwater inflows to the bay.

The relative contributions of sources of freshwater for current and future conditions were compared. The relative importance of all sources has remained constant for both periods. Atmospheric deposition was the main freshwater contributor for all periods and contributed over half of all freshwater entering the bay. Figure 3-10 above shows the relative contributions of freshwater inflows by source for historical, current, and future conditions. The results indicate that although the overall volume of freshwater inflows to the bay has changed between scenarios, the relative importance of individual sources has not changed significantly. The greatest change in any source is the point-source contribution. Point-source inflows occurred during the current period, but the City of Sarasota wastewater treatment plant will stop its discharges to the bay in the future. The current point-source discharge accounts for only 4% of the total inflow to the bay.

Thus, land use changes in the past have changed the volume but not the timing of freshwater entering Sarasota Bay. Also, the relative importance of individual sources of freshwater has not changed significantly. The current urban nature of the watershed precludes major land use changes in the future, and future changes to freshwater inflows are expected to be small.

The results of the analysis suggest that although freshwater inflows have increased since the historical period, future freshwater inflows should very much resemble current inflows. No adverse effects due to changes to freshwater inflows are expected for the future.

3.3 WATER QUALITY

This section provides a framework for managing the estuarine and freshwater aquatic resources of Sarasota Bay and its watershed by protecting and enhancing in-bay and tributary water quality. Maintaining appropriate water quality is crucial to protecting the health of the bay's living resources, many of which depend on managing watershed-based activities. The bay and watershed system depend on water quality in the bay. Water quality in the bay is affected by natural process and anthropogenic activities in the watershed and can be characterized by several parameters:

- *Seagrass* is not a water quality parameter, but its abundance and distribution depends on several water quality constituents. Thus, seagrass can be used as a keystone species, which acts as an integrating metric of the bay's health. Seagrass requires light to grow; subsequently if water clarity and resultant light penetration are low, seagrasses are confined to shallow areas of the bay. If nutrient levels reach extreme levels, high algal growth will limit the extent of seagrass growth by increasing shading in the water column. Thus, the extent of seagrass coverage in the bay provides insight into overall water quality conditions.
- *Salinity* is a measure of dissolved salt in the water. The salinity gradient in the bay and tidal segments of tributaries varies constantly according to precipitation, tidal action, and internal circulation. Salinity is a major factor controlling the distribution of estuarine flora and fauna.
- *Dissolved Oxygen (DO)* is the amount of O_2 dissolved in water. Aquatic animals need oxygen to survive, and low DO levels can deplete areas of valuable fish and benthos.
- *Nutrients* are important sources of food for vegetation. However in excessive amounts nutrients can cause high algal growth rates which can negatively affect DO levels and water clarity. Nitrogen and phosphorus promote vegetation and algal growth; however, nitrogen is the controlling or limiting nutrient in many estuaries including Sarasota Bay. Thus, the control of nitrogen inputs must be a priority for a successful management plan.
- *Chlorophyll* is a measure of the abundance of algae in water. High chlorophyll levels are an indicator of high algal growth rates. If chlorophyll is uncontrolled, eutrophication can result in detrimental effects to water clarity and DO levels.
- *Water clarity* is a controlling factor in the depth to which seagrass, which depends on light penetrating the water, can grow. Thus water clarity largely controls the extent of seagrass coverage in the bay. Seagrass is an extremely valuable habitat and food source for many aquatic species, and also stabilizes bay bottom sediments.
- *Suspended solids* is the amount of fine-grained organic and mineral matter within the water column. Total suspended solids (TSS) can affect water clarity and, most

often after large rainstorms with high stormwater runoff, bury beneficial bay bottom habitat.

The Sarasota Bay WQMP discusses factors that affect water quality in the bay and tributaries, and the consequences of degraded water quality on natural resources. Specific activities completed in developing the WQMP included:

- Summarizing existing water quality characteristics of Sarasota Bay and its tributaries.
- Comparing existing water quality (nutrients and DO) to regulatory criteria and management targets.
- Estimating current and projected future pollutant loading levels to the bay and identifying "hot spots" in the bay and tributaries.
- Establishing water quality Levels of Service (LOS) standards for the bay and tributary tidal creeks.
- Presenting potential projects for the improvement and protection of water quality in the bay and tributaries.

3.3.1 Estuarine Water Quality Status and Trends

Monitoring water quality and assessing status and trends has several benefits:

- Describes current and past environmental conditions.
- Facilitates early detection of problems.
- Assesses the effectiveness of existing management efforts.

Water quality in the bay has been regularly monitored for salinity, nutrients (total nitrogen [TN] and total phosphorus [TP]), DO, TSS, water clarity, and other parameters since 1998. A review of in-bay concentration data shows:

- Statistically significant decreasing trends in TP, TSS, and turbidity over the period of record.
- No statistically significant trends in chlorophyll *a*, or TN, or water clarity.

These results indicate that current water quality conditions in the bay as a whole are good. Parameters that could indicate undesirable conditions (TN, chlorophyll) are stable. Additionally, targets for seagrass survival are being met or exceeded, signifying that existing water quality conditions are appropriate for seagrass growth, and that current management efforts to protect bay resources are successful. Figure 3-11 and Figure 3-12 show seagrass coverage and chlorophyll concentrations in the bay in comparison to targets (a desired ecological condition) and thresholds (a level above which undesirable conditions exist) that were adopted by SBEP in 2010.Targets and thresholds are further discussed below in Section 3.3.3.

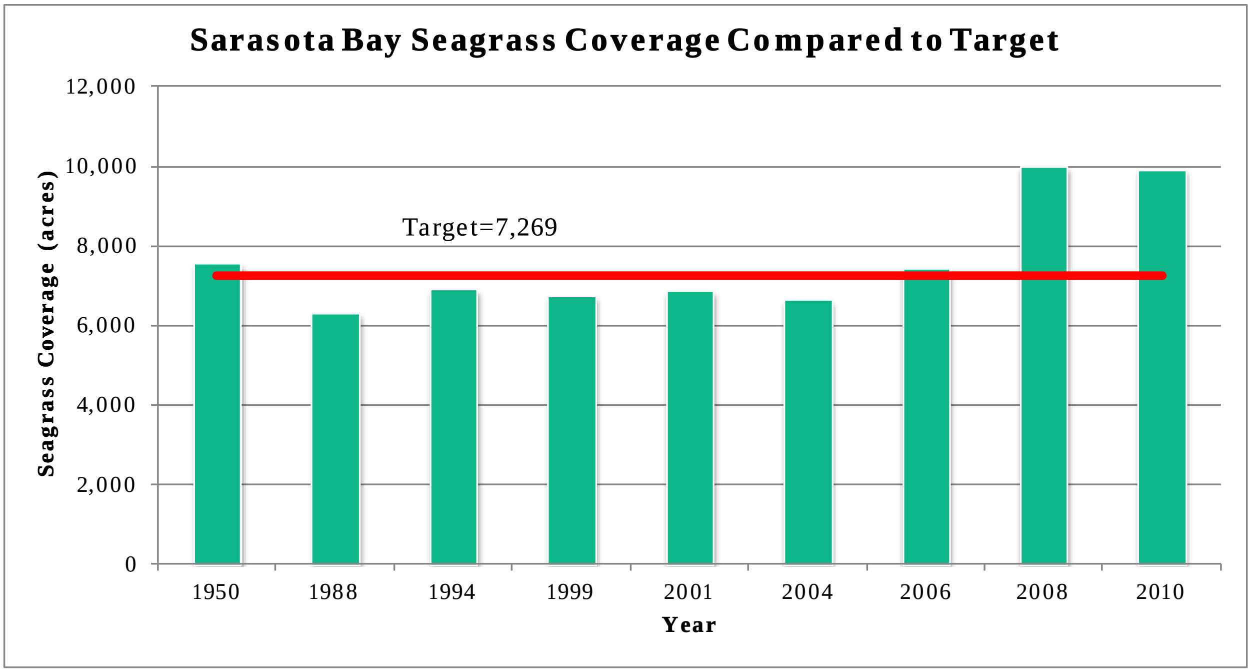


Figure 3-11 Sarasota Bay Seagrass Coverage shown with SBEP target (7,269 acres)

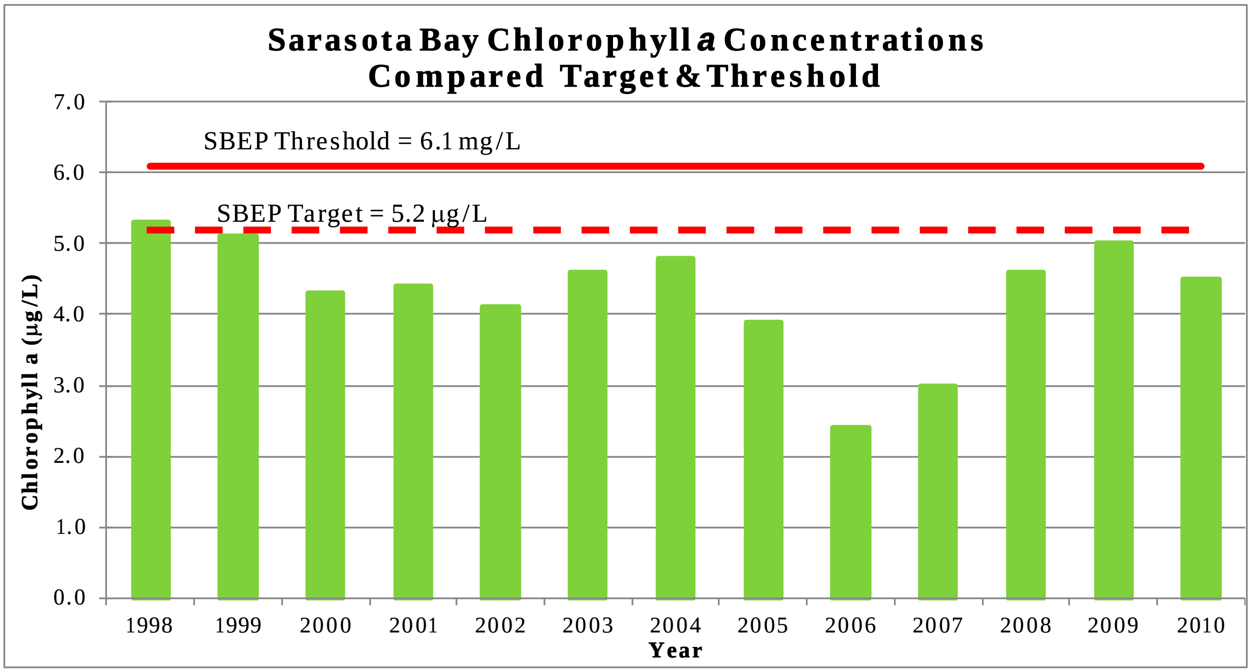


Figure 3-12 Sarasota Bay Chlorophyll Concentrations shown with SBEP Target (6.1 µg/L) and Threshold (5.2 µg/L)

3.3.2 Hydrologic and Pollutant Loading

Evaluating current levels of pollutant loading to the bay, especially nutrients and TSS, and projecting potential future loading rates, can provide an early warning to potential problems. Sources of pollutant loading to the bay include the following:

- Atmospheric Deposition (direct precipitation to the open water estuary).
- Baseflow (shallow groundwater seepage).
- Direct Runoff (stormwater that enters the bay).
- Irrigation (by reclaimed water).
- Point Sources (surface water discharges from wastewater treatment plants or industrial facilities).
- Septic Tanks.

Current and projected future loadings to the bay were estimated with the SIMPLE-Monthly computer model, which was used for SBEP, Sarasota County, and SWFWMD pollutant-loading studies. Future loads were estimated by making assumptions developed in concert with the County and SWFWMD regarding likely conditions for land use, wastewater treatment and disposal options, and atmospheric deposition rates for an unspecified future period. The 1989–2008 rainfall was used to generate both current and future conditions loads. Using current rainfall for future conditions was the preferred approach because future rainfall is difficult to predict, but even more importantly, using the same rainfall for both conditions allows a comparison of loadings for both scenarios due only to changes in anthropogenic conditions and not natural variability.

Figure 3-13 shows annual loadings for 1989 through 2008, which represents current conditions. Inter-annual variation is largely a function of rainfall, as sources other than atmospheric deposition, direct runoff, and baseflow (all are driven by rainfall) are relatively small. Future loadings to the bay are somewhat smaller than current as a result of the projected elimination of surface water discharges from the City of Sarasota's wastewater treatment plant (with more reclaimed water for irrigation), and a projected reduction in atmospheric deposition TN loading based on estimates developed by EPA (Dennis and Arnold, 2007). Because the watershed is generally urbanized at present, no large changes in land use-based loadings such as direct runoff and baseflow are foreseen.

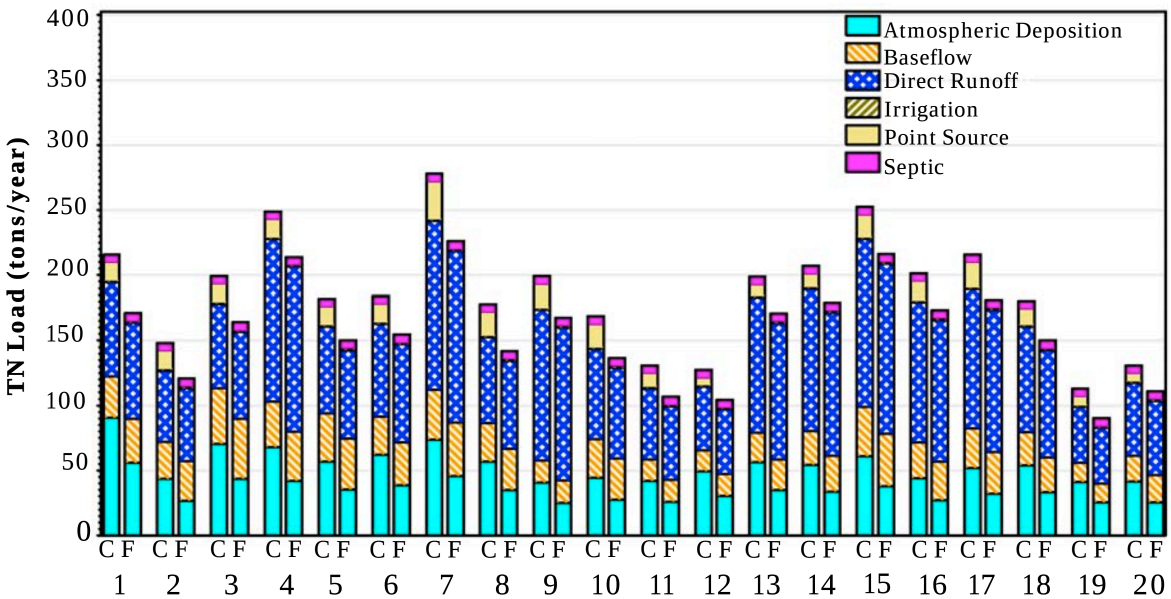


Figure 3-13 TN Loads to Sarasota Bay for Current (C) and Future (F) Conditions. Values across the horizontal axis (1–20) represent years of rainfall used for both scenarios (1989–2008)

3.3.3 Comparison of Ambient Water Quality to Regulatory Criteria and Management Levels of Service (LOS)

Setting resource protection LOS is one of the most important elements of an effective watershed management plan. An overall approach for protecting Sarasota Bay's resources has recently been established through the work of SBEP, SWFWMD, Sarasota County, other local governments, FDEP, and other interested parties.

In-bay water quality was compared to current and existing water quality criteria (targets and thresholds). The development of Water Quality LOS is based on a paradigm that distinguishes targets from thresholds, i.e., that distinguishes water quality management levels from regulatory levels. A **target** is a desired water quality condition and can be used as an "early warning" of undesirable change in water quality. However, there may be years in which water quality targets may be exceeded without causing significant changes in the receiving waterbody. Therefore, some allowable amount of variation should not elicit a significant degradation in water quality and, subsequently, seagrass coverage. **Thresholds** have often been set to allow for variability in annual conditions, and to meet the need for a regulatory level. Where these regulatory levels have not been established, there remains the need for a second water quality management level that elicits significant responses to their exceedance. Therefore, a distinction is made between a target, i.e., a desired water quality condition, and a threshold, i.e., a water quality level above which undesirable conditions exist.

For the SBEP work, a target for seagrass coverage was set for the bay. Water quality conditions that coincided with periods of desirable seagrass coverage were then identified. These water quality conditions were used to develop targets and thresholds that would be protective of seagrasses. Targets and thresholds are further discussed in the WQMP Appendix C Water Quality, Section 5 – Water Quality Levels of Service and Section 6 – Dissolved Oxygen.

The comparison of bay water quality to existing and proposed targets and thresholds includes the following findings:

- Seagrass extent meets the adopted SBEP acreage coverage criteria of 7,269 acres (Figure 3-11). SBEP (of which Sarasota County and SWFWMD are members) sponsored an investigation to determine a desirable, realistic goal for seagrass growth based on a review of current and historical data (Janicki Environmental, Inc., 2010).
- Ambient chlorophyll concentrations meet the adopted SBEP chlorophyll criteria (Figure 3-12). SBEP also sponsored extensive investigations to determine appropriate limits for chlorophyll in the bay that would promote seagrass growth (Janicki Environmental, Inc., 2010, 2011).
- Ambient TN concentrations meet SBEP NNC (Figure 3-14). TN loads, and TP concentrations and loads also meet their respective criteria. A criterion is not met if it is not achieved in any 2 years of a 3-consecutive-year period. Although the TN concentration was not met in 2010 (Figure 3-14), it was met in 2008 and 2009; thus, the criterion was met. SBEP, Sarasota County, SWFWMD, and others supported work that resulted in establishing these nutrient targets and thresholds for the purpose of limiting algal growth rates and keeping chlorophyll concentrations at levels that promote seagrass growth.

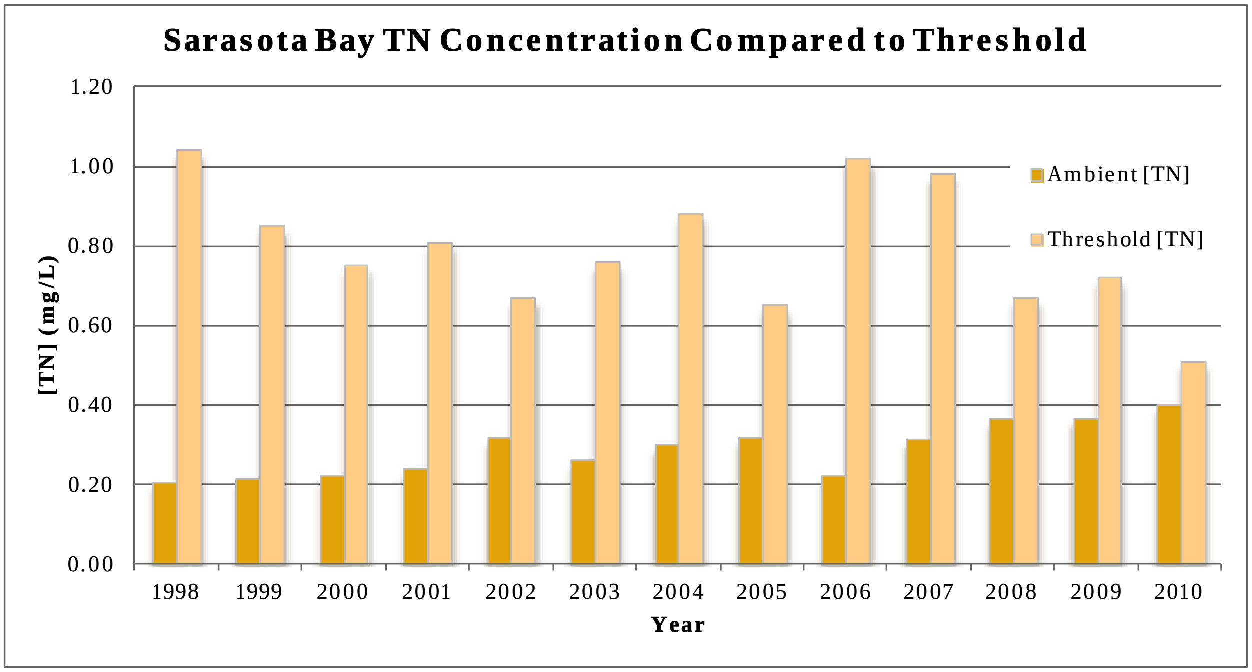


Figure 3-14 Comparison of Annual TN Loadings to Sarasota Bay to SBEP Threshold, which varies by year

❖ DO levels in the bay meet current and proposed DO criteria. In Florida DO has traditionally been held to a standard based on concentration. The DO standard for marine waters is a minimum concentration of 4.0 mg/L. Recognizing that the standard does not allow for variability in natural conditions based on water temperature or salinity, FDEP has proposed DO criteria based on percent saturation, which is the expected amount of DO in aquatic environments given ambient conditions. For predominantly marine waters (Class II and III, which includes Sarasota Bay), those standards are:

- The daily average percent DO saturation shall not be below 41.7%.
- The 7- and 30-day average percent DO saturations shall not be below 51.0 and 56.5%, respectively.

A review of in-bay DO concentration data revealed that both the existing and proposed standards were met each year of the period of record (1998 through 2010). This shows that algal growth, which can cause depressed DO at excessive rates, and inputs of oxygen consuming organisms (biochemical oxygen demand – BOD) are being successfully controlled in Sarasota Bay.

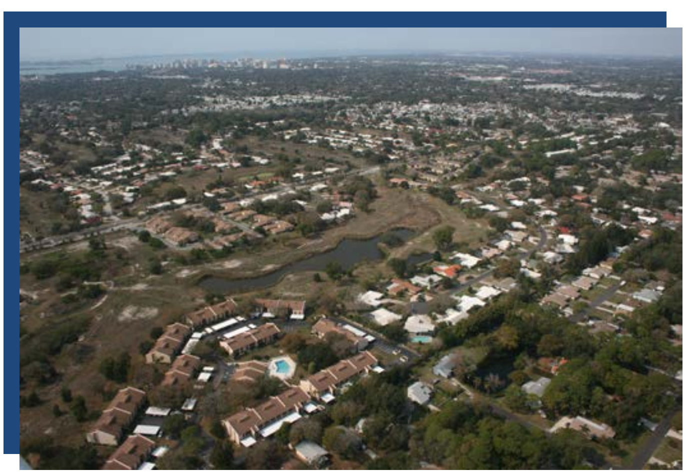
❖ No open bay segments are considered impaired under the State's Impaired Waters Rule (IWR) (Chapter 62-303, FAC). FDEP administers the EPA's Total Maximum Daily Load (TMDL) program in Florida. The TMDL program is intended to identify water bodies that are receiving a higher pollutant load than can be assimilated while maintaining the water body's designated use. If a water body does not meet State water quality standards according to IWR protocol, that water body is deemed "impaired." A TMDL may result that identifies excessive pollutant loadings and sources and specifies required reductions in pollutant loads to enable the water body to meet its designated use. No portions of the open water bay have been deemed impaired under the TMDL program, again providing evidence that water quality conditions in the bay are good overall.

Table 3-3 summarizes ambient water quality in Sarasota Bay as compared to Water Quality LOS. Although the above indicators provide abundant evidence of a healthy estuary, some local areas of the bay and some tributaries have water quality issues. A defensible strategy for managing bay water quality is to maintain current conditions overall; however, if isolated problem areas are identified then remedial action should be considered. Coastal areas and tidal portions of tributaries with limited circulation are especially vulnerable to water quality problems, as discussed below in Section 4.1.3, Section 4.2.3, Section 4.3.3, and Section 4.4.3.

Table 3-3 Summary of Water Quality LOS Targets for Sarasota Bay

Variable	Targets	Status
Seagrass (acres)	7,269	Meets criterion
Chlorophyll *a* (µg/L)	5.2	Meets criterion
TN Concentration (mg/L)	0.38	Meets criterion
TN Load (tons/year)	215	Meets criterion
TP Concentration (mg/L)	0.15	Meets criterion
TP Load (tons/year)	31.8	Meets criterion
Impaired Water Body	Varies by Parameter	Not Impaired

3.4 NATURAL SYSTEMS



While the Sarasota Bay Watershed still contains some beneficial upland, wetland, stream, and estuarine natural systems, the effects of urbanization and other land development have diminished their abundance, diversity, and beneficial functions. Approximately 10% of the watershed is comprised of undeveloped upland habitats and freshwater and estuarine (mangroves and saltmarsh) wetland natural systems, but only a fraction of these natural systems is in public ownership. As a result, the protection of the benefits provided by these remaining natural systems is even more essential.

3.4.1 Critical Estuarine Systems

3.4.1.1 Seagrass

Seagrasses are a fundamental component of the ecological structure of most Florida estuaries. Seagrasses provide numerous benefits including stabilizing sediments, providing refuge for juvenile fishes and invertebrates, and serving as a food source for manatee and sea turtles.

SWFWMD has performed aerial seagrass mapping surveys approximately biennially since 1988. Sarasota Bay appears to be somewhat stable with respect to seagrass persistence over time relative to other segments in Sarasota County. Despite the lack of persistence, the estimated acreage in 2010 (9,917 acres) (Figure 3-15) was 31% higher than that estimated from 1948 historical photographs (7,557 acres) and exceeds the target of 7,269 acres. The reason for the increase over time is not known but could reflect improved water clarity and quality. The improved water clarity and quality observed within Sarasota Bay are likely a result of improvements to the wastewater treatment system and expansion of the service area as well as stormwater regulations and LID retrofits/improvements that have been made. Seagrass targets for the bay are presented above in Section 3.3.3.

As previously mentioned, seagrasses are a critical component of estuaries such as Sarasota Bay and are important and useful indicators of the ecological health of an estuary. The recovery and positive seagrass coverage trends observed in Sarasota Bay is a true ecological success story and the continued effort of stakeholders should support this trend.

Photo Credit: Sarasota County

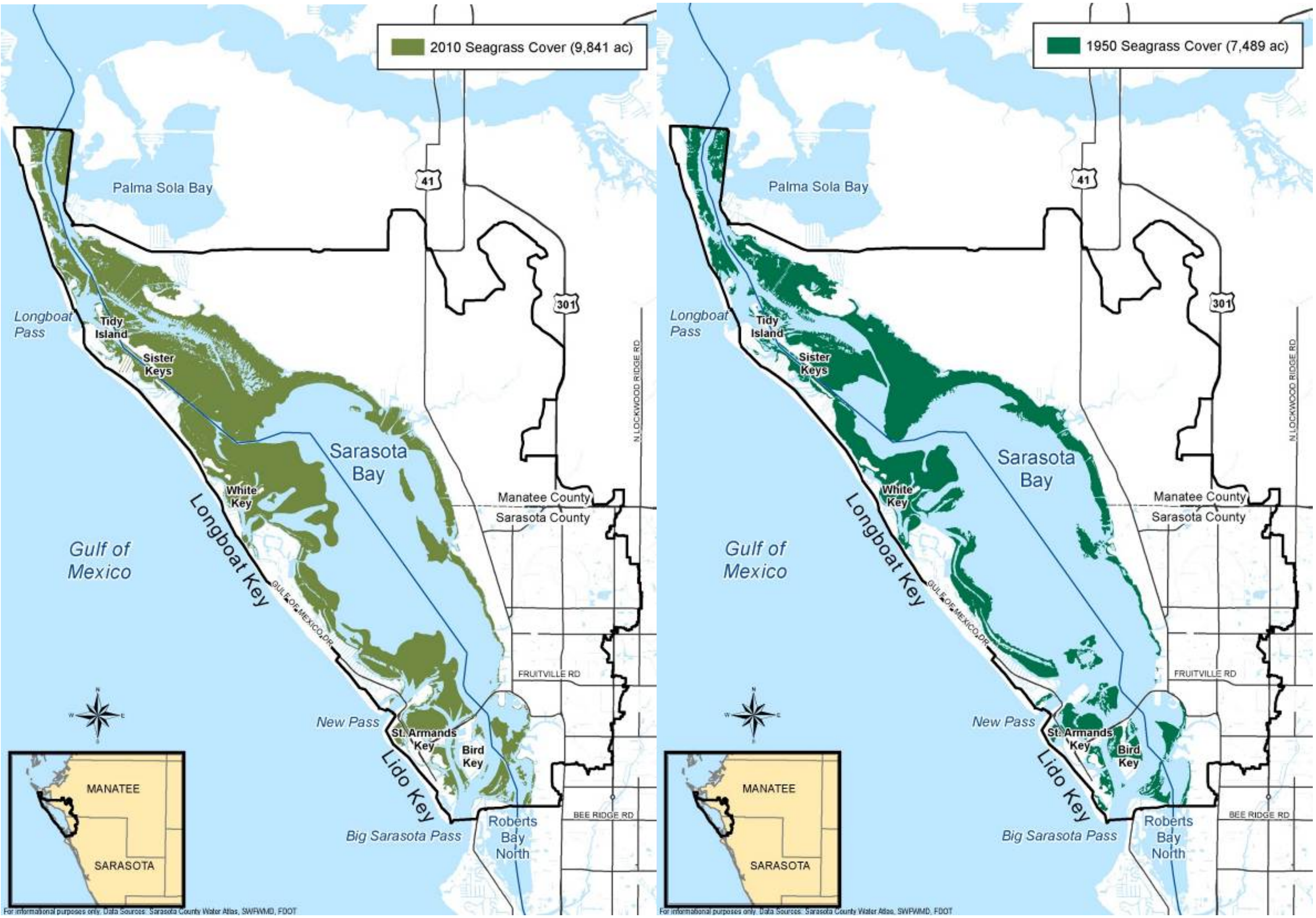


Figure 3-15 Left: 2010 Seagrass Coverage in Sarasota Bay; Right: Circa 1950 Seagrass Coverage in Sarasota Bay

3.4.1.2 Shoreline

The Sarasota Bay shoreline is not only the boundary of the estuary and the watershed but also plays an important role in the ecology of the system. Shorelines define the land-water interface and are ecological transition zones between terrestrial and aquatic life. Shorelines include a littoral zone where diverse habitat types affect the organization of floral and faunal assemblages and the interactions between terrestrial and aquatic plants and animals. Littoral zones are especially important in tidal water bodies. Human activities including mechanical dredging and filling and depositing channel spoil material have significantly altered the bays' shorelines since population began growing along the coast in the 1920s.

In 1948 Sarasota Bay had approximately 93 miles of shoreline, 37% of which was hardened. The historical areas with the most significant modification included the mainland in the City of Sarasota downtown waterfront as well as the barrier islands south of Longboat Key. Bird Key, St. Armands Key, Coon Key, City Island, and Bay Island were all products of early dredge-and-fill operations. Other areas along the mainland shoreline had also been modified by the late 1940s, as had the village of Cortez to the north, the north end of Longboat Key, and Anna Maria Island.

By 2008 the bay had 150 miles of total shoreline, an increase of over 60%. The additional shoreline is mainly dredge-and-fill canals but is also due to the emergence of numerous mangrove islands in the bay. Substantial shoreline hardening had taken place as well, increasing by over 150% to 138 km. See Appendix D, Section 2.3 for detailed information and figures showing the shoreline changes.

3.4.1.3 Oysters

Oysters are an important indicator of estuarine health, and their status can help identify water-management problems. Oyster reefs serve several valuable ecological functions. They provide habitat for estuarine fauna, including conch, mud crab, fish, and other bivalves (Wells, 1961; Tolley and Volety, 2005) and help improve water quality by filtering as they feed.

Sarasota County conducts an oyster monitoring program throughout its estuaries with two sites in Sarasota Bay—one in Hudson Bayou off Osprey Avenue and one in the bay south of the mouth of Hudson Bayou—to document the viability of existing oyster bars in the County's bays and tidal creeks. For the most recent 6 years of data collected, the percent-live oysters ranged from a high of 78% in fall 2006 to a low of 62% in spring 2009. These scores were generally higher than percent-live oysters at an upstream site, which ranged from a low of 55% in fall 2006 to a high of 81% 6 months later.

Sarasota County contracted with Photo Science, Inc. in 2010 to conduct a photogrammetric survey of all oyster bars within County waters. In the south half of Sarasota Bay, oysters were most prolific along the shore of Longboat Key and City Island to the west and in the tidal reaches of Hudson and Whitaker Bayous to the east (Figure 3-16). A total of 87 individual oyster bars ranging in size from 0.01 to 0.25 acre and having a total areal extent of 3.8 acres were identified. Historically, oysters had a much greater range in the bay (Figure 3-16).

3.4.1.4 Scallops

Scallops are also an important indicator of estuarine health. Once plentiful along Florida's southwest coast, they now exist locally in greatly diminished abundance. Several potential causes of the decline in the scallop population include decline in available habitat, changes in water quality, and over-harvesting. This decline led to drastic changes in the way scallops were managed in State waters. In 1994, waters south of the Suwannee River were closed to commercial harvesting while recreational limits were reduced. Through a combination of restoration and management practices, the recreational fishery was re-opened in West-Central Florida but still remains closed in the Sarasota Bay estuarine system.

Sarasota County has partnered with Fish and Wildlife Research Institute (FWRI) and Albritton Farms in placing scallop monitoring traps in bays throughout the County. Drifting scallop spat attach themselves to the traps, which are collected every other month and taken to FWRI for laboratory analysis. Additionally, Sarasota County and Sarasota Bay Watch conduct annual scallop searches in the County's bays. Figure 3-17 shows the results of the 2008 search (Sarasota County, 2008). Based on field notes from the scallop searches, the most scallops were observed either near passes and/or in areas with seagrass meadows, their preferred habitat. The number of scallops observed in recent years has dropped, with 947 found in 2008, 136 scallops in 2009, and only 12 in 2010. However, as this is a volunteer effort, the number of scallops found may reflect the number of participants in the searches or may be caused by natural variability. Sarasota Bay had by far the most scallops found in any SBEP bay segment during the 2008 search.

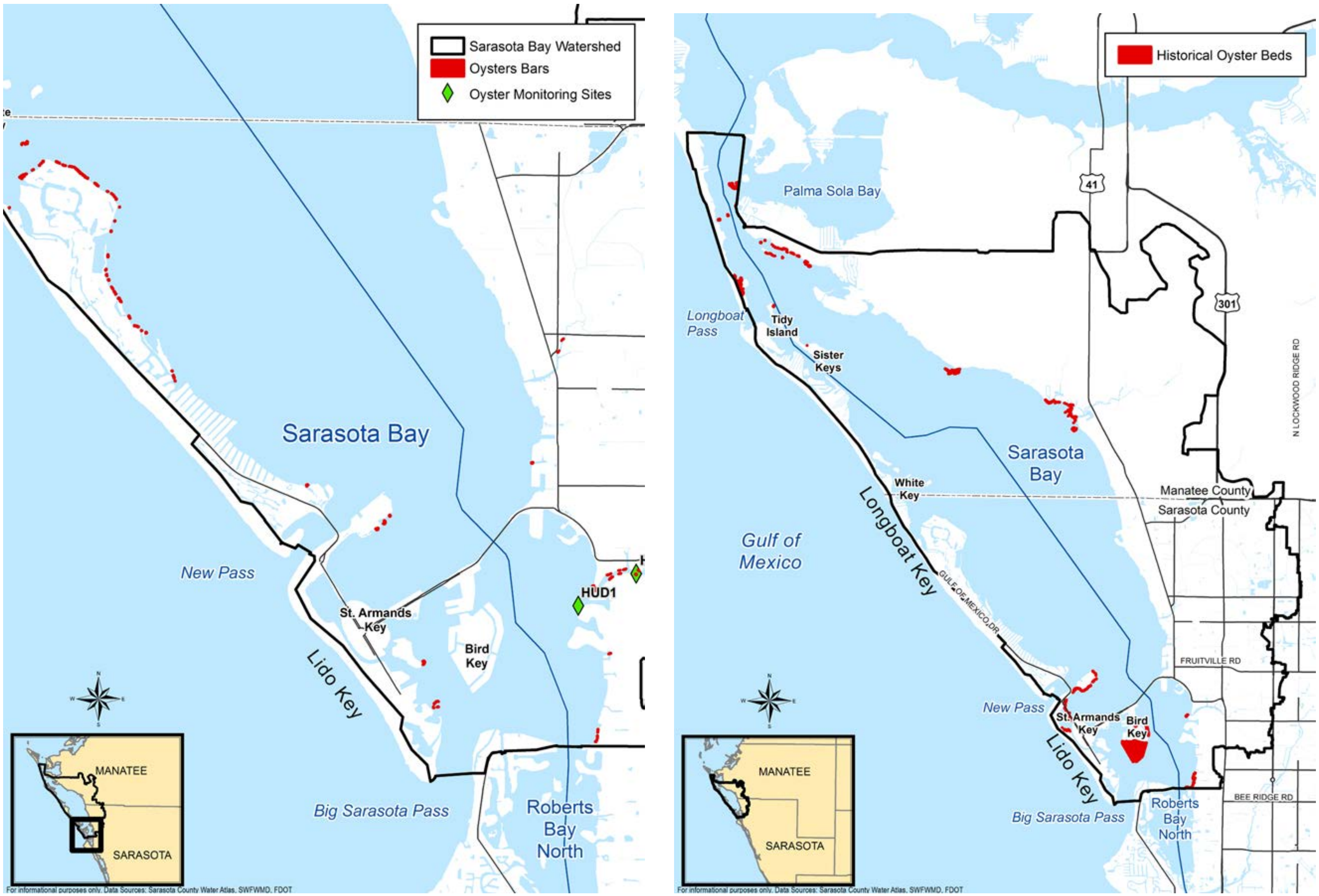


Figure 3-16 Left: Oyster Bars within Sarasota Bay; Right: Estimated Historical (1948) Oyster Beds in Sarasota Bay (Photo Science, Inc., 2007)

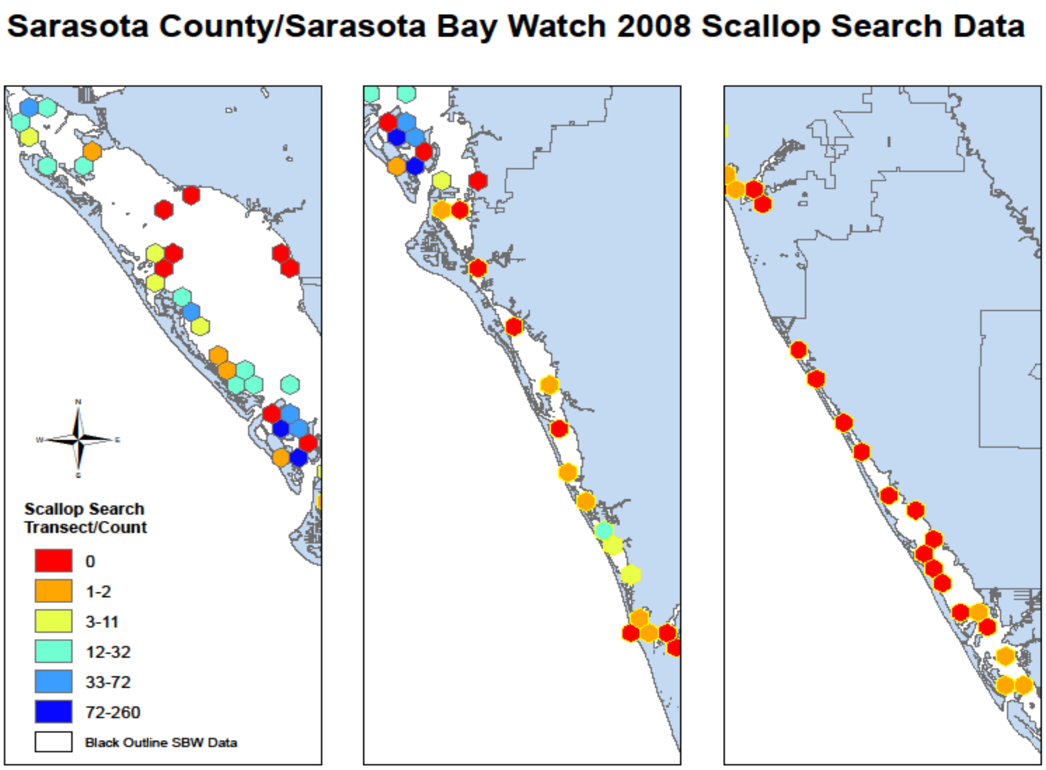


Figure 3-17 Results of 2008 Sarasota County/Sarasota Bay Watch Scallop Search

3.4.1.5 Tidal Creeks

Tidal creeks, or coastal streams as they are called in the Sarasota County Comprehensive Plan, are relatively small coastal tributaries that link between freshwater, terrestrial, and estuarine systems. Because of their close connection to the marine and freshwater systems, tidal creeks play a unique and integral role in the ecological function of coastal estuaries.

Two tidal creeks are tributaries to Sarasota Bay—Whitaker Bayou and Hudson Bayou. The physiography and history of these creeks have been documented in Appendix A – Project Background and Physical Setting, Section 1.3. As reported, these tidal creeks and their watersheds have been developed for urban land uses, with little remaining natural wetlands and floodplain.

Sarasota County conducted ecological monitoring and assessment in coastal creeks for the Sarasota County Tidal Creek Condition Index (TCCI) from 2008 through 2011. (Figure 3-18). Sixteen tidal creeks in Sarasota County are assessed annually. Whitaker Bayou was ranked lowest (poorest ecological quality) of the creeks scored, and Hudson Bayou had the fourth lowest score. The low scores suggest that these are significantly altered creek systems with ecological stresses caused by their urbanized watersheds.

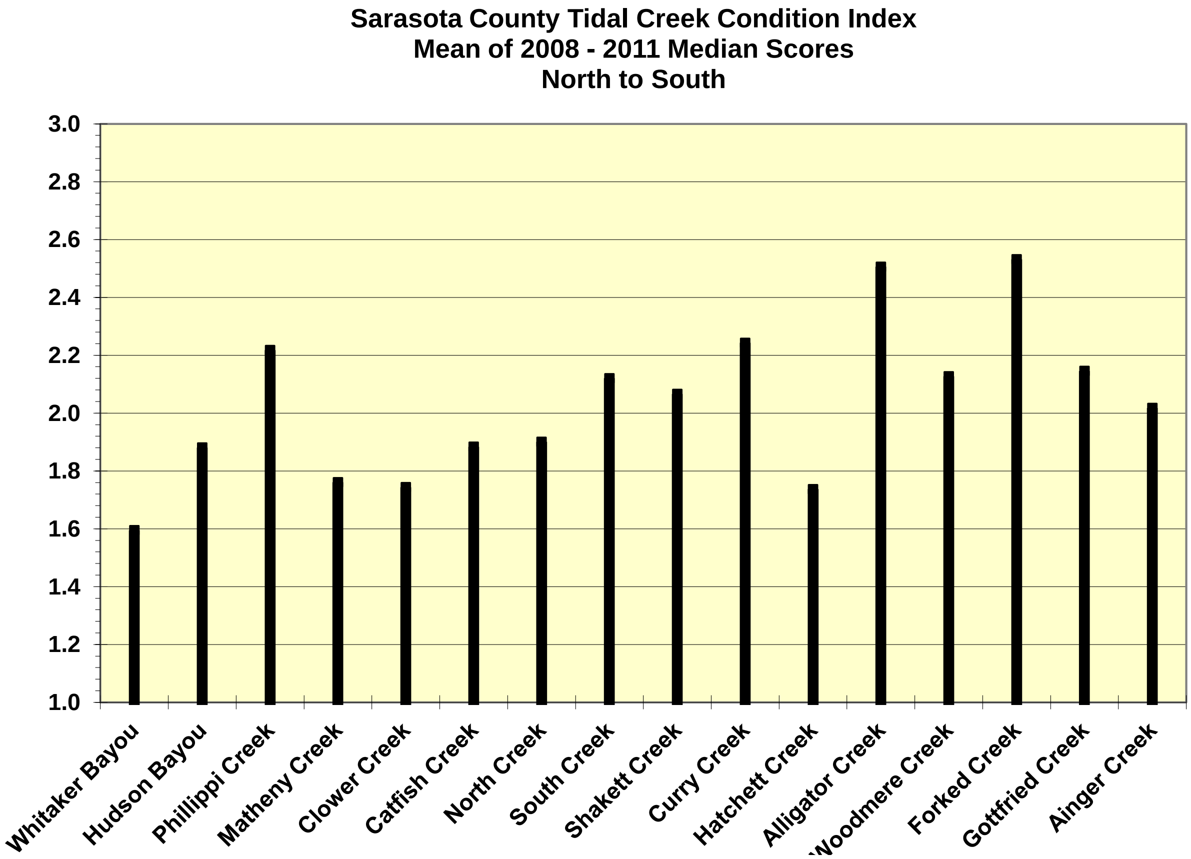
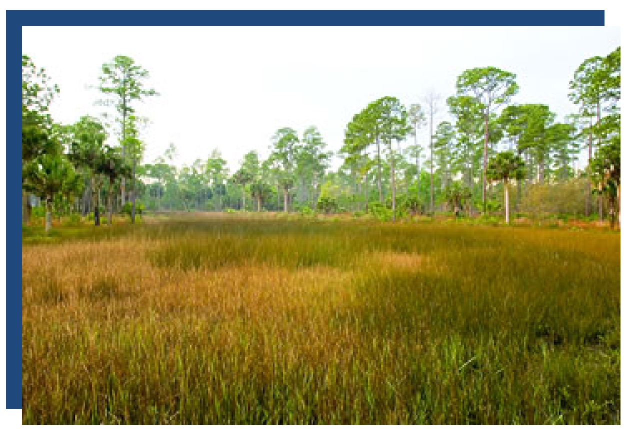


Figure 3-18 Tidal Creek Condition Index Scores (2008–2010)
Creeks in the Sarasota County portion of the Sarasota Bay Watershed (Whitaker and Hudson Bayous) are shown at left.

3.4.2 Freshwater Natural Systems

3.4.2.1 Streams



Small streams and wetlands provide crucial linkages between aquatic and terrestrial ecosystems and between upstream watersheds and tributaries and the downstream rivers and lakes. The health of Sarasota Bay's small streams is critical to the ultimate health of Whitaker Bayou, Hudson Bayou, and Sarasota Bay. The health of streams is often linked to changes that occur to the stream channel such as dredging, straightening, and removing the bank and adjacent vegetation. Due to the extensive residential and commercial development that has occurred in Sarasota Bay, a majority of Whitaker and Hudson Bayous' freshwater tributaries have been dredged and channelized and are referred to as canals.

3.4.2.2 Wetlands

Wetlands are often referred to as the 'kidneys' of the landscape and are a significant factor in the health and existence of other natural resources of the watershed, such as rivers, streams, inland lakes, groundwater, wildlife, and estuaries. Wetlands play a key role in storing and modifying potential pollutants, such as chemical fertilizers, in ways that maintain downstream water quality. They also export organic carbon to streams and other downstream water bodies. In limited amounts, organic carbon is essential to maintaining a healthy aquatic ecosystem.

Based on 1940s aerial imagery, the Sarasota Bay Watershed contained approximately 11,463 acres of freshwater wetlands with herbaceous depressional marshes comprising 78% of the total wetland acreage. In 2008, Sarasota Bay had 1,384 acres of freshwater wetlands; 571 acres are herbaceous and 813 acres are forested. This is an 88% loss in wetland acreage for this 60-year period. Wetland losses are primarily due to filling to convert land to residential and commercial use or dredging to make water features (Figure 3-19).

Figure 3-19 Left: Pre-Development Aerial Depicting Numerous Freshwater Wetlands, Right: 2011 Aerial Depicting Historical Wetlands Now Residential and Commercial Land Uses

3.4.2.3 Natural Systems Results

Natural systems are self-sustaining living ecosystems such as wetlands, streams, seagrass beds, and upland vegetation communities that support a diversity of organisms and provide many valuable ecosystem-based services. Appendix D presented a summary and trends of the critical estuarine and freshwater natural systems found in Sarasota Bay. Six opportunities to enhance existing or create natural systems on public lands were identified and conceptual designs developed (See Appendix G).

Positive trends were observed in seagrass coverage in Sarasota Bay, and efforts by stakeholders to achieve this should be a model for other watersheds. No clear trends were observed for oysters. Large losses of mangrove acreage have occurred in Sarasota Bay since the 1940s and before wetland protection regulations were implemented. However, small (<0.25 acre) patches of mangroves are now widely distributed in Sarasota Bay in areas not present historically. The County's mangrove monitoring program provides valuable data to assess mangrove extent and trimming practices. With over 90% of the parcels adjacent to major watercourses developed before 1995 and lacking a naturally vegetated watercourse buffer, the emphasis should be on persuading homeowners to incorporate naturally vegetated setbacks into their landscape rather than deterring buffer impacts on undeveloped parcels. An abundance of opportunities exists to work with homeowners to convert waterward portions of their backyards dominated by turf grass to native, low-maintenance species. Approximately 50% of the total shoreline in Sarasota County portions of Sarasota Bay has been hardened. The goal for natural shoreline should be to maintain existing extents while working to increase extents over time, even at a parcel-by-parcel level. Appendix D presents LOS targets and recommendations for several of these important natural systems.

3.5 FLOOD PROTECTION

The Sarasota Bay Watershed is subject to coastal and inland flooding. Coastal flooding sources include storm surge and wind-driven waves. Inland flooding results from excessive rainfall. Storm surges are caused by high winds, and coastal and inland flooding are usually associated with hurricanes or other tropical storms. The relatively flat and low-lying topography of Sarasota County makes it inherently prone to both types of flooding, and the County's "poorly drained" soils further promote inland flooding. Additionally, development has changed the natural environment within the Sarasota Bay Watershed and likely exacerbated the flooding problem before modern stormwater management regulations were implemented. Increased impervious surfaces throughout the heavily urbanized Hudson Bayou, Whitaker Bayou, and Sarasota Coastal basins have decreased rainfall infiltration, and gutters and storm sewers speed runoff to the channels. As a result, more water runs off more quickly, and drainage systems, including creeks, can become overloaded, leading to flooding.

The Sarasota County Watershed Management Program endeavors to address inland flooding. The County's goal with regard to flood protection is to minimize flood risk to protect human safety and property in existing developed areas while protecting natural and beneficial functions of the remaining floodplain. This WQMP does not contain new analyses of flood conditions since the conditions have been analyzed and recommendations for improvements were previously proposed. Instead, this WQMP provides an overview of existing flood-protection-related activities and previous flood-protection recommendations. This section is an important component of the WQMP as flooding in the watershed directly impacts water quality in the tributaries and bay. Water quality best management practices (BMPs) are often designed to capture debris and sediment and remove pollutants during low-flow events and may not be as effective during larger storm events. Additionally, during large storm events, runoff may pool or flow in areas outside drainage systems, such as over roads or in parking lots, and may collect more debris and pollutants than a low-flow event fully contained within a drainage system with water quality BMPs. Therefore, reducing the risk of flooding is an important component of improving water quality in Sarasota Bay.

3.5.1 History of Flooding and Sarasota County Stormwater Program

Historically, the Sarasota Bay Watershed was predominately a mosaic of isolated wetlands and pine flatwoods. During normal seasonal cycles, the water in these wetlands expanded into pine flatwoods with wet-season rainfall and contracted to isolated pockets of wetlands during the dry season. In the early 1900s, residents of Sarasota County established a Mosquito Control District that installed ditches in mangrove areas along the coast and extended the natural creeks inland to connect many of the large, isolated wetlands. The result is a network of man-made drainage ditches that dramatically altered the movement of freshwater from the land to tidal creeks, estuaries, and bays and in turn extended the tidal influence inland. Over time many wetlands and floodplains were filled without mitigation or compensation, and impervious surfaces were created. As a result, flood storage capacity was reduced and runoff increased, raising flood stages and decreasing water quality in creeks and bays. Since much of the watershed is now densely populated, flooding affects homes, businesses, and agriculture in the floodplains, especially those areas developed before the adoption of County Land Development Regulations (LDR) in 1981 (Figure 3-20).

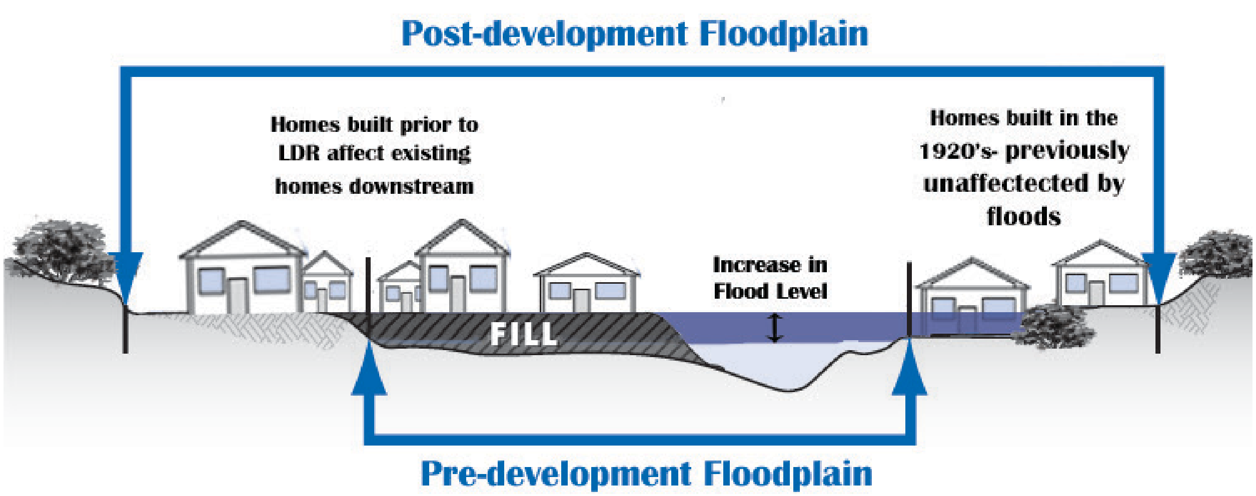


Figure 3-20 Floodplain Changes Schematic (Adapted from *www.dnr.sc.gov*)

Sarasota County took the first step toward developing a stormwater program in 1981 with the creation of the Stormwater Management Division. By the early 1990s, the Sarasota County Stormwater Environmental Utility (SEU) initiated a Countywide basin master planning project to develop hydrologic and hydraulic models to identify problematic flooding areas for all of the County's major watersheds. These models are also used to analyze proposed drainage improvements to the County's stormwater system. The Hudson Bayou, Business District, and Whitaker Bayou Basin Master Plans were completed in 1994, 2002, and 2003, respectively. An addendum to the Hudson Bayou Basin Master Plan was issued in 1997. In addition, SEU continues to maintain the models by updating them periodically. The updated models are made available to developers to use as a base model to ensure that proposed projects will not impact neighboring areas.

In the mid-1990s, the LDR was modified to require stormwater systems to be designed for a 100-year storm (10 inches of rain in 24 hours). The County also started the first stormwater capital improvement assessments. The County then completed feasibility analyses for projects in problem areas identified in the Basin Master Plans. Several of these projects are included in the County's Capital Improvement Program (CIP). By the late 1990s, the SEU Strategic Plan was adopted and revenue bonds were issued to fund more stormwater improvement projects. Today, several CIP projects, such as stormwater control structures, retrofit projects, and retention and detention ponds, have been constructed throughout the Sarasota Bay Watershed.

For more information on Legislation and Ordinances in place to minimize damage caused by flooding, see Appendix E – Section 3.0.

3.5.2 Flood Protection Level of Service (FPLOS)

The stormwater quantity FPLOS requires that public and private stormwater management systems provide adequate control of stormwater runoff. The stormwater quantity or FPLOS and design criteria are defined in the Sarasota County Comprehensive Plan and LDR (Table 1) and used throughout the Basin Master Plan program (See Appendix E – Section 5.1).

The goal of the FPLOS design criteria is to prevent flooding of emergency shelters and structures providing essential services during storms equal to or exceeding the 100-year event (10 inches in 24 hours). The FPLOS goal for habitable structures and employment/service centers is no flooding from storms up to and including the 100-year storm. Flooding of garages, barns, sheds, and other out-buildings is not considered structure flooding. The FPLOS established for roadways varies depending on the classification of the street or roadway. The goal of these criteria is to prevent flooding of evacuation routes and major arterial roadways during storms up to and including the 100-year event. Figure 3-21 shows acceptable flooding for a 100-year storm. For more information the FPLOS and acceptable flooding criteria, See Appendix E – Section 4.0.

Figure 3-21 Acceptable Flooding for a 100-Year Storm

3.5.3 Planning Studies and Efforts

The drainage plans and programs from the early 1920s through the 1960s emphasized removing surface waters from the land, primarily for mosquito control and agricultural uses. Water quality did not begin emerging as a major concern until the late 1960s.

In 1984, the Board of County Commissioners recognized major inadequacies in the existing stormwater management system and authorized the preparation of a Stormwater Master Plan to assess the need for improving major drainage systems in the developed portions of the County. The objectives of the plan included:

- ❖ Assessing the adequacy of primary stormwater conveyance systems in developed or developing basins.
- ❖ Estimating the cost for public stormwater improvements as watersheds are developed to their ultimate use.
- ❖ Prioritizing stormwater management needs of each basin within a framework of the needs within the entire County.
- ❖ Developing a plan or identifying options available to the County for financing the cost of construction, operation, and maintenance of stormwater management facilities.

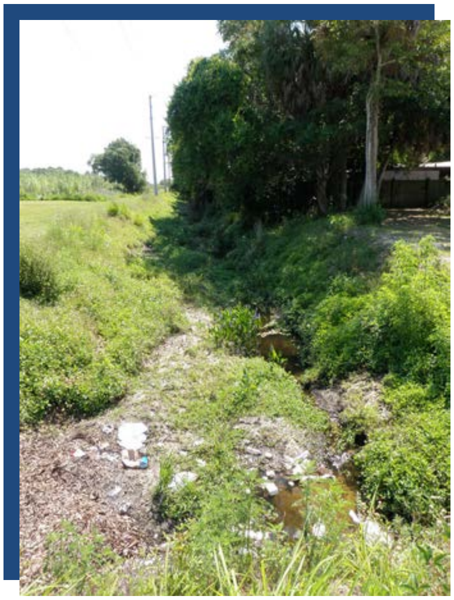
3.5.4 Basin Master Planning

Numerous hydrologic studies dating back to the late 1970s have been completed throughout the Sarasota Bay Watershed. The Basin Master Plans listed below were based on a detailed analysis of these studies, the existing and projected land uses, existing drainage facilities, and projected stormwater drainage management needs. This information was used to develop hydrologic and hydraulic models using ICPR’s routing engine to simulate runoff, conveyance, and flooding conditions for the Whitaker Bayou and Hudson Bayou Basins. Model results were used to identify the location and magnitude of existing flooding problems in the basins. Based on model results, the plans provide recommendations for facilities improvement and management standards that will need to be met by the private sector for new construction and the expansion of existing activities to bring stormwater conveyance systems within the basins into compliance with the recommended FPLOS criteria.

Sarasota Bay Watershed Basin Master Plans:

- *Whitaker Bayou – December 2003 and December 2004*
- *Hudson Bayou and Business District – September 1994*

3.6 SEDIMENT MANAGEMENT



Sediment production is a natural watershed process, but urbanization and other land-use changes can impact the processes associated with the sedimentation cycle: erosion, transport, and deposition. Within an urbanized setting like the Sarasota Bay Watershed, sediment production has two primary sources: wash-off from land surface and in-stream channel erosion. Bank steepness, degree of concentration (runoff velocity), and stability (e.g., vegetation) influence the quantity of the sediment load that reaches the waterbody. Increased sediment load from wash-off and in-stream erosion can affect water quality, natural habitat, navigation, flood control, and recreational uses downstream. In addition, alterations in circulatory patterns caused by dredging can re-suspend and transport existing sediments.

Sediment transported and deposited in waterbodies can disrupt aquatic ecosystems. Excess sediment can cloud the water, which can suffocate fish and block the light required by aquatic plants for photosynthesis. In addition, sediment-rich discharges tend to carry higher loadings of pollution because nutrients, pesticides, and heavy metals adsorb to and are transported along with sediment. Pollutants of concern including TSS, TN, and TP are associated with the sediment and contaminants attached to sediment in the Sarasota Bay Watershed.

Nitrogen and phosphorus are nutrients that occur in soils naturally. Increased erosion increases the nutrient load to the system. Other common sources of nitrogen and phosphorus in an urbanized area are septic systems, pet wastes, urban debris, grass clippings, fertilizer, industrial wastes, and landfills. Additionally, Florida’s geology contains sedimentary deposits of marine origin, some of which are high in phosphorus content. The watershed’s phosphorus-rich geology and soils, therefore, significantly influence the TP concentrations in the Sarasota Bay tributaries and estuary. Excess nutrients combined with the tropical temperatures in Sarasota County can lead to excessive algal growth impacting the recreational aspects of the waterways as well as creating an oxygen deficit for the marine life and aquatic habitats.

Previous studies show some sediment in the Sarasota Bay tributaries (Whitaker Bayou and Hudson Bayou) contains substantial levels of contaminants, including toxic metals, pesticides, petroleum, and other organic compounds (Dixon et al, 1990, PBS&J, 2003). The Sarasota Bay Watershed is highly urbanized with older neighborhoods that provide only minimal stormwater retention or detention. The untreated runoff contributes sediment and associated pollutants to Hudson and Whitaker Bayous and Sarasota Bay. However, sediments in the bay proper have been reported to be uncontaminated.

Watershed management includes identifying sediment problems, identifying sediment sources, and recommending improvement projects that address the source as well as capturing sediment before it reaches the estuaries. Several potential sediment management projects were identified throughout the watershed for this plan. These potential projects incorporate strategies such as providing source control to reduce or remove solids in upland areas, implementing maintenance practices designed to reduce sedimentation, and improving eroding and sloughing banks for long-term stability.

Source control activities include activities such as LID projects, street sweeping, and construction-area silt fencing. Regularly scheduled maintenance activities include cleaning out baffle boxes, removing vegetation debris resulting from maintenance activities from swales and roadside ditches, replacing or repairing damaged infrastructure, and maintaining control structures, weirs, and pumps. Bank stabilization in an urban setting is challenging. For stabilization to be effective in the long term, management and restoration should not be limited to a single point in the stream but will be more effective when conducted as multiple projects along a channel system. Implementing projects that incorporate these strategies will reduce turbidity, increase clarity, and reduce nutrient and sediment load and therefore improve the overall health of the tributaries and Sarasota Bay.

See Appendix F for detailed Sediment Management Plan information for Sarasota Bay. Sediment management recommendations are summarized for each of the basins in Section 4 of this plan.

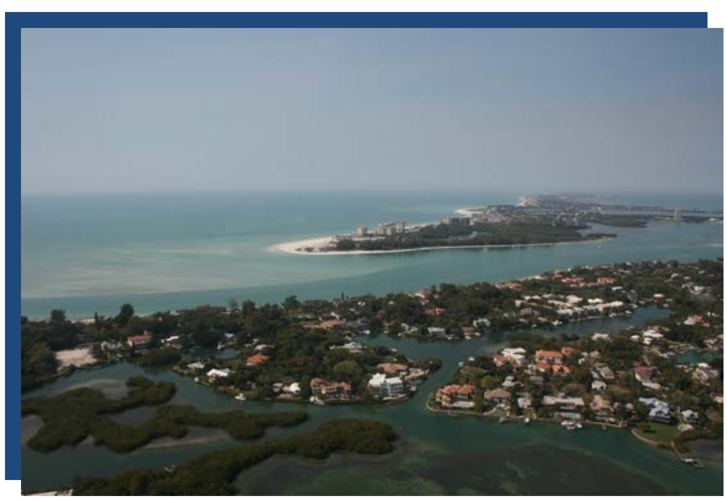
3.7 SARASOTA BAY WATERSHED SUMMARY AND RECOMMENDATIONS

The Sarasota Bay Watershed is relatively flat and has an average annual rainfall of 53 inches. The majority of the watershed has been altered, leaving only isolated natural and conservation areas for many threatened and endangered native species. Only about 10% of the watershed is undeveloped, which significantly affects water quality, water quantity (flow), habitat, and flooding risks. The highly urbanized watershed consists of a lot of older neighborhoods that provide only minimal stormwater retention or detention. The surface water runoff from the rainfall flows across the watershed terrain through ditches, storm drains, creeks, and wetlands, and eventually into Sarasota Bay. The untreated runoff contributes sediment and associated pollutants to Sarasota Bay and its tributaries. Previous studies show some sediment in the Sarasota Bay tributaries contains substantial levels of contaminants, including toxic metals, pesticides, petroleum, and other organic compounds. However, sediments in the bay proper have been reported to be uncontaminated.

Freshwater inflows to Sarasota Bay originate from sources in nature and from human activities. Rainfall is the primary source of freshwater in the Sarasota Bay system. Atmospheric deposition (direct rainfall to the open water estuary) contributes the most freshwater to Sarasota Bay of any source (see Figure 3-22). This is because the relative size of the open water estuary is large with respect to the watershed land area.

The relative contributions of sources of freshwater for historical, current, and future conditions indicate that although freshwater inflows have increased since the historical period, future freshwater inflows to the bay as a whole should very much resemble current inflows. The only exception is for inflows from Whitaker Bayou, which will be reduced from current levels when discharges from the City of Sarasota wastewater treatment plant stop. No adverse effects due to changes to freshwater inflows are expected for the future.

Although the water quality indicators provide abundant evidence of a healthy estuary, some local areas of the bay or in tributaries have water quality issues. The entire bay currently meets State water quality standards; however, some of the watershed's stream segments have listed impairments. A defensible strategy for managing bay water quality is to maintain current conditions overall; however if isolated problem areas are identified then remedial action should be considered. Coastal areas and tidal portions of tributaries with limited circulation are especially vulnerable to water quality problems.



Several potential projects were identified throughout the watershed for this plan. These potential projects incorporate strategies such as providing source control to reduce or remove solids in upland areas, implementing maintenance practices designed to reduce sedimentation, improving eroding and sloughing banks for long-term stability, capturing excess runoff before it enters the streams, improving natural habitats, and providing buffers to capture nutrients. Implementing these projects will help the Sarasota Bay remain a healthy system.

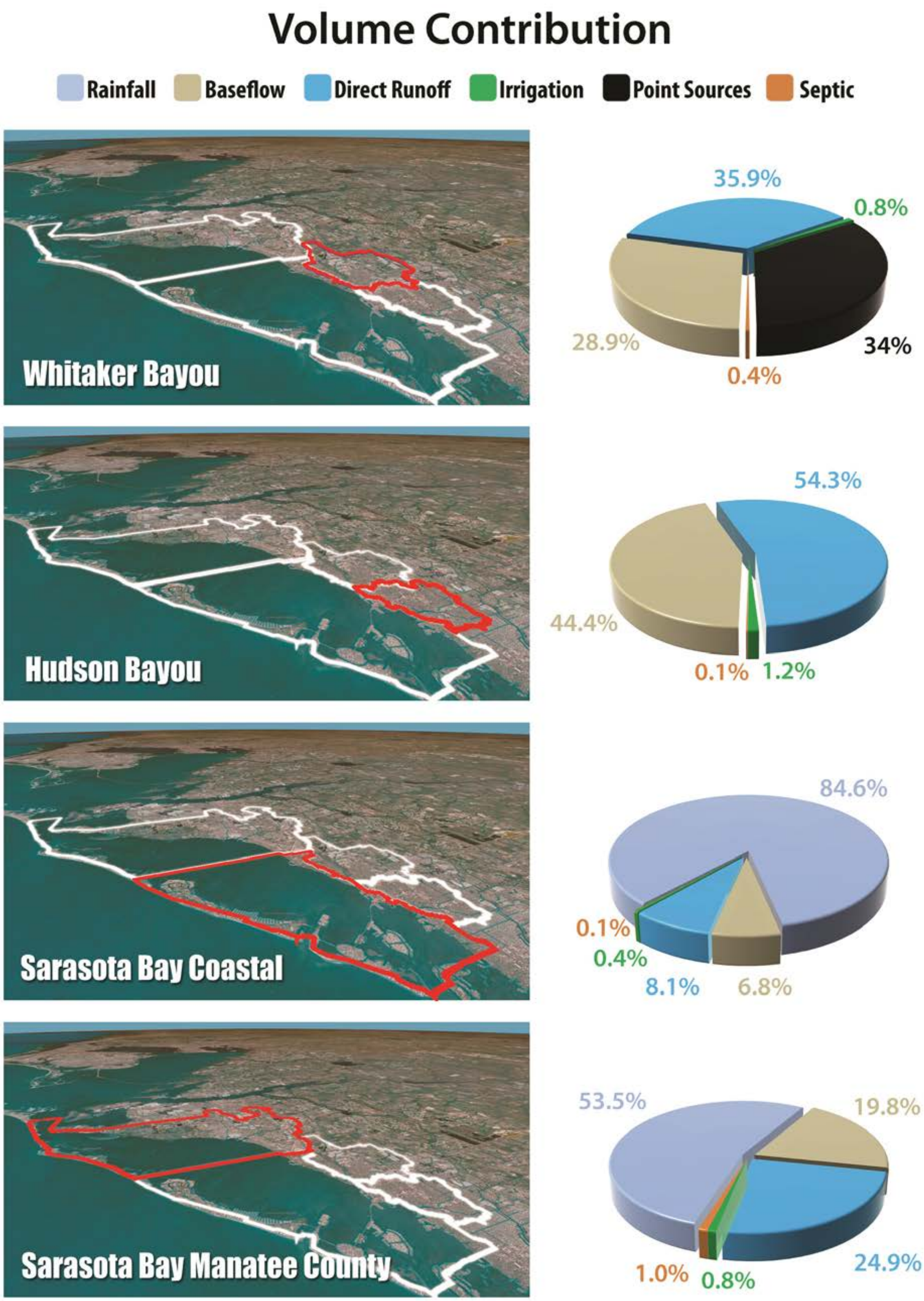


Figure 3-22 Volume Contribution by Source for each Basin

3.7.1 Project and Program Recommendations

Information was collected and assembled, including results from previous tasks, data collected from previous studies, GIS data, and stakeholder input, to identify potential projects in the Sarasota Bay Watershed. The investigation began with a GIS desktop analysis to identify water quality, sediment, natural systems, and water supply 'hot spots' throughout the watershed. These hot spots were then refined to potential project sites. Finally, field investigations were conducted to evaluate potential project options. This methodology is summarized in Figure 3-23. Benefits and costs, including capital and operation and maintenance costs, were calculated at a conceptual level for each recommended project. Non-quantitative benefits were also documented and considered in ranking the projects based on priority. See Section 4 of Appendix G for project benefits and Section 6 for conceptual-level project sheets and cost estimates.

While cooperative funding is provided by SWFWMD, the inclusion of proposed projects, corrective actions, and BMPs in this plan does not confer any special status, approval, permitting standing, or funding from SWFWMD. Requests for funding assistance will have to meet the requirements of funding programs and be subject to SWFWMD's Governing Board appropriating funds.

Further, all projects are subject to County and SWFWMD regulatory review and permitting and are designed to be consistent with the Sarasota County Comprehensive Plan and the Sarasota County Code of Ordinances. Where applicable, all regulatory authorizations shall be obtained before a project can begin. To address these concerns, regulatory coordination will occur at the planning stages for each project discussed in this WQMP to ensure a streamlined permitting review process and address consistency with the Sarasota County Comprehensive Plan and Sarasota County Code of Ordinances before the project is designed.

Twenty-eight projects are recommended throughout the Sarasota Bay Watershed. If all 28 projects were implemented, the County would benefit by removing approximately 1,900 pounds of TN annually and could prevent up to 26,511 cubic yards of sediment from entering the streams.

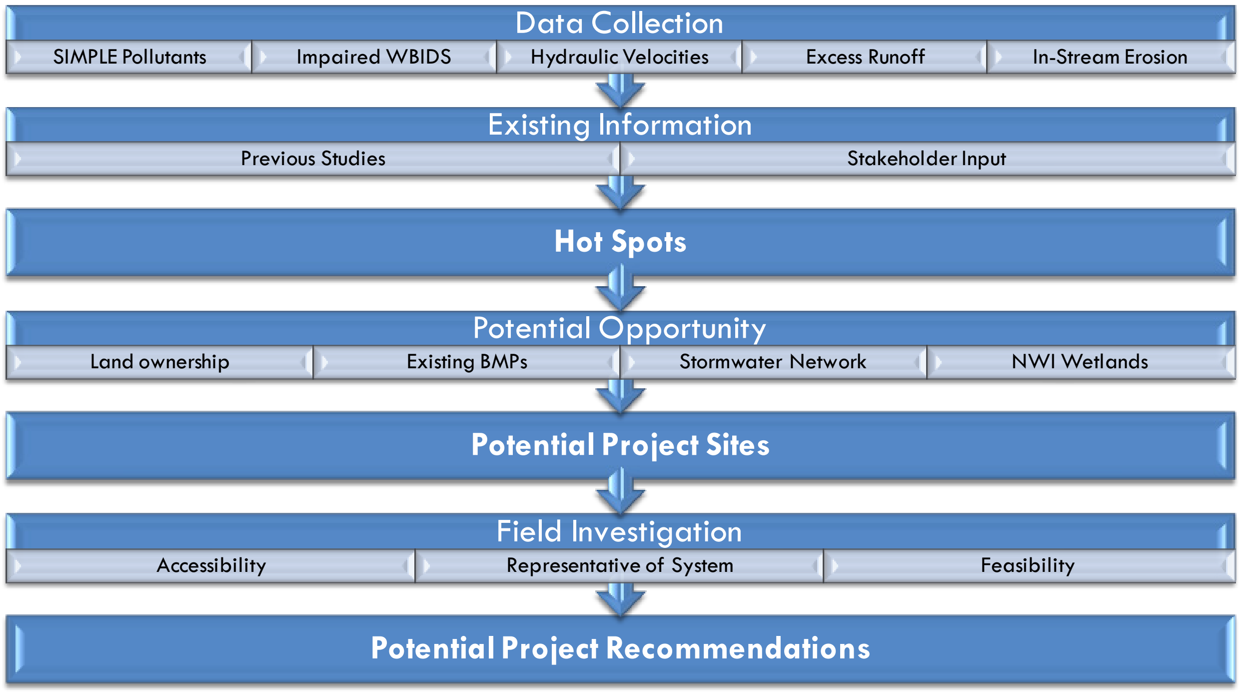


Figure 3-23 Methodology Used to Develop Potential Project Recommendations

Table 3-4 lists the projects by project rank calculated based on water quality regulatory impairments and benefit to cost ratio. Figure 3-24 shows the locations of each project in the watershed.

Table 3-4 Project Priority Ranks by Regulatory Requirement

Project ID	Project Name	Basin	Impairment	TN Reduction (lb/year)	Sediment & Erosion Prevention (cy)	Benefits / Costs	Priority Rank
Impaired WBID (FDEP Consent Decree) No TMDL							
NS5	Payne Park	HB	DO, Fecal Coliform	74	0	1.83	7
WS12	Lime Lake Park	WB	TN, DO, Fecal Coliform	0	0	1.67	8
NS6	Hudson Bayou Oak Street Canal	HB	DO, Fecal Coliform	9	0	1.07	12
WS05	Orange Avenue Park	WB	TN, DO, Fecal Coliform	18	0	1.06	13
WQ5	Hudson Bayou North Branch	HB	DO, Fecal Coliform	9	0	0.82	16
WQ10	Ringling Blvd. Sidewalks	HB	DO, Fecal Coliform	20	0	0.23	21
WS10	Martin Luther King Park	WB	TN, DO, Fecal Coliform	1	0	0.02	26
No Impairment							
NS4	North Water Tower Park	WB	-	775	0	5.10	1
WS04	Arlington Park and Aquatic Complex	HB	-	0	0	4.64	2
NS2	Bayfront Park Shore	SBC	-	0	2270	3.80	3
SMP6	Sarasota High School at Hatton Street	HB	-	105	21574	2.88	4
SMP2	Whitaker Canal at Leonard Reid Ave	WB	-	157	1400	2.86	5
NS1	Arlington Park	HB	-	61	0	2.54	6
SMP3	Orange Avenue	HB	-	90	85	1.37	9
WS07	Gillespie Park	HB	-	0	0	1.18	10
SMP7	Sarasota High School at Tamiami Trail	HB	-	16	0	1.17	11
WQ2	Bayfront Parking Lot	SBC	-	217	0	1.04	14
SMP5	Bayfront Park and Marina South	SBC	-	31	0	1.03	15

Table 3-4 Project Priority Ranks by Regulatory Requirement

Project ID	Project Name	Basin	Impairment	TN Reduction (lb/year)	Sediment & Erosion Prevention (cy)	Benefits / Costs	Priority Rank
WQ7	10th St Outfall	SBC	-	192	0	0.63	17
WS02	Bay Haven Elementary School	SBC	-	4	0	0.63	18
NS3	Longboat Key Bayfront Park	SBC	-	17	0	0.57	19
SMP4	Bayfront Park and Marina North	SBC	-	14	0	0.39	20
WS11	Robert Taylor Community Complex	WB	-	1	0	0.20	22
WQ1	North Gillespie Park	HB	-	0	460	0.11	23
WS06	Ken Thompson Park Preserve	SBC	-	11	0	0.11	24
SMP8*	10th St Boat Basin Dock	SBC	-	0	630	0.05	25
WQ9	Hudson Bayou East Branch	HB	-	0	92	0.02	27

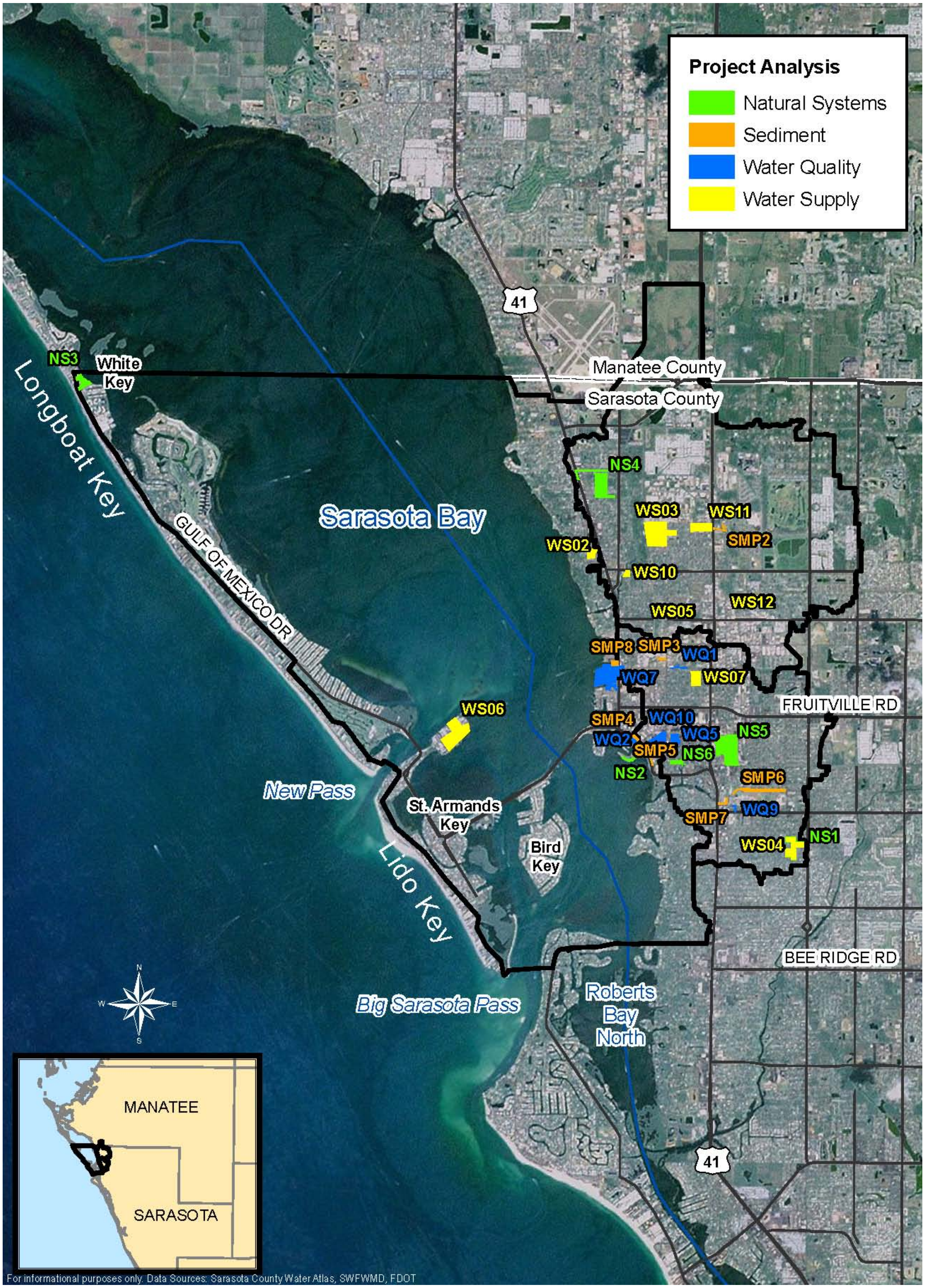


Figure 3-24 Location of Recommended Projects in the Sarasota Bay Watershed

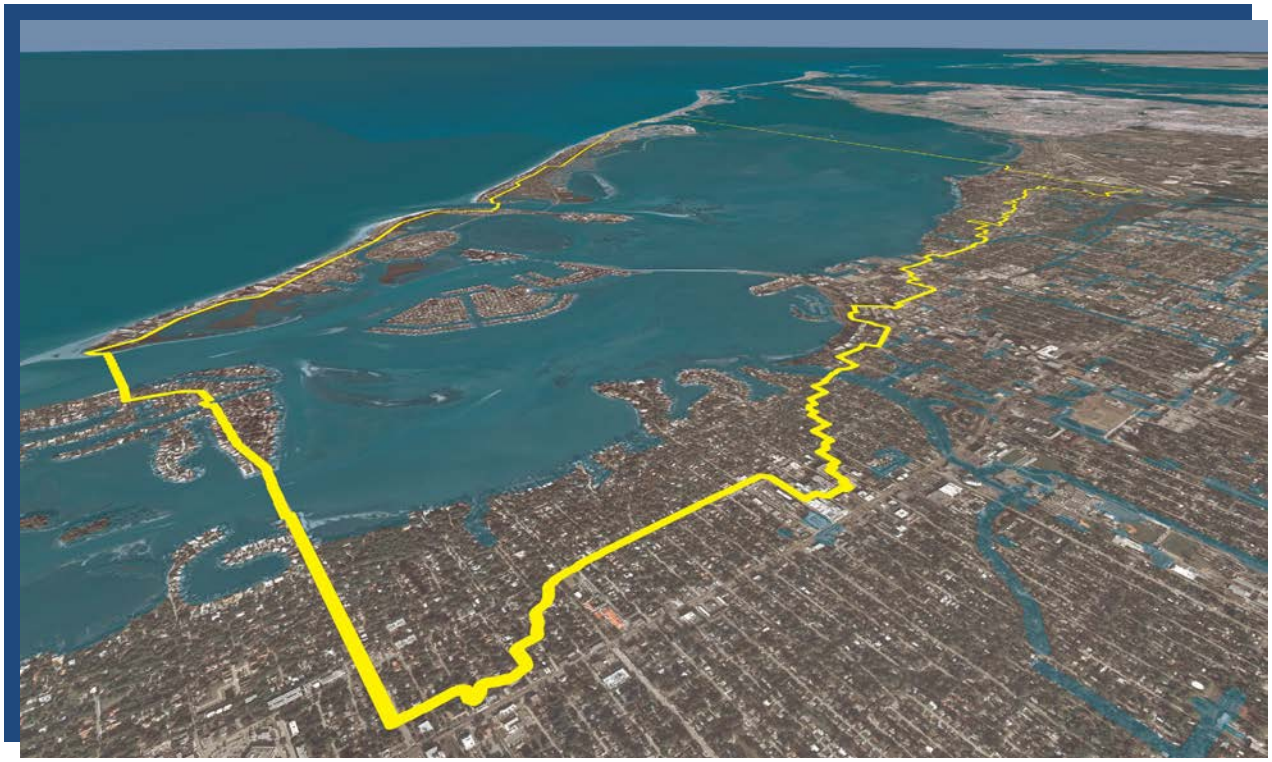
In addition to the 28 projects identified above, 26 programs were also recommended as part of this WQMP. The recommended programs are centered on sustainability and conservation in Sarasota Bay and throughout Sarasota County (Table 3-5). Some have direct nutrient-reduction impacts, while others have less quantifiable impacts but are important to improving environmental quality throughout the County. See Appendix G – Section 5 for more information on recommended programs.

Table 3-5 Program Recommendations

Section	Program Name	Existing County Program
5.1	Stormwater Harvesting	
5.2	Rainwater Harvesting/Cisterns	Yes
5.3	Fertilizer Ordinance	Yes
5.4	Watercourse Setback	Yes
5.5	Septic Tank Pump-Out Regulation	Yes
5.6	Public Outreach and Education	Yes
5.7	Teacher Training/Campus Projects	
5.8	Aquatic Harvester	
5.9	Street Sweeping	Yes
5.10	National Pollutant Discharge Elimination System (NPDES)	Yes
5.11	Facilitating Agricultural Resource Management Systems	
5.12	Preservation Areas	Yes
5.13	Mangrove Monitoring	Yes
5.14	Shoreline Softening	
5.15	Septic Replacement Program	Yes
5.16	Septic to Cistern	Yes
5.17	Strategic Maintenance Manual	Yes
5.18	Stormwater Manual	Yes
5.19	Composting Pilot Study	
5.20	Low-Impact Development (LID)	Yes
5.21	Exotic Plants Management Program	Yes
5.22	Boat Ramp BMP Program	
5.23	Irrigation Utilities for New Development	Yes
5.24	Public Education on Water Conservation Practices	Yes
5.25	Potable Water Demand-Side Management Analysis	
5.26	Florida Water Star^{SM}	Yes

4.0 SARASOTA BAY BASINS

4.1 SARASOTA BAY COASTAL



4.1.1 Characterization and Physical Setting

The portion of the Sarasota Bay Coastal (SBC) Basin within the County covers 3,543 acres and consists of the barrier islands and coastal mainland that drain directly to the bay. Historically, this basin was a system of many barrier islands and mangrove islands separated by two passes connecting Sarasota Bay to the Gulf of Mexico; however, drastic changes have occurred in this basin since that time (Figure 4-1).

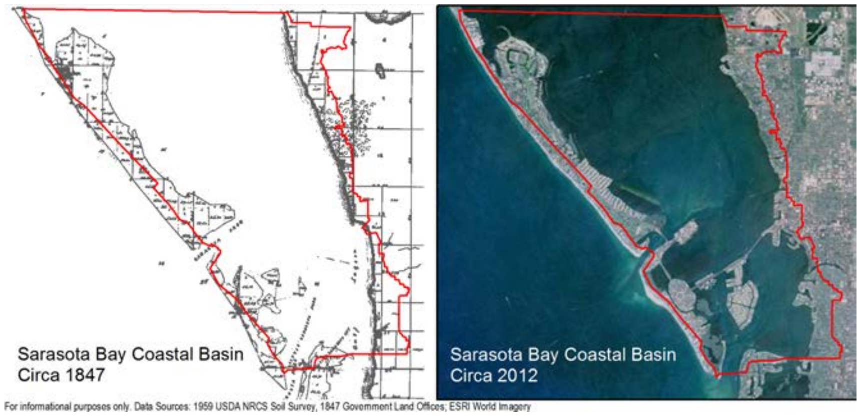


Figure 4-1 Sarasota Bay Coastal Bay Area Survey circa 1847 vs. Sarasota Bay Costal Aerial circa 2012

In 1890, the U.S. Army Corps of Engineers began dredging what would eventually become the ICW, which spurred development in the area. Shallow parts of the estuary were dredged and deposited to enlarge existing islands or create new ones. In the early 1900s, Lido Key was created from a collection of smaller islands. Shortly after, a bridge connecting the mainland to the islands was constructed. By the mid-1900s most of the coastal mainland had been developed and barrier islands had been enlarged and platted for development. In the late 1950s, the estuary around Bird Key was dredged and filled to create a subdivision more than ten times the size of the original island. Today the coast and barrier islands are highly urbanized with older neighborhoods that provide only minimal, if any, stormwater retention or treatment (Table 4-1). Therefore, untreated runoff contributes sediment and pollutants from the area to Sarasota Bay.

Table 4-1 Sarasota Bay Coastal Basin Current Land Use (SWFWMD 2008)

Land Use	Sarasota Bay Coastal	
	Acres	Percent
Medium- Density Residential	1,619	46%
Commercial	458	13%
High-Density Residential	436	12%
Golf Course	317	9%
Forest, Open Area, and Park	284	8%
Wetlands	218	6%
Transportation/ Utilities	148	4%
Low-Density Residential	63	2%
Agriculture	0	0%
Pasture	0	0%
Row Crops	0	0%
Light Industrial	0	0%
Total	3,543	100%

4.1.2 Water Quantity

4.1.2.1 Water Budget

Freshwater inflows from individual basins within the Sarasota Bay Watershed were examined in the same manner as the watershed as a whole to evaluate spatially-specific issues. Current conditions were compared to historical conditions to help understand how watershed-based activities have altered freshwater inflows to the bay from the basins over time. Current and future conditions were also compared to help identify any potential problems that may arise in coming years. Using a basin-specific approach also helps identify potential projects to address anticipated future problems.

The water budget examined freshwater inputs to the bay from the SBC Basin. For this WQMP, the SBC Basin is referred to as the SBC-South Basin, which includes the portion of the coastal basin within Sarasota County. The SBC-North Basin includes lands outside the County, as shown in Table 3-2 in Section 3.2.3.1.

Historical, current, and future freshwater inflows to Sarasota Bay from the SBC-South Basin were estimated using the methods summarized above and detailed in Appendix B. Selected results are presented below. The analyses of these data included examining and comparing the spatial and temporal variation in freshwater inputs to Sarasota Bay for historical, current, future inflows.

Rainfall patterns are shown and discussed in Section 3.2.3.1 above. Annual precipitation ranges from 43.5 to 54.3 inches per year between 1989 and 2008, with less rainfall occurring closer to the coast.

Total annual freshwater inflows to the bay from SBC-South Basin for historical, current, and future conditions were compared. Current rainfall was used to develop inflow estimates for all scenarios. Inflows for the current period were almost 49% higher than for the historical period, a result of higher runoff and baseflow (Figure 4-2). Freshwater inflows from baseflow and direct runoff all increase significantly under current conditions, based on SIMPLE model results. The most likely explanation for the higher runoff and baseflow is that urbanization is accompanied by a reduction in wetlands and natural vegetation with a subsequent lowering of evaporation and ET rates and loss of on-site storage. Surface water that once was returned to the atmosphere now flows directly to the bay or infiltrates the remaining soil, where some of the water becomes baseflow. Increases in impervious surfaces associated with urbanization (e.g., parking lots, roofs) also allow more surface water to reach the bay as runoff.

Inflows for the future scenario were virtually unchanged from the current period (5% higher). As with the watershed as a whole, existing urban conditions preclude significant future land use.

Seasonal patterns of freshwater inflows for historical, current, and future conditions were also compared. The seasonal patterns remain very similar (Figure 4-3). This demonstrates that, land use changes may alter the volume but not the timing of freshwater inflows to the bay.

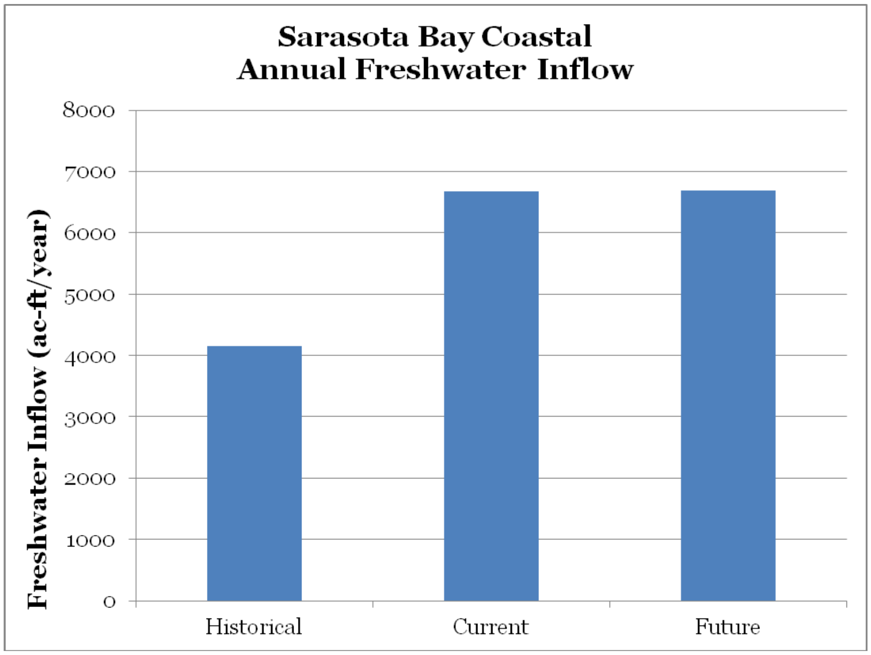


Figure 4-2 Mean Annual Total Freshwater Inflow to Sarasota Bay from the Sarasota Bay Coastal South Basin for Historical, Current, and Future Conditions

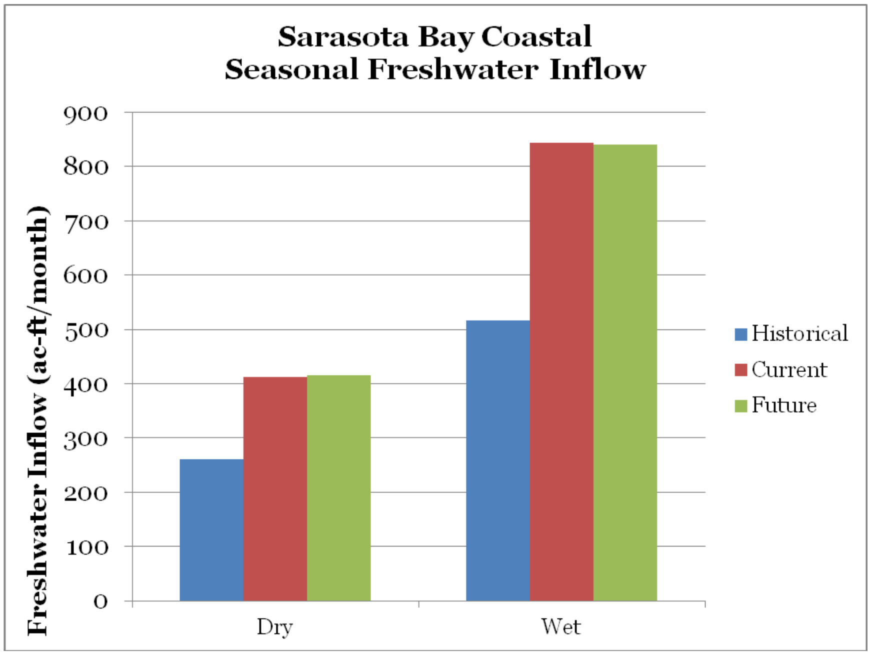


Figure 4-3 Seasonal Variability in Total Freshwater Inflows to Sarasota Bay from the Sarasota Bay Coastal South Basin for Historical, Current, and Future Conditions

Although the magnitudes of inflows from individual sources in SBC-South have changed, their relative contributions have not. Atmospheric deposition includes only rainfall to the bay, so it is not included in basin inflows. Runoff and baseflow are the most significant sources, with irrigation and septic tanks contributing small loads, with no point sources present. This condition is constant for all scenarios. Figure 4-4 compares inflow source relative contributions for the three scenarios.

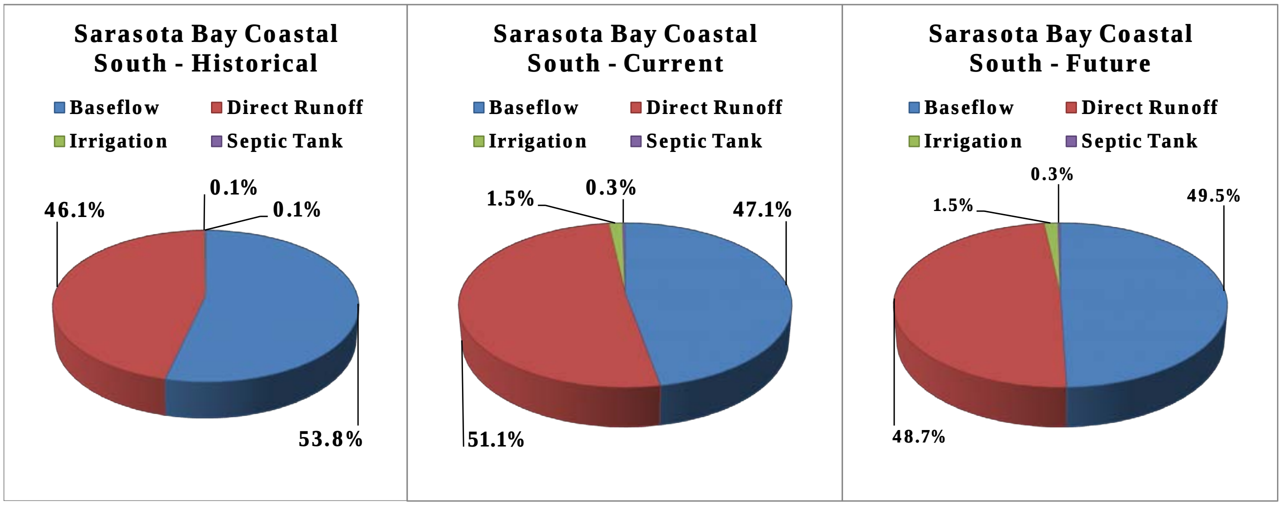


Figure 4-4 Relative Contributions of Sources of Freshwater Inflows to Sarasota Bay from the Sarasota Bay Coastal South Basin for Historical, Current, and Future Conditions.

The spatial and temporal patterns of freshwater inflows in the SBC-South Basin are very similar to those of the watershed as a whole. Total freshwater inflows from SBC-South Basin have increased from historical to current levels, but very little change exists between current and future inflows. This is a reflection of the current urban nature of the basin, which was among the earliest areas in the watershed to develop. Seasonal patterns have not changed significantly between the scenarios, indicating that changes in land use do not alter the seasonal pattern of inflows to the bay. Additionally, while the magnitudes of inflows from individual sources have changed between scenarios, their relative contributions have not. Because future freshwater inflows are anticipated to very much resemble current inflows, no adverse effects due to changes to inflows in the future are expected.

4.1.3 Water Quality

The SBC Basin comprises land along the east coast of Sarasota Bay that is not within a tributary basin. The area is generally defined as the extent of land with surface water runoff entering the bay directly, not through a stream network. However, named tributaries (Whitaker Bayou, Hudson Bayou, Bowlees Creek, and Cedar Hammock Creek) all pass through the SBC as the streams approach the coast. Figure 3-4 illustrates that the most downstream portions of the tributary basins are contained within the SBC Basin.

Approximately half of the Sarasota Bay Watershed is located north of the County boundary with Manatee County. For this WQMP, the SBC Basin has been subdivided into two portions: SBC-South, which includes the basin area in Sarasota County, and SBC-North, which includes lands outside the County. To assess Sarasota Bay as a whole, the entire watershed was evaluated for hydrologic and pollutant loadings; however, all management options address only areas within Sarasota County.

4.1.3.1 Tributary Water Quality Status and Trends

No water quality sampling sites are within the SBC-South Basin; thus, conditions of runoff and baseflow originating in the SBC Basins cannot be quantified using existing data.

However, the basin contains some of the most densely developed land in the watershed, so runoff likely has characteristics of other urban areas with higher TN, TP, and TSS concentrations than less intensively developed land. Also, the high percentage of impervious surface (e.g., paving, roofs) will create higher rates of runoff than areas with porous soils and lawns.

4.1.3.2 Hydrologic and Pollutant Loading

Hydrologic and pollutant loads for current and future conditions were estimated for the SBC-South Basin as part of the SIMPLE modeling discussed above. Figure 4-5 compares TN loads for the two scenarios by source. Because atmospheric deposition includes only loadings falling onto the open water estuary, that source is not included in the basin loading.

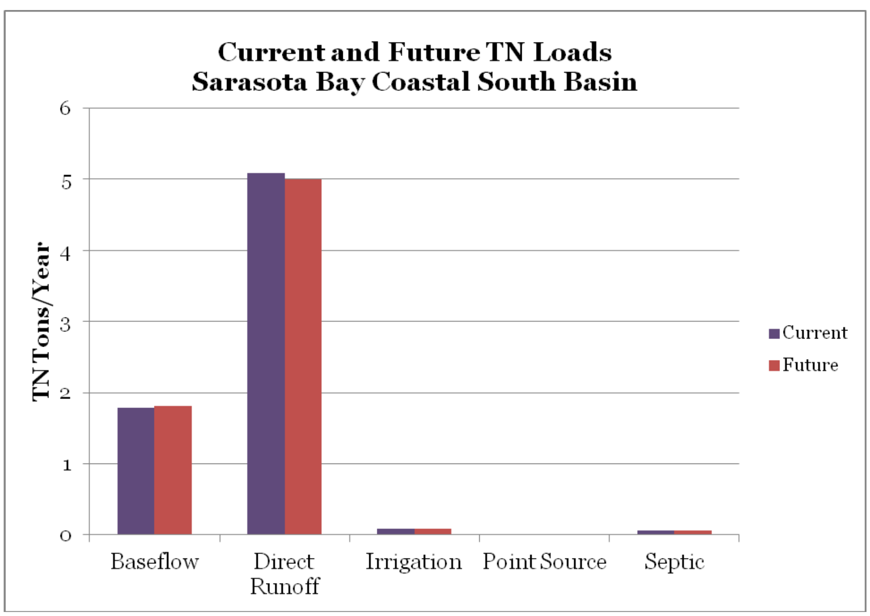


Figure 4-5 Comparison of Current and Future TN Loadings from Sarasota Bay Coastal South Basin

The SBC Basin has one of the highest TN, TP, and TSS loading rates of any basin in the watershed (Figure 4-6). The SBC-North Basin also has among the lowest unit area loads (UAL) of any basin, mainly a result of the lower extent of urbanization in the north. The UAL is the watershed load (direct runoff + baseflow) divided by the basin area. This normalization allows loading rates from basins of different sizes to be compared. The SBC-South Basin has a higher UAL than SBC-North, reflecting its higher level of urbanization. UALs for basins are compared in Appendix C, Section 4.4.1.3.C, Figure 4-21.

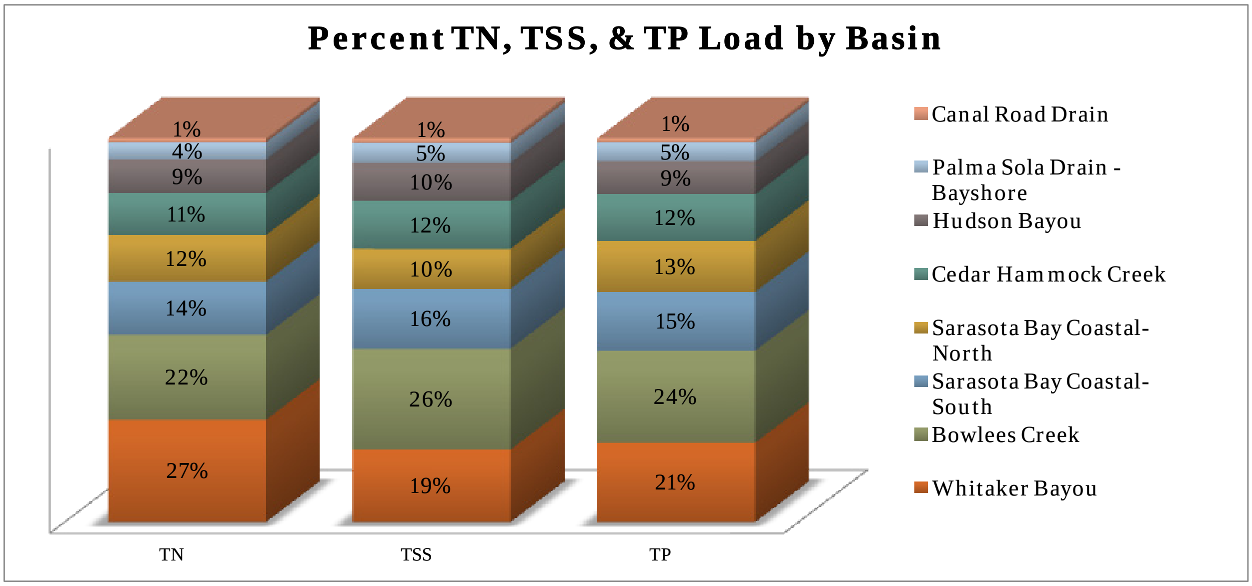


Figure 4-6 Basin Load Comparison

Baseflow and direct runoff are the dominant sources of loadings from the basin. Less than 1% difference exists in current and future loadings in SBC-South, as the basin is already highly urbanized with little opportunity for additional urbanization in the future.

4.1.3.3 Comparison of Ambient Water Quality to Regulatory Criteria and Management Levels of Service (LOS)

Setting resource protection LOS is one of the most important elements of an effective watershed management plan. An overall approach for protecting Sarasota Bay's resources has recently been established through the work of SBEP, SWFWMD, Sarasota County, other local governments, FDEP, and other interested parties.

- FDEP Freshwater Numeric Nutrient Criteria (NNC)—No water quality sampling sites are in this basin; thus, this LOS is not applicable here.

- FDEP Current and Proposed DO Standards—Because no water quality sampling locations are within the SBC-South Basin, this LOS is not applicable.
- Some areas of the SBC-South Basin are included in impaired water bodies under the State's IWR (Chapter 62-303, FAC). The FDEP TMDL program is discussed in Section 3.3. Portions of the SBC-South Basin are contained in WBIDs for Hudson Bayou (WBID 1953) and (Whitaker Bayou (WBID 1936) and in the SBC-North Basin for West Cedar Hammock Creek (WBID 1885). These waterbodies are all deemed impaired for DO, nutrients, or both and are discussed by basin below.
- Basin Loadings—Annual TN, TP, and TSS loadings from the SBC-South Basin for 1989 through 2008 were developed as part of the SIMPLE modeling. Figure 4-7 compares the TN loadings to LOS management targets and thresholds that have been developed for this WQMP. The SBC-South Basin loading target (8.4 tons/year) is the average of annual loads for 2001 through 2005. This is consistent with reference period approach used to develop chlorophyll targets. A higher threshold (10.5 tons/year) was also determined to allow for variability within the system. Loads were higher than the threshold during 1 year (1995) and were higher than the target during 5 years. To not meet the LOS, the annual load must be higher than the threshold for 2 years of a 3-consecutive-year period; thus, the LOS was met during this period.

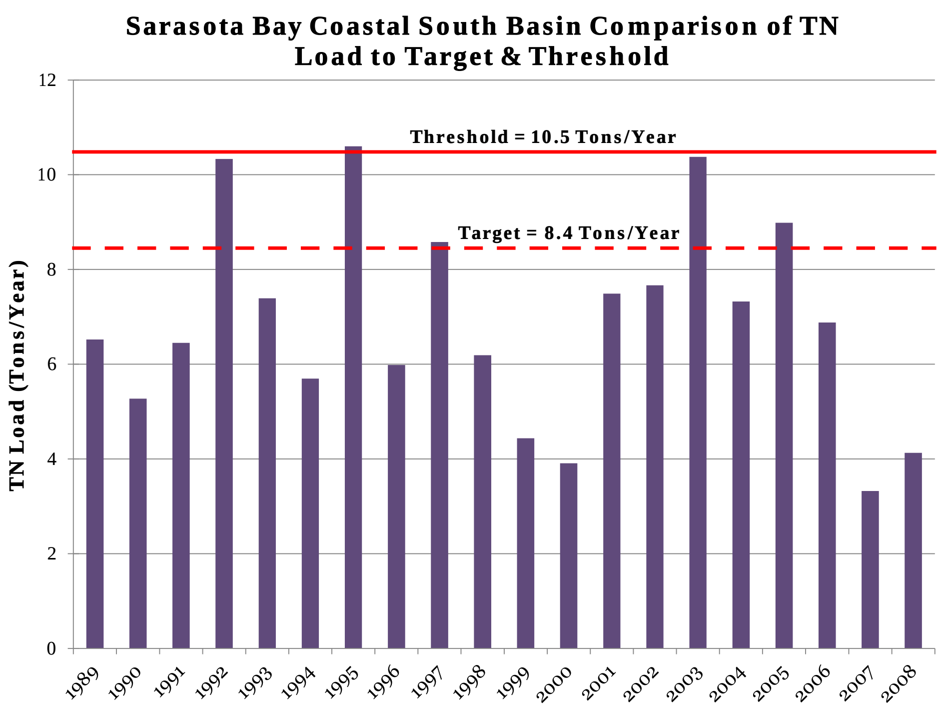


Figure 4-7 Comparison of Annual TN Loads to Target and Threshold –Sarasota Bay Coastal South Basin

Two water quality projects (Figure 4-8) identified in this basin could reduce TN by approximately 400 pounds per year. Project WQ2-Bayfront Parking Lot is located in the parking lot along Bayfront Drive near Ringling Boulevard. There have been reports of trash and debris entering the bay from this site. This site is also located downstream of areas with high TN, TP, and TSS. Installing the recommended LID components and baffle boxes will reduce pollutants entering the bay; specifically, TN could be reduced by over 200 pounds per year. Project WQ7-10th Street Outfall is adjacent to Sarasota Bay and Tamiami Trail at the west end of 10th Street. This area draining to this site has high TN, TP, TSS, and BOD. A large culvert discharges untreated runoff directly to the bay, and the basin typically acts as a settling basin for sediments and has many floatables after storm events. Installing the recommended LID components and sediment box upstream has the potential to reduce TN by almost 200 pounds/year, and proper maintenance of the sediment box will reduce the amount of floatables and settling occurring in the basin.

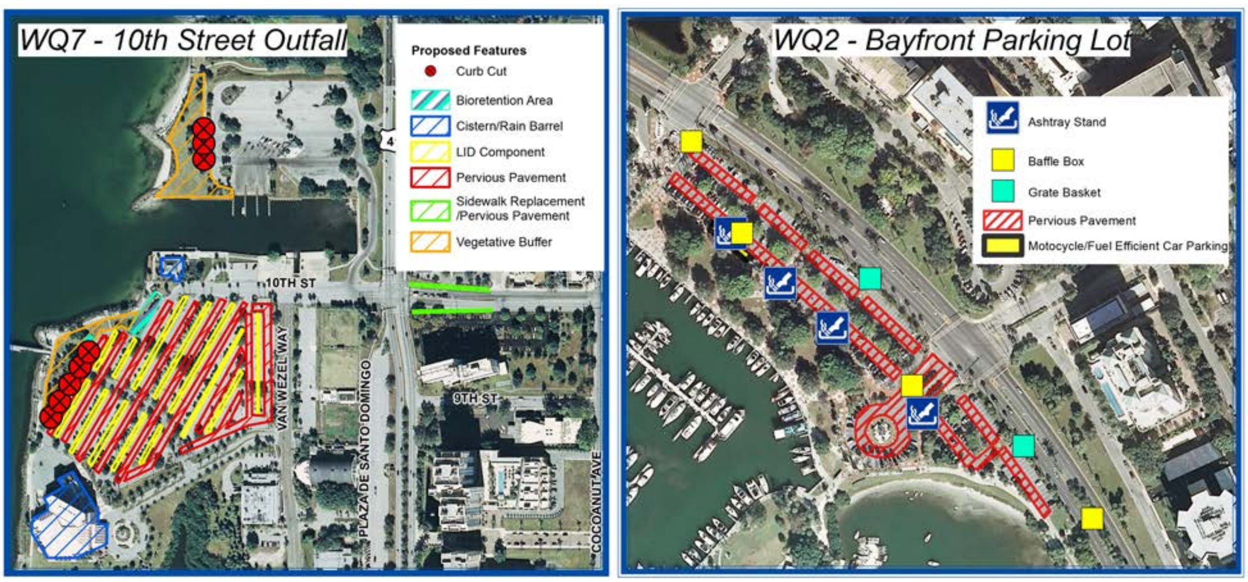


Figure 4-8 Sarasota Bay Coastal Basin Water Quality Projects

4.1.4 Natural Systems

The SBC Basin is highly urbanized and less than 8% of the basin is composed of undeveloped uplands, much of which is public parks. As a result, very little natural habitat exists for wildlife in this basin. Additionally, approximately 6% of the basin is comprised of wetlands, most of which is mangroves. While upland natural systems are very rare in SBC Basin, mangroves and seagrass provide invaluable ecosystems services to the coastal areas. These estuarine systems are summarized in Section 3.4.1 and freshwater natural systems for the watershed are summarized in Section 3.4.2.

Two natural system improvement projects were identified within SBC Basin: Longboat Key Bayfront Park and Bayfront Park and Marina North. These projects propose creating a living shoreline, wetland buffer enhancement, and wetland creation to provide water quality improvement, wildlife habitat, and shoreline protection as well as provide educational features due to the high public use of these parks. The natural system improvement projects are presented in detail in Appendix D, and conceptual plans and cost estimates are provided in Appendix G.

Bayfront Park Shoreline: Left: Red Mangroves Dominate Shoreline near County Restroom, Right: Rock Armor along East Shoreline

4.1.5 Flood Protection

The SBC Basin is subject to rainfall-induced and tidal flooding. The County is developing a detailed flood model for the coastal regions. The County and SWFWMD have partnered on the Coastal Fringe Watershed Management Plan to develop 100-year floodplains and identify areas not meeting the FPLOS and recommended projects to alleviate flooding.

4.1.6 Sediment Management

Much of the SBC Basin, which includes the barrier islands and coastal mainland, was developed before stormwater regulations were implemented, making these developed areas likely contributors of sediment directly to the bay.

Several areas in this basin were evaluated for potential sediment management projects because they exhibited elevated TSS levels and/or visual erosion or debris or sediment build-up. Three sediment management projects are recommended in the SBC Basin (see Section 4.1.7.1 and Figure 4-9 and Figure 4-10). In addition to implementing the recommended projects, general sediment management measures throughout the basin are recommended to minimize the amount of sediment, debris, and pollutants reaching the bay. Source control activities such as LID development projects, street sweeping, and construction-area silt fencing should be implemented.

Additionally, maintenance activities including cleaning out baffle boxes, removing vegetation debris resulting from maintenance activities from swales and roadside ditches, replacing or repairing damaged infrastructure, and maintaining control structures and weirs should be done regularly.

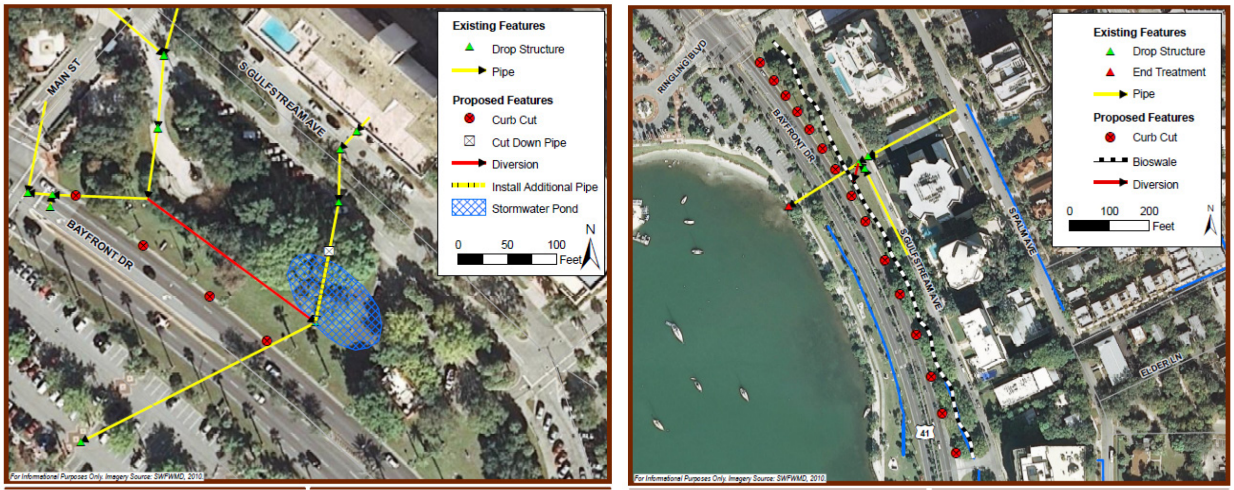


Figure 4-9 Left: SMP4 – Bayfront Park and Marina North; Right: SMP5 – Bayfront Park and Marina South

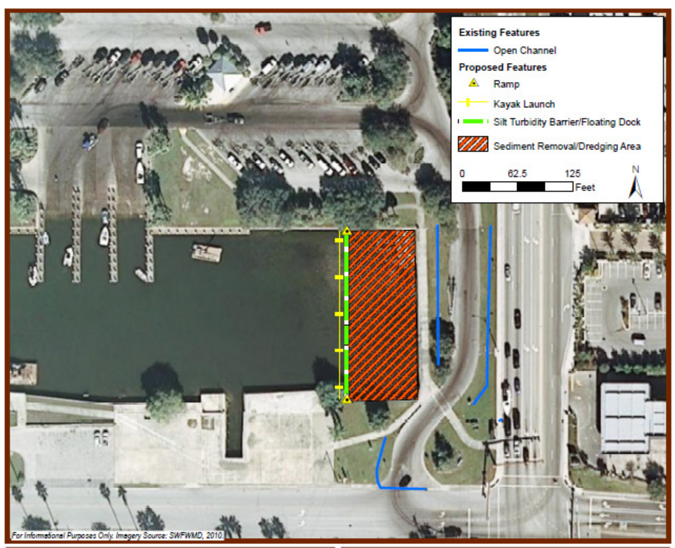


Figure 4-10 SMP8 – 10^{th} Street Boat Basin Dock

4.1.7 Sarasota Bay Coastal South Basin Summary and Recommendations

The SBC-South Basin consists mainly of medium-density residential and commercial land uses and is the most densely developed basin in the watershed. The land consists of barrier islands and coastal mainland that drain directly to the bay.

Because much of the basin was developed before stormwater management regulations, much of the runoff from the basin is untreated. Urban runoff reaching the bay can impact seagrass acreage, saltwater wetlands, fishing resources, and scallop population. Additionally, occasional closures of shellfish harvesting waters and no swim advisories for Bird Key Park occur (Sarasota County Comprehensive Plan Appendix B, page B-20).

The SBC-South Basin contains downstream reaches of Hudson Bayou which has been deemed impaired for TN and Whitaker Bayou which has been deemed impaired for TN and DO by FDEP through the TMDL program. Despite this, the basin meets management LOS for TN and TP concentrations and targets and helps support desirable levels of seagrass in the bay.

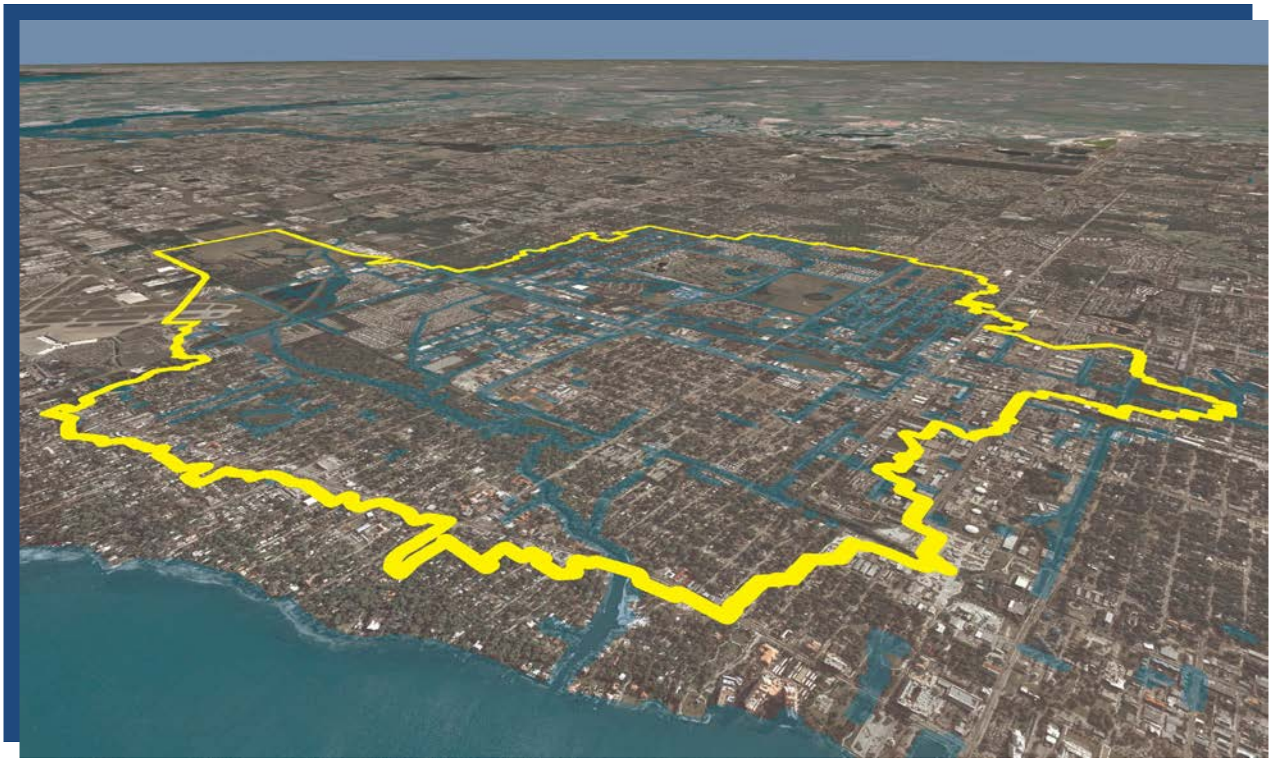
The SBC Basin has among the highest total TN, TP, and TSS loading rates of any basin in the watershed. Baseflow and direct runoff are the dominant sources of loadings from the basin. However, the basin is already highly urbanized with limited opportunity for additional development in the future, which reduces the chances of increased pollutant loading levels due to increased urbanization. The high level of urbanization also limits space available to implement traditional surface water quality treatment facilities. Sarasota County should look for opportunities to work with Manatee County through SBEP or other facilitators if water quality problems arise.

4.1.7.1 Project Recommendations

If implemented, nine projects recommended in the SBC Basin could reduce TN by approximately 490 pounds per year and prevent or remove approximately 2,900 cubic yards of sediment and 7 acre-feet of direct runoff from reaching the bay, in addition to providing habitat improvements worth 0.2 UMAM credits. Living shorelines and vegetated buffers will also help reduce runoff, thereby reducing the amount of pollutants reaching the waterbodies. The County should work with property owners to properly maintain mangroves and implement a 50-foot watercourse setback. Sarasota County should also look for opportunities to work with Manatee County through the SBEP or other facilitator if water quality problems arise.

		Flood Protection	Water Quality		Natur al Syste		Water Supply					
Project ID	Project Name	County Flood Control Benefits	Cubic Yards of Erosion Prevention and Sediment Control	Annual Pounds of Total Nitrogen Removal	UMAM Mitigation Bank Credits of Herbaceous Wetlands	UMAM Mitigation Bank Credits of Forested Wetlands	Annual Acre-feet of Beneficially Used Harvested Water	Estimated Value of Major Benefits	Opinion of Probable Cost	Present Value of O & M	Present Value of Costs	Benefits / Costs
NS2	Bayfront Park Shore	0	2270	0	0.04	0	0	$95,000	$20,055	$4,962	$25,017	3.80
WQ2	Bayfront Parking Lot	0	0	217	0	0	0	$1,041,600	$938,500	$63,164	$1,001,664	1.04
SMP5	Bayfront Park and Marina South	0	0	31	0	0	0	$148,800	$137,500	$7,047	$144,547	1.03
WQ7	10th St Outfall	0	0	192	0	0	0	$921,600	$1,362,400	$90,059	$1,452,459	0.63
WS02	Bay Haven Elementary School	0	0	4	0	0	3	$55,329	$80,800	$7,047	$87,847	0.63
NS3	Longboat Key Bayfront Park	0	0	17	0.18	0	0	$100,500	$101,621	$73,339	$174,960	0.57
SMP4	Bayfront Park and Marina North	0	0	14	0	0	0	$67,200	$124,000	$46,444	$170,444	0.39
WS06	Ken Thompson Park Preserve	0	0	11	0	0	4	$100,972	$884,900	$37,384	$922,284	0.11
SMP8*	10th St Boat Basin Dock	0	630	0	0	0	0	$25,200	$476,400	$46,005	$522,405	0.05
	Sarasota Bay Coastal Basin Total	0	2900	486	0.22	0	7	$13,630,103	$13,396,852	$1,185,471	$14,582,323	---

4.2 WHITAKER BAYOU



4.2.1 Characterization and Physical Setting

The Whitaker Bayou Basin covers approximately 4,667 acres. Its surface water system has undergone significant alterations over the past century. Historical data indicate that Whitaker Bayou only extended about a quarter of a mile inland. Moderately drained soils associated with scrubby flatwoods were at the historical extent of the bayou (Figure 4-11). A second waterway in the basin extended northeast from the flatwoods toward a poorly drained hammock soil, typically found adjacent to ponded areas or sloughs. Infiltration is affected by the seasonal fluctuation of the water table; therefore, these systems could have been joined during the wet season.

By the mid-1900s Whitaker Bayou extended beyond its historical extent, possibly to include the second waterway. Today the bayou continues inland, branching off into several smaller waterways such as canals and ditches that extend several miles throughout the watershed. The drainage basin originates just north of the Manatee-Sarasota County boundary, and runoff flows from the upper reaches generally southward across the watershed terrain through ditches, storm drains, and canals and eventually into Whitaker Bayou.

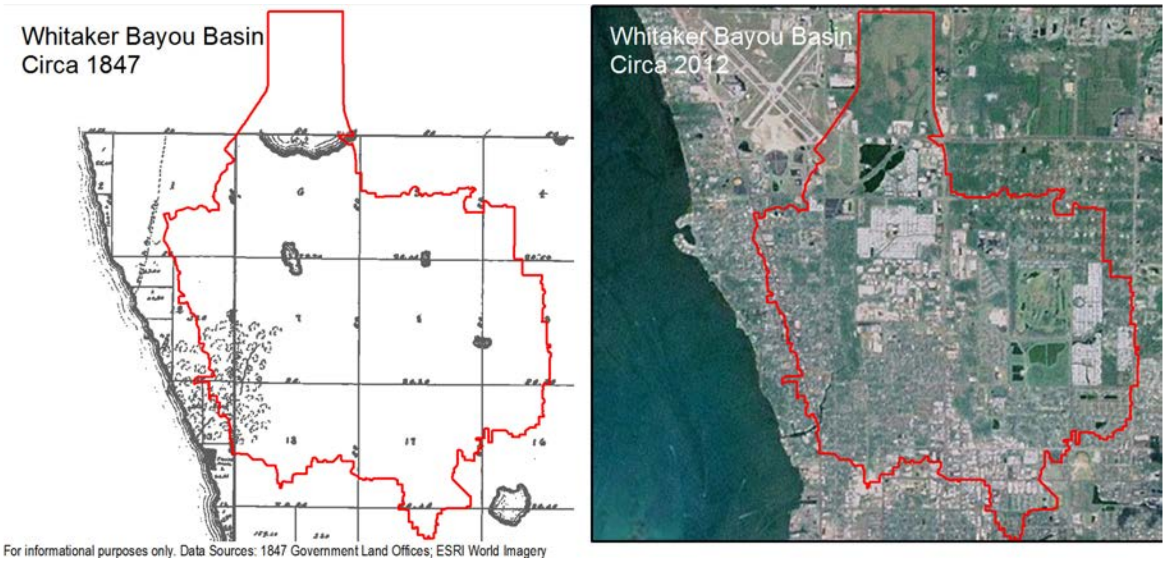


Figure 4-11 Whitaker Bayou Basin Survey Circa 1847 vs 2012

The Whitaker Bayou Basin has been significantly altered by development. Natural banks have been hardened with sea walls and additional canals dredged to accommodate waterfront living and boating (Figure 4-12). The bayou drains the highly urbanized basin (Table 4-2), consisting primarily of older development that provides only minimal stormwater retention or detention, including part of the City of Sarasota. The untreated runoff contributes sediment and pollutants to Whitaker Bayou.

Figure 4-12 Whitaker Bayou circa 1910 (Credit: Sarasota Historical Society) vs Whitaker Bayou circa 2004 (Credit: R T Clapp, Sarasota County Water Atlas)

Whitaker Bayou also receives effluent from the City of Sarasota's advanced wastewater treatment facility, but the discharge from the treatment facility has been demonstrated to have minimal negative impact on the receiving waterbody and has met antidegradation standards as defined in the Florida Administrative Code. In August 2011, the City started construction on a deep well injection system to remove this discharge from entering the bayou. Nonetheless, problems such as sedimentation, erosion, oxygen depletion, habitat alteration, and hardened shorelines have occurred in the Whitaker Bayou Basin (Sarasota County Comprehensive Plan Appendix B, page B-20).

Table 4-2 Whitaker Bayou Basin Current Land Use (SWFWMD 2008)

Land Use	Whitaker Bayou	
	Acres	Percent
Medium- Density Residential	1,227	26%
Light Industrial	673	14%
High-Density Residential	651	14%
Forest, Open Area, and Park	423	9%
Commercial	409	9%
Low-Density Residential	349	7%
Transportation/ Utilities	338	7%
Wetlands	184	4%
Pasture	181	4%
Golf Course	127	3%
Water	103	2%
Agriculture	1	<1%
Row Crops	0	0%
Total	4,666	100%

For more information on the watershed attributes, such as land use, topography, and geology, see Section 3 of Appendix A. Information on the public lands, recreational facilities, and threatened and endangered species within the watershed can be found in Sections 5 through 7 of Appendix A.

4.2.2 Water Quantity

4.2.2.1 Water Budget

Freshwater inflows from individual basins within the Sarasota Bay Watershed were examined in the same manner as the watershed as a whole to evaluate spatially-specific issues. Current conditions were compared to historical conditions to help understand how watershed-based activities have altered freshwater inflows to the bay from the basins over time. Current and future conditions were also compared to help identify any potential problems that may arise in coming years. Using a basin-specific approach also helps identify potential projects to address anticipated future problems.

Historical, current, and future freshwater inflows from the Whitaker Bayou Basin to Sarasota Bay were estimated using the methods summarized above and detailed in Appendix B. Selected results are presented below. The analyses of these data included examining and comparing the spatial and temporal variation in freshwater inputs to Sarasota Bay originating from the Whitaker Bayou Basin. Spatial, annual, and seasonal variations in rainfall are described, followed by comparisons of historical and current inputs, and current and future flows.

Rainfall patterns are shown and discussed in Section 3.2.3.1. Annual precipitation ranges from 43.5 to 54.3 inches per year between 1989 and 2008, with less rainfall occurring closer to the coast.

Total annual freshwater inflows to the bay from Whitaker Bayou Basin for historical, current, and future conditions were compared. Current rainfall was used to develop inflow estimates for all scenarios. Inflows for the current period were more than double those for the historical period, a result of higher runoff and baseflow based on SIMPLE model results, and discharges from the City of Sarasota's wastewater treatment plant (Figure 4-13). The most likely explanation for higher baseflow and runoff is that urbanization is accompanied by a reduction in wetlands and natural vegetation with a subsequent lowering of evaporation and ET rates and reduction in on-site storage. Surface water that once was returned to the atmosphere now either flows directly to the bay or infiltrates the remaining soil, where some of the water becomes baseflow. Also, increases in impervious surfaces associated with development (e.g., parking lots, roofs) allow more surface water to reach the bay as runoff.

Inflows for the future scenario were approximately 30% lower than for the current period. Anticipated reductions in discharges from the City of Sarasota wastewater treatment plant more than offset small increases in baseflow and runoff.

Seasonal patterns of freshwater inflows for historical, current, and future conditions were also compared. The seasonal patterns remain very similar (Figure 4-14). This demonstrates that, especially for the historical and current conditions, land use changes may alter the volume but not the relative monthly pattern of freshwater inflows to the bay.

Although the magnitudes of inflows from individual sources in Whitaker Bayou have changed, their relative contributions have not. Atmospheric deposition includes only rainfall to the bay, so it is not included in basin inflows. Runoff and baseflow are the most significant sources, with irrigation and septic tanks contributing small loads. Point-source loads were the third largest inflow source during the current period, but were not present during the historical or future period. Figure 4-15 compares inflow source relative contributions for the three scenarios.

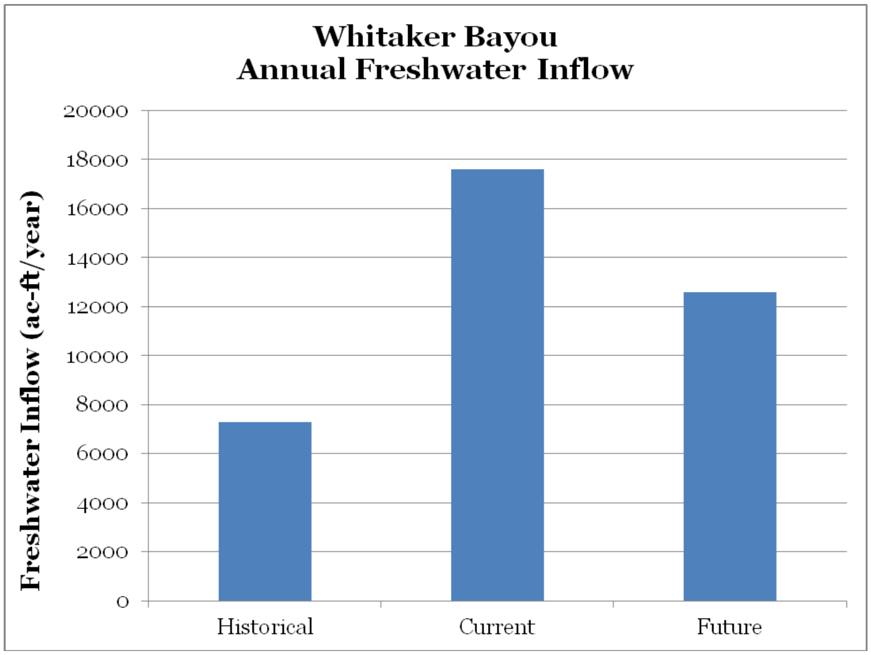


Figure 4-13 Mean Annual Total Freshwater Inflow to Sarasota Bay from the Whitaker Bayou Basin for Historical, Current, and Future Conditions

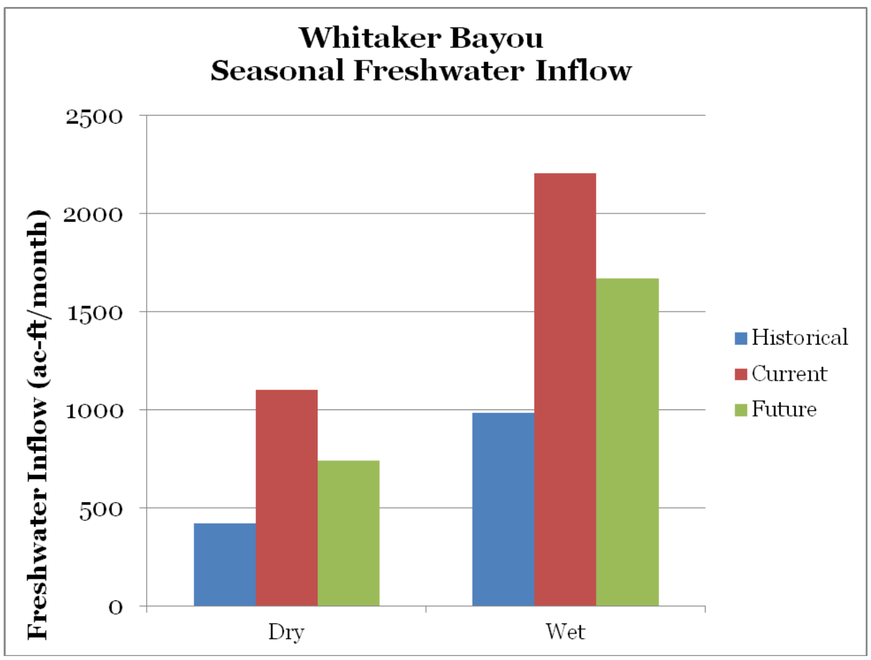


Figure 4-14 Seasonal Variability in Total Freshwater Inflows to Sarasota Bay from Whitaker Bayou for Historical, Current and Future Conditions

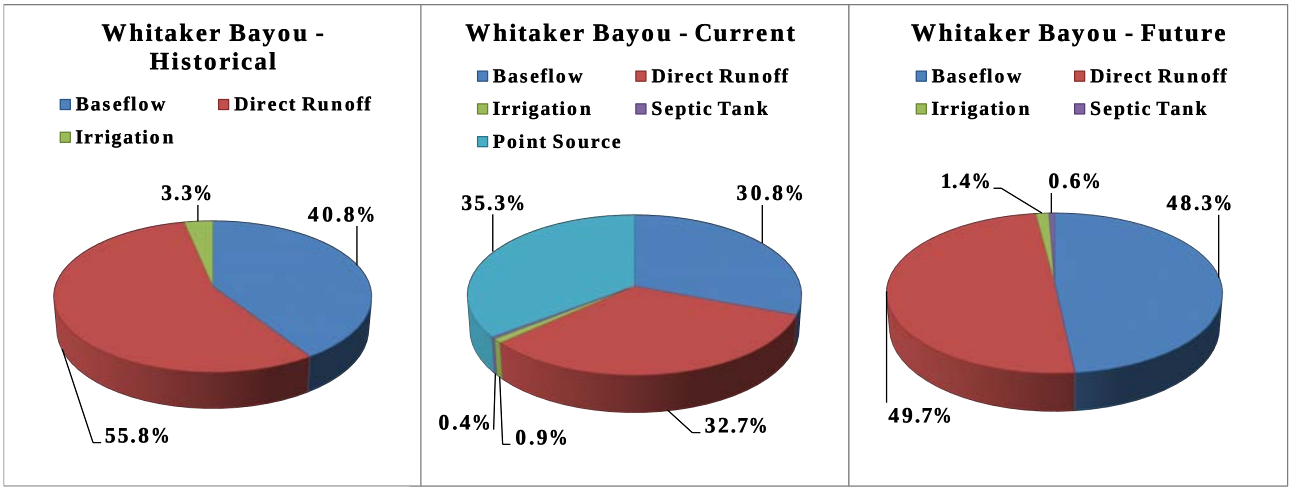


Figure 4-15 Relative Contributions of Sources of Freshwater Inflows to Sarasota Bay from Whitaker Bayou Basin for Historical, Current, and Future Conditions

The spatial and temporal patterns of freshwater inflows in the Whitaker Bayou Basin are less similar to those of the watershed as a whole because of the large effect of the wastewater discharges under current conditions. Total freshwater inflows from Whitaker Bayou Basin have increased from historical to current levels, but, unlike other basins, a significant reduction occurs in freshwater inflows from Whitaker Bayou for future conditions because of the anticipated cessation of wastewater effluent discharges. Seasonal patterns have not changed significantly between the scenarios, indicating that changes in land use do not alter the seasonal pattern of inflows to the bay. Additionally, while the magnitudes of inflows from individual sources have changed between scenarios, their relative contributions have not, with the exception of the current conditions point source.

The results of the analysis suggest that although inflows have increased since the historical period and future freshwater inflows will likely be less than current inflows. No adverse effects due to changes to inflows in the future are expected.

Two water supply projects were recommended to reduce direct runoff to the bayou. WS2-Bay Haven Elementary School and WS06-Ken Thompson Park Preserve recommend installing rain barrels on public buildings and using captured stormwater for irrigation. They also recommend installing LID retrofits such as permeable parking pavers. If implemented, these projects can beneficially use 7 acre-feet of harvested water per year.

4.2.3 Water Quality

4.2.3.1 Tributary Water Quality Status and Trends

Whitaker Bayou has three sampling sites within the basin. A review of ambient water quality data revealed no trends in chlorophyll, TN, TP, TSS, or DO for the sampling period of 2006 through 2010. A slight increasing trend (not statistically significant) in water color was observed at the one marine sampling site.

4.2.3.2 Hydrologic and Pollutant Loading

Hydrologic and pollutant loads for current and future conditions were estimated for the Whitaker Bayou Basin as part of the SIMPLE modeling discussed in Section 3.2.2 and Appendix C, Water Quality. Figure 4-16 compares TN loads for the two scenarios by source. Because atmospheric deposition includes only loadings falling onto the open water estuary, that source is not included in the basin loading.

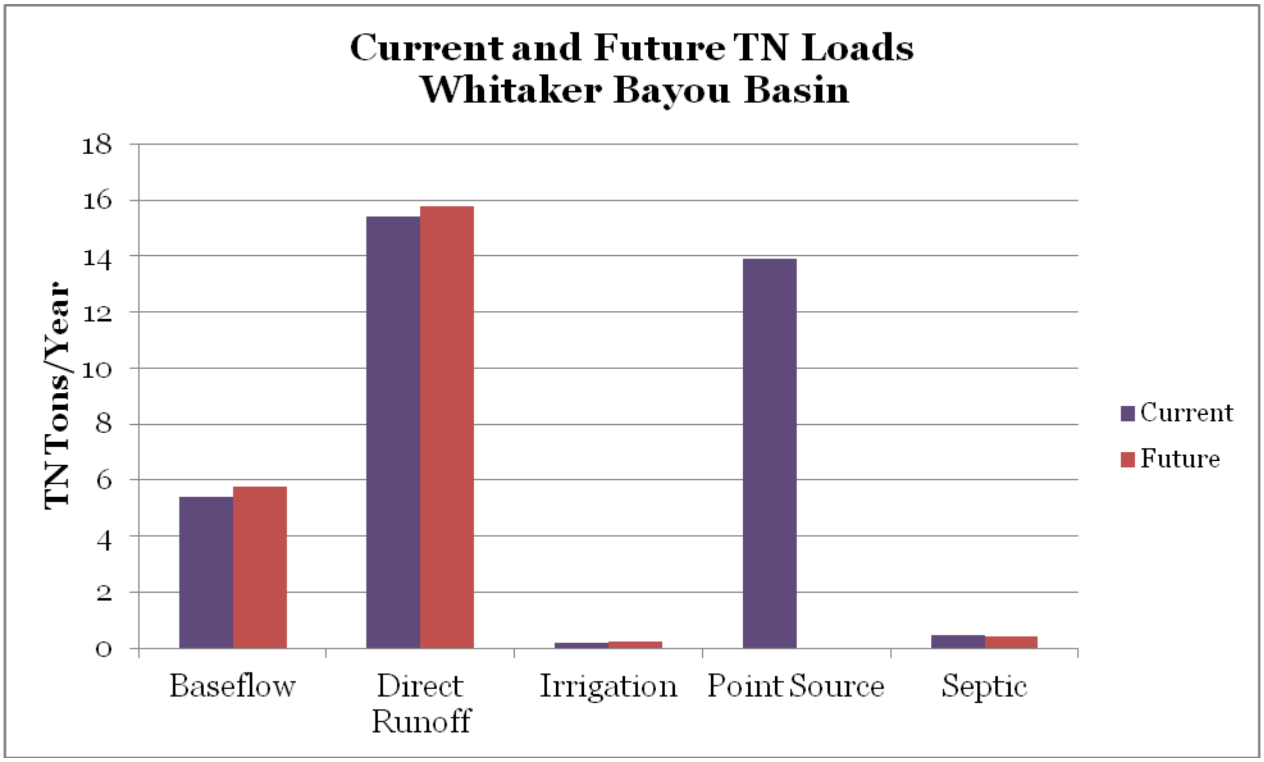


Figure 4-16 Comparison of Current and Future TN Loadings from Whitaker Bayou Basin

The basin has the highest total basin loading of any basin in the watershed for current conditions. Whitaker Bayou has the only significant point-source load in the watershed, but surface water discharges from the wastewater plant are projected to cease in the future. This will result in a reduction in future TN loadings of almost 40% from current conditions.

The Whitaker Bayou Basin has moderate UALs. The UAL is the watershed load (direct runoff + baseflow) divided by the basin area. This normalization allows loading rates from basins of different sizes to be compared. No significant difference exists in current and future baseflow and direct runoff loadings, as the basin is already highly urbanized with little opportunity for additional urbanization in the future. TN UALs for basins are compared in Appendix C, Section 4.4.3.1C, Figure 4-21.

4.2.3.3 Comparison of Ambient Water Quality to Regulatory Criteria and Management Levels of Service (LOS)

Ambient water quality was compared to several regulatory limits and management criteria to assess the ecological health of Whitaker Bayou (Table 4-3). Results of the assessments include the following:

- FDEP Freshwater NNC—Until recently Florida had only narrative water quality standards for nutrient concentrations. FDEP has adopted NNC for freshwater streams for TN and TP to provide quantifiable regulatory limits. The standards vary by bioregion, which allows the standards to reflect local conditions. Sarasota Bay is in the Peninsula bioregion, with thresholds of 1.65 mg/L for TN and 0.49 mg/L for TP. These criteria are applicable only to freshwater streams. TN and TP levels in freshwater reaches of the Whitaker Bayou Basin met the criteria in all years (2007–2010), as shown in Figure 4-17.

Table 4-3 Summary of Water Quality LOS Targets for Whitaker Bayou

Variable	Whitaker Bayou Targets	Whitaker Bayou Status
Chlorophyll *a* (µg/L)	Marine: 11	2008-exceedance
Current state DO Standards (mg/L)	Freshwater: DO > 5 Marine: DO>4	Exceeds DO criteria
FDEP Proposed DO Standards	Marine: Daily DO>41.7% 7 day > 51% 30 day > 56.5% Freshwater: DO >= 34%	Exceeds DO criteria
TN Concentration (mg/L)	0.82	Meets criterion
TN Load (tons/year)	26.4	Meets criterion
TP Concentration (mg/L)	0.27	Meets criterion
TP Load (tons/year)	2.57	Meets criterion
Impaired Water Body	Varies by Parameter	Marine portion impaired for low DO Marine portion impaired for TN

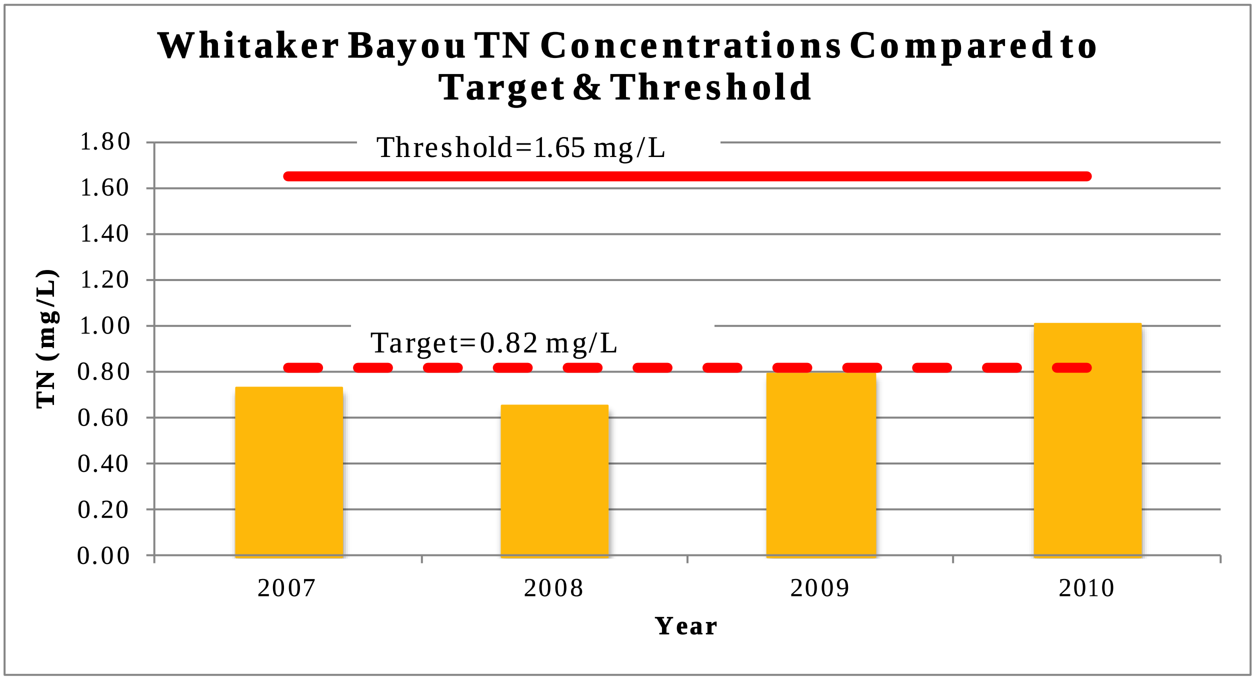


Figure 4-17 Comparison of the Freshwater TN Threshold and Target to TN Concentrations in Whitaker Bayou

- In Florida DO has traditionally been held to a standard based on concentration. The current State DO standard for freshwater requires that DO remain above 5.0 mg/L at all times, and the current minimum concentration for marine waters is 4.0 mg/L. Recognizing that the standard does not allow for variability in natural conditions based on water temperature or salinity, FDEP has proposed DO criteria based on percent saturation, which is the expected amount of DO in aquatic environments given ambient conditions.

- For predominantly marine waters (Class II and III, which includes Sarasota Bay), those standards are:

  - The daily average percent DO saturation shall not be below 41.7%.

    and

  - The 7- and 30-day average percent DO saturations shall not be below 51.0 and 56.5%, respectively.

  The proposed State DO standards for Class III freshwater is:

  - The daily average percent DO saturation shall not be below 67% in the Panhandle West bioregion or 34% in the Big Bend, Northeast, and Peninsula bioregions. (The entire Sarasota Bay system is within the Peninsula bioregion.)

Whitaker Bayou has three sampling sites in both the freshwater and marine portions of the stream. Both freshwater and marine sites met their respective current and proposed DO standards in all years with data (2003–2011).

- Impaired Water Bodies—FDEP administers the EPA's TMDL program in Florida. The TMDL program is intended to identify water bodies that are receiving a higher pollutant load than can be assimilated while maintaining the water body's designated use. If a water body does not meet State water quality standards according to the State's IWR protocol, that water body is deemed "impaired." A TMDL may result that identifies excessive pollutant loadings and sources and specifies required reductions in pollutant loads to enable the water body to meet its designated use.

The marine portion of Whitaker Bayou is identified by its WBID 1936 (Figure 4-18). The WBID was deemed impaired for DO, attributed to elevated BOD, TN, and TP concentrations, and is included on the FDEP 1998 303(D) List of Impaired Water Bodies. The marine portion of Whitaker Bayou was also identified as impaired for nutrients (TN) because of elevated chlorophyll *a* concentrations. The chlorophyll *a* threshold for marine waters is 11 µg/L. Chlorophyll *a* in samples from Whitaker Bayou exceeded that value by a factor of three in 2008, leading to the impairment determination. The WBID was also deemed impaired for fecal coliform based on exceedances of the fecal coliform standard of 400 counts/100 milliliters. These impairments, dating from over 10 years ago, are based on the application of the FDEP IWR criteria (Chapter 62-303, FAC). The bases for impairment under the IWR are different from the NNC and DO criteria discussed above.

Although Whitaker Bayou is currently classified as impaired, its status may change in the future. Water quality conditions are likely to improve after the current discharges from the City of Sarasota's wastewater treatment plant are stopped. The termination of point-source loading is expected to reduce the potential for high chlorophyll and fecal coliform bacteria in the WBID.

Figure 4-18 Impaired WBIDs within the Sarasota Bay Watershed – Whitaker Bayou (WBID 1936) and Hudson Bayou (WBID 1953)

- Basin Loadings—Annual TN, TP, and TSS loadings from the Whitaker Bayou Basin for 1989 through 2008 were developed as part of the SIMPLE modeling. Figure 4-19 compares the TN loadings to targets and thresholds that have been developed for this WQMP. The Whitaker Bayou Basin loading target (26.4 tons/year) is the average of annual loads for 2001 through 2005. This is consistent with the reference period approach used to develop chlorophyll targets (Janicki Environmental, 2010). A higher threshold (32.7 tons/year) was also determined to allow for variability within the system. Loads were below the threshold during all years and were higher than the target during 4 years. To not meet the criteria, the annual load must be higher than the threshold for 2 years of a 3-consecutive-year period; thus, the criteria was met during this period.

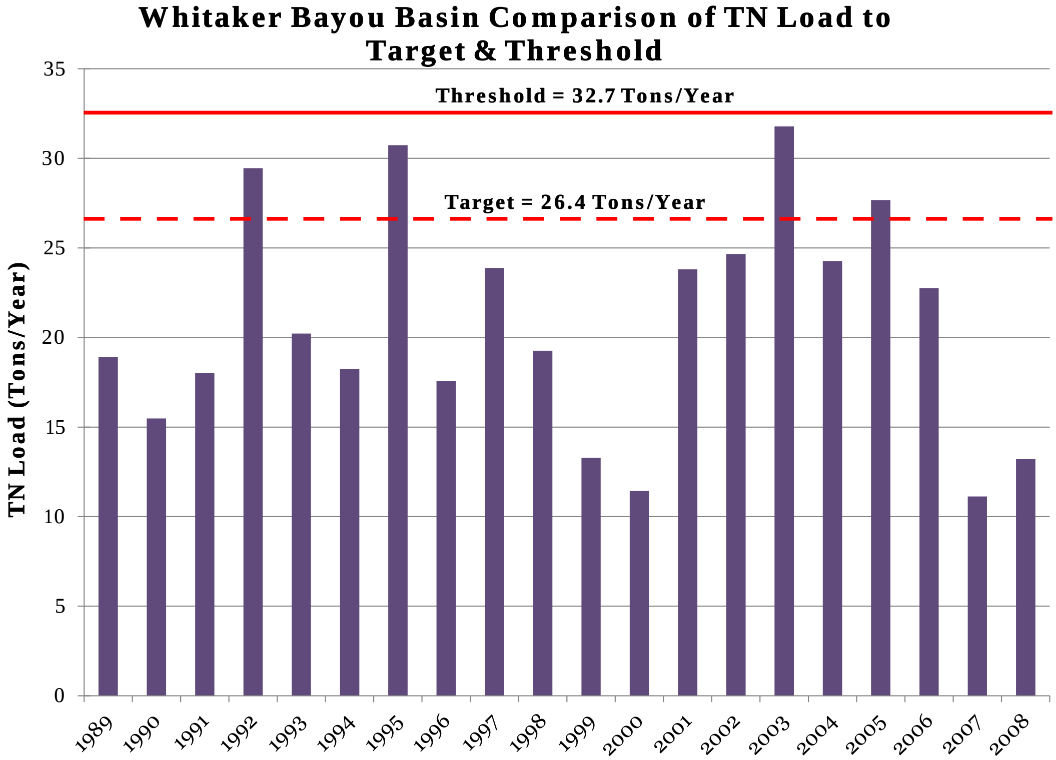


Figure 4-19 Comparison of Annual TN Loads to Target and Threshold – Whitaker Basin

Although no water quality projects were recommended in the Whitaker Bayou Basin due to limited public sites available, six projects were identified in the watershed that address habitat improvements, direct runoff reduction, and sediment and erosion control. If implemented, these projects could reduce TN to the bayou and bay by approximately 950 pounds per year and could prevent 1,400 cubic yards of sediment from reaching the waterbodies. In addition to the recommended projects, the County should look to improve existing public properties with LID retrofits such as permeable parking pavers, bioswales, and rain barrels. The County should also work with homeowners and maintenance staff to install bioswales and curb cuts in older neighborhoods where stormwater systems do not provide treatment.

4.2.4 Natural Systems

The Whitaker Bayou Basin is also a highly urbanized with only approximately 9% of the basin being comprised of undeveloped uplands. A majority of these undeveloped uplands is improved pasture found in the Manatee County portion of the basin and a large tract south of Rolling Green Golf Course. Additionally, approximately 4% of the basin is comprised of wetlands that vary in size and quality. As a result, very little of the historical natural systems exist in Whitaker Bayou Basin. However, one natural system improvement projects was identified and developed within Whitaker Bayou Basin: North Water Tower Park. This project proposes stream enhancement, wetland creation, and stormwater treatment to enhance downstream water quality and create much-needed wildlife habitat as well as providing educational features due to the high public use of this park. This natural system improvement project is presented in detail in Appendix D, and conceptual plans and cost estimates are provided in Appendix G.

Mixed Wetland Hardwood Community in North Water Tower Park

4.2.5 Flood Protection

The Whitaker Bayou Basin Master Plan identifies numerous flood-prone areas. One-hundred-and-fifty-four habitable structures are estimated to be susceptible to flooding from the 100-year, 24-hour storm, and 275 roadway locations are estimated to have an FPLOS deficiency. Seven alternative improvements were evaluated in the Whitaker Bayou Flood Attenuation Alternatives Analysis Report (Boyle Engineering, 2004). Flooding conditions under the seven alternatives reveal that less than a third of the parcels are eliminated from structural flooding during at 100-year, 24-hour storm. Hence, structural flooding will continue to be a major concern in the Whitaker Bayou Basin. Table 5-1 in Appendix E – Flood Protection lists CIP projects that address deficient FPLOS in the Whitaker Bayou Basin.

Upland Community in North Water Tower Park

4.2.6 Sediment Management

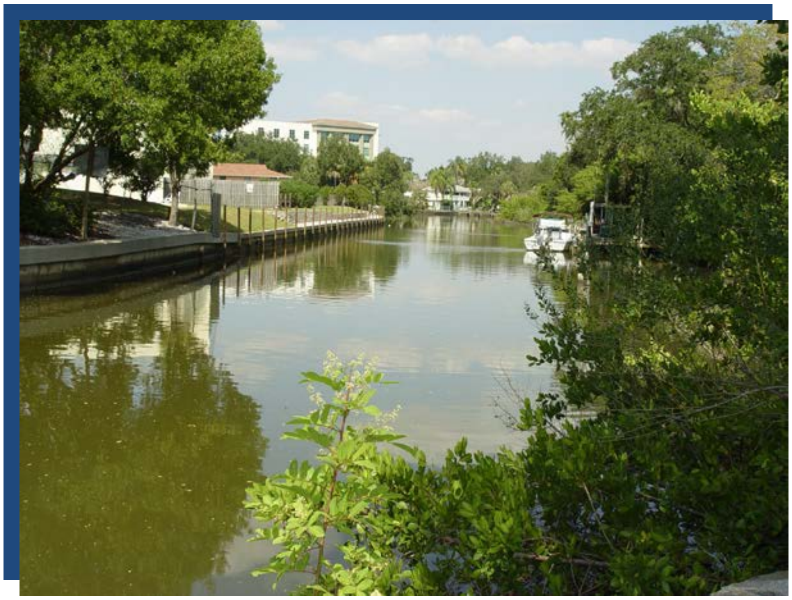
The Whitaker Bayou Basin—which includes most of the City of Sarasota—is highly urbanized, and most of the development—including over 400 acres of commercial, industrial, utilities, and transportation property—occurred before stormwater regulations were implemented. As such, sediment management BMPs and bank stabilization measures were not incorporated, making these developed areas likely contributors of sediment to Whitaker Bayou and Sarasota Bay.

Previous studies have verified substantial levels of contaminants, including toxic metals, pesticides, petroleum, and other organic compounds in Whitaker Bayou. Additionally, numerous areas in the basin and bayou have elevated TSS levels, as estimated by SIMPLE, areas of bare earth, streams with high velocity, and/or visual erosion or sediment build up. Therefore, many areas were evaluated for potential sediment management projects.

Only one sediment management project is recommended in the Whitaker Bayou Basin (Figure 4–20); however, general sediment management measures throughout the basin should be implemented to minimize the amount of sediment, debris, and pollutants reaching bay. Source control activities such as LID redevelopment projects, street sweeping, and construction-area silt fencing should be implemented. Maintenance activities including cleaning out baffle boxes, removing vegetation debris resulting from maintenance activities from swales and roadside ditches, replacing or repairing damaged infrastructure, and maintaining control structures and weirs should also be done regularly.

Figure 4-20 SMP2-Erosion along the Waterway on the South Side of Myrtle Street, West of Leonard Reid Avenue

4.2.7 Whitaker Bayou Summary and Recommendations



Whitaker Bayou is a highly urbanized basin that has changed in land use and hydrology since the mid-1900s. These changes have impacted flood control, water quality, and natural habitat.

With the extension of the bayou farther east, stormwater drains more quickly through the land. The lack of storage can cause widespread flooding throughout the basin. The Whitaker Bayou Basin Master Plan identified 154 habitable structures to be susceptible to flooding from the 100-year, 24-hour storm, and 275 roadway locations to have an FPLOS deficiency. Seven alternative improvements were evaluated in the Whitaker Bayou Flood Attenuation Alternatives Analysis Report (Boyle Engineering, 2004). Flooding conditions under the seven alternatives reveal that less than a third of the parcels are eliminated from structural flooding during at 100-year, 24-hour storm. Hence, structural flooding will continue to be a major concern in the Whitaker Bayou Basin.

The spatial and temporal patterns of freshwater inflows in the Whitaker Bayou Basin are less similar to those of the watershed as a whole because of the large effect of the wastewater discharges under current conditions. Total freshwater inflows from Whitaker Bayou Basin have increased from historical to current levels, but unlike other basins a significant reduction in freshwater inflows occurs from Whitaker Bayou for future conditions because of the anticipated cessation of wastewater effluent discharges. Seasonal patterns have not changed significantly between the scenarios, indicating that changes in land use do not alter the wet-dry season pattern of inflows to the bay. Additionally, while the magnitudes of inflows from individual sources have changed between scenarios, their relative contributions have not with the exception of the current conditions point source.

The results of the water budget analysis suggest that no adverse effects due to changes to inflows in the future are expected. Four water supply projects have been identified in Whitaker Bayou to capture and beneficially use stormwater upstream to help reduce inflows from direct runoff.

As noted above, the Whitaker Bayou Basin has been determined by FDEP to have impaired water quality through their TMDL program. Impairments include low DO caused by high BOD, TN, and TP; the high TN is evidenced by high levels of chlorophyll *a*. However, insufficient data are available to determine if these water quality impairments are having an undesirable effect on aquatic communities. Additionally, Whitaker Bayou has met the State's NNC for TN and TP as well as existing and proposed DO criteria.

The basin is highly urbanized, so little opportunity exists for increases in land use-based pollutant loadings. Water quality conditions are likely to improve in the future when point-source discharges are eliminated as projected.

4.2.7.1 Project Recommendations

Six projects recommended in the Whitaker Bayou Basin incorporate sediment management, water quality, natural systems, and water supply components. Living shorelines and vegetated buffers will also help reduce runoff, thereby reducing the amount of pollutants reaching the waterbodies and improving natural systems. The County should work with property owners to properly maintain mangroves and implement a 50-foot watercourse setback.

		Flood Protection	Water Quality		Natural Systems		Water Supply					
Project ID	Project Name	County Flood Control Benefits	Cubic Yards of Erosion Prevention and Sediment Control	Annual Pounds of Total Nitrogen Removal	UMAM Mitigation Bank Credits of Herbaceous Wetlands	UMAM Mitigation Bank Credits of Forested Wetlands	Annual Acre-feet of Beneficially Used Harvested Water	Estimated Value of Major Benefits	Opinion of Probable Cost	Present Value of O & M	Present Value of Costs	Benefits / Costs
NS4	North Water Tower Park	0	0	775	0.35	0.99	0	$3,897,330	$653,738	$110,047	$763,785	5.10
SMP2	Whitaker Canal at Leonard Reid Ave	0	1400	157	0	0	0	$809,600	$189,200	$94,041	$283,241	2.86
WS12	Lime Lake Park	0	0	0	0	0	10	$120,430	$25,500	$46,444	$71,944	1.67
WS05	Orange Avenue Park	0	0	18	0	0	6	$158,658	$103,100	$46,444	$149,544	1.06
WS11	Robert Taylor Community Complex	0	0	1	0	0	1	$16,843	$77,200	$7,047	$84,247	0.20
WS10	Martin Luther King Park	0	0	1	0	0	0	$4,800	$187,200	$30,337	$217,537	0.02
	Whitaker Bayou Basin Total	0	1400	952	0	0	17	$5,007,661	$1,235,938	$334,360	$1,570,298	---

4.3 HUDSON BAYOU

4.3.1 Characterization and Physical Setting

The Hudson Bayou Basin covers 2,392 acres and is entirely within the bounds of the City of Sarasota. Its surface water system has undergone significant alteration over the past century (Figure 4-21). Historical data do not confirm the location of a tidal creek that is a tributary to Hudson Bayou but do indicate the presence of a few inland waterways. By the mid-1900s, Hudson Bayou extended about 1 mile inland from the bay and branched out into several smaller waterways that continued several miles inland throughout much of the very developed basin.

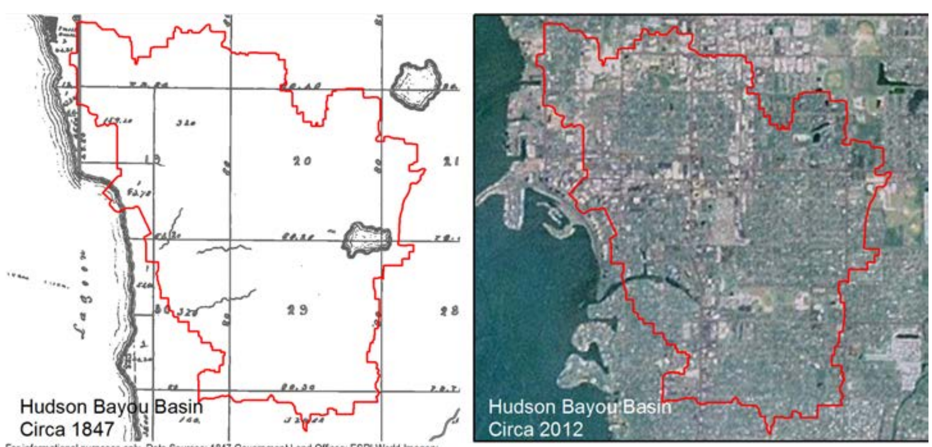


Figure 4-21 Hudson Bayou Basin Survey Circa 1847 vs 2012

Today, the Hudson Bayou Basin is highly urbanized (Table 4-4) with older neighborhoods that provide only minimal stormwater retention or detention. The untreated runoff contributes sediment and pollutants to Hudson Bayou. Hudson Bayou has areas of historical polluted sediments. Studies (Dixon et al., 1990; PBS&J, 2003) reveal artificially elevated lead concentrations in sediment throughout the bayou and tributary creek, including the tidal portion. Testing of sediments in Hudson Bayou determined that the pollution is more concentrated in the deeper sediments than in the top sediment layers, indicating that historical activities in the watershed impacted the quality of sediments in the waterway, but conditions may have improved. Nonetheless, problems such as sedimentation, erosion, habitat alteration, and hardened shorelines have occurred in the Hudson Bayou Basin. Additionally, the entire length of the bayou is in the floodplain and is therefore at risk for flooding (Sarasota County Comprehensive Plan Appendix B, page B-20).

Table 4-4 Hudson Bayou Basin Current Land Use (SWFWMD 2008)

Land Use	Hudson Bayou	
	Acres	Percent
Medium- Density Residential	988	41%
Commercial	768	32%
High-Density Residential	215	9%
Light Industrial	169	7%
Forest, Open Area, and Park	121	5%
Transportation/ Utilities	109	5%
Water	26	1%
Wetlands	10	0%
Agriculture	0	0%
Low-Density Residential	0	0%
Golf Course	0	0%
Pasture	0	0%
Row Crops	0	0%
Total	2406	100%

For more information on the basin attributes, such as land use, topography, and geology, see Section 3 of Appendix A – Characterization. Information on the public lands, recreational facilities, and threatened and endangered species within the basin can be found in Sections 5 through 7 of Appendix A.

4.3.2 Water Quantity

4.3.2.1 Water Budget

Freshwater inflows from individual basins within the Sarasota Bay Watershed were examined in the same manner as the watershed as a whole to evaluate spatially-specific issues. Current conditions were compared to historical conditions to help understand how watershed-based activities have altered freshwater inflows to the bay from the basins over time. Current and future conditions were also compared to help identify any potential problems that may arise in coming years. Using a basin-specific approach also helps identify potential projects to address anticipated future problems.

Historical, current, and future freshwater inflows from the Hudson Bayou Basin to Sarasota Bay were estimated using the methods summarized above and detailed in Appendix B. Selected results are presented below. The analyses of these data included examining and comparing the spatial and temporal variation in freshwater inputs from Hudson Bayou for historical, current, and future conditions.

Rainfall patterns are shown and discussed above in Section 3.2.3.1. Annual precipitation ranged from 43.5 to 54.3 inches per year between 1989 and 2008, with less rainfall occurring closer to the coast.

Total annual freshwater inflows to the bay from Hudson Bayou Basin for historical, current, and future conditions were compared. Current rainfall was used to develop inflow estimates for all scenarios. Inflows for the current period were almost 70% higher than for the historical period, a result of higher runoff and baseflow (Figure 4-22). Freshwater inflows from baseflow and direct runoff all increase significantly under current conditions, based on SIMPLE model results. The most likely explanation for this is that urbanization is accompanied by a reduction in wetlands and natural vegetation with a subsequent lowering of evaporation and ET rates and a reduction in on-site storage. Surface water that once was returned to the atmosphere now either flows directly to the bay or infiltrates the remaining soil, where some of the water becomes baseflow. Also, increases in impervious surfaces (e.g., parking lots, roofs) allow more surface water to reach the bay as runoff.

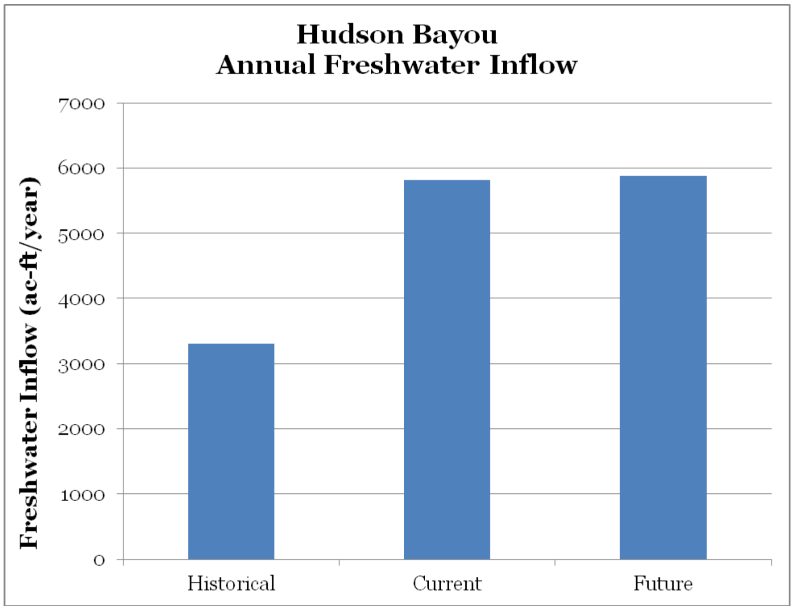


Figure 4-22 Mean Annual Total Freshwater Inflow to Sarasota Bay from the Hudson Bayou Basin for Historical, Current, and Future Conditions

Inflows for the future scenario were virtually unchanged from the current period (3% higher). As with the watershed as a whole, existing urban conditions preclude significant future land use.

Seasonal patterns of freshwater inflows for historical, current, and future conditions were also compared. The seasonal patterns remain very similar (Figure 4-23). This demonstrates that, especially for the historical and current conditions, land use changes may alter the volume but not the wet season-dry season patterns of freshwater inflows to the bay.

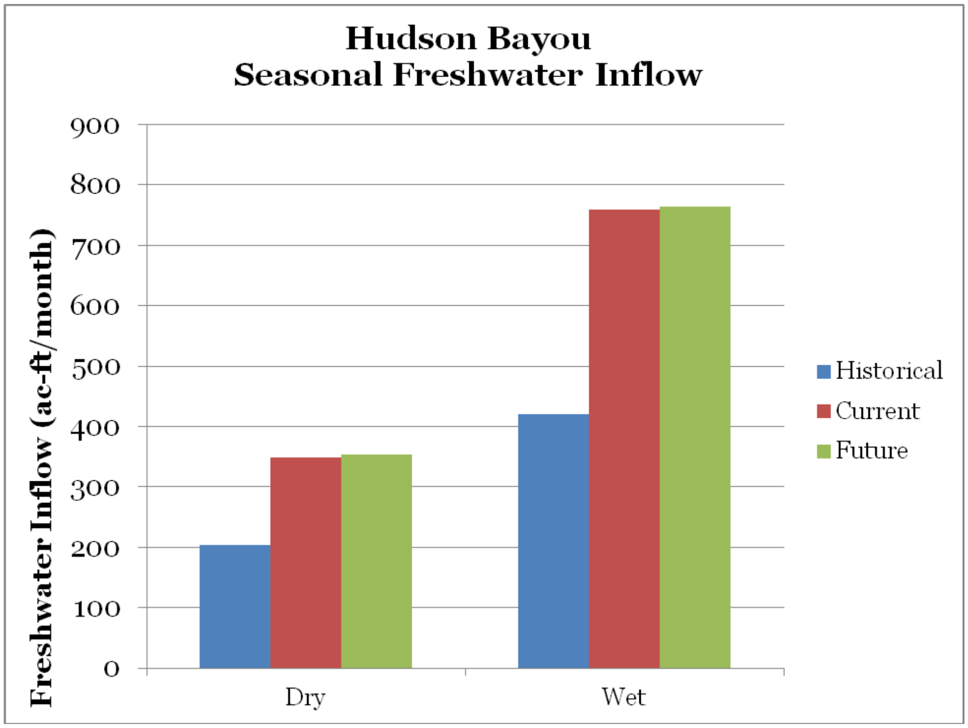


Figure 4-23 Seasonal Variability in Total Freshwater Inflows to Sarasota Bay from the Hudson Bayou Basin for Historical, Current, and Future Conditions

Although the magnitudes of inflows from individual sources in Hudson Bayou have changed, their relative contributions have not. Atmospheric deposition includes only rainfall to the bay, so it is not included in basin inflows. Runoff and baseflow are the most significant sources, with irrigation and septic tanks contributing small loads, and no point sources present. This condition is constant for all three periods assessed. Figure 4-24 compares inflow source relative contributions for the three scenarios.

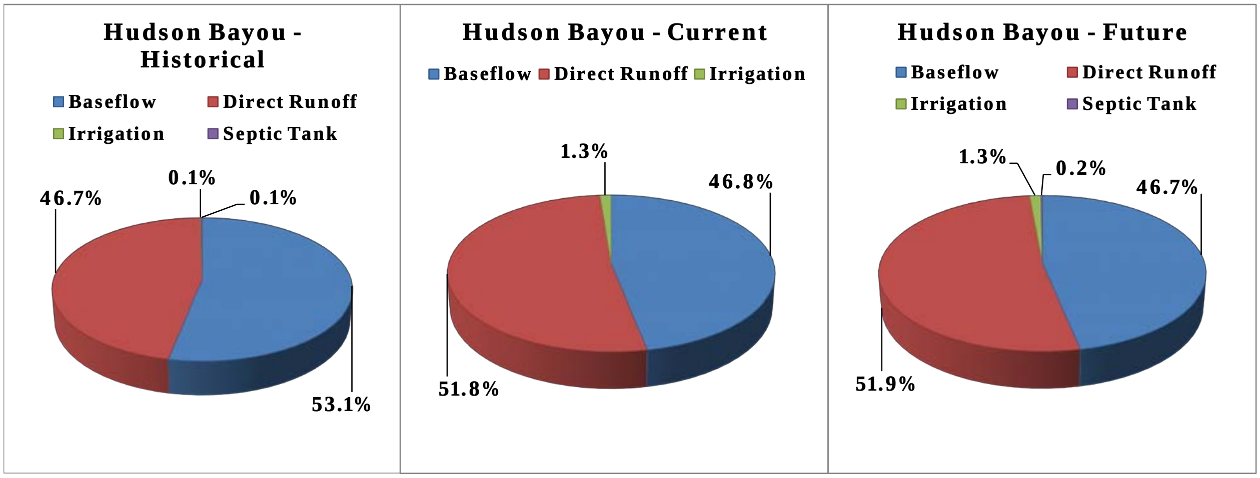


Figure 4-24 Relative Contributions of Sources of Freshwater Inflows to Sarasota Bay from the Hudson Bayou Basin for Historical, Current, and Future Conditions

The spatial and temporal patterns of freshwater inflows in the Hudson Bayou Basin are very similar to those of the watershed as a whole. Total freshwater inflows from Hudson Bayou Basin have increased from historical to current levels, but very little change exists between current and future inflows. This is a reflection of the current urban nature of the basin. Seasonal patterns have not changed significantly between the scenarios, indicating that changes in land use do not alter the wet season-dry season pattern of inflows to the bay. Additionally, while the magnitudes of inflows from individual sources have changed between scenarios, their relative contributions have not.

The results of the analysis suggest that although freshwater inflows have increased since the historical period, future freshwater inflows should very much resemble current inflows. These patterns are similar to freshwater inflows in other Sarasota Bay Basins.

However, Hudson Bayou has ongoing issues with low DO in the marine segment of the stream, as shown in Appendix C. Enhancing freshwater inflows and circulation to this water body could have a beneficial effect on DO; therefore, recommended that future investigations explore means of enhancing DO levels in Hudson Bayou.

Two water supply projects were recommended to reduce direct runoff to Hudson Bayou. The WS4-Arlington Park and Aquatic Complex and WS7-Gillespie Park projects include installing rain barrels on public buildings and using captured stormwater for irrigation. They also recommend installing LID retrofits such as permeable parking pavers. If implemented, these projects can beneficially use 42 acre-feet of harvested water per year.

4.3.3 Water Quality

4.3.3.1 Tributary Water Quality Status and Trends

Hudson Bayou has three sampling sites within the basin. A review of ambient water quality data revealed no trends in chlorophyll, chlorophyll or TP for the sampling period of 2006 through 2010. A slight increasing trend (not statistically significant) in TN and decreasing trend (not statistically significant) in DO was observed.

4.3.3.2 Hydrologic and Pollutant Loading

Hydrologic and pollutant loads for current and future conditions were estimated for the Hudson Bayou Basin as part of the SIMPLE modeling discussed above. Figure 4-25 compares total TN loads for the two scenarios by source. Because atmospheric deposition includes only loadings falling onto the open water estuary, that source in not included in the basin loading. Baseflow and direct runoff are the two dominant sources of loading from the basin. Less than 1% difference exists between current and future loadings in the Hudson Bayou Basin, as the basin is already highly urbanized with little opportunity for additional urbanization in the future.

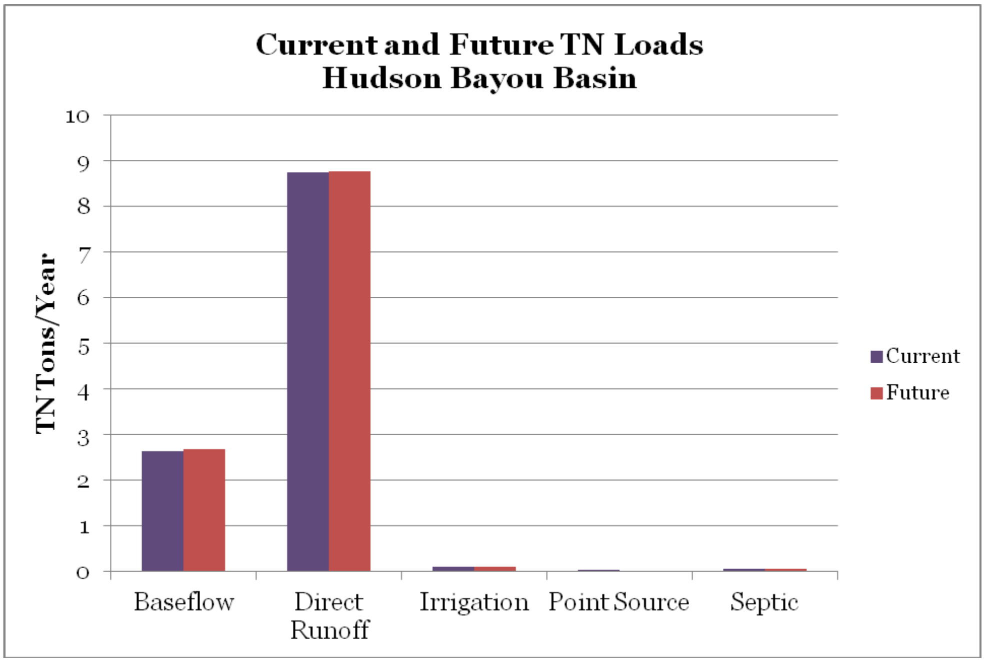


Figure 4-25 Comparison of Current and Future TN Loadings from Hudson Bayou Basin

The basin has moderate levels of total pollutant loading rates with respect to other basins in the watershed. The Hudson Bayou Basin also has among the highest UALs of any basin, mainly a result of the high level of urbanization in the basin. The UAL is the watershed load (direct runoff + baseflow) divided by the basin area. This normalization allows loading rates from basins of different sizes to be compared. TN UALs for Sarasota Bay Basins are compared in Appendix C, Water Quality, Section 4.4.3.1.C, Figure 4-21.

4.3.3.3 Comparison of Ambient Water Quality to Regulatory Criteria and Management Levels of Service (LOS)

Ambient water quality was compared to several regulatory limits and management criteria to assess the ecological health of Hudson Bayou. Results of the assessments include the following:

- FDEP Freshwater NNC—Until recently Florida had only narrative water quality standards for nutrient concentrations. FDEP adopted NNC for freshwater streams for TN and TP to provide a quantifiable limit. The standards vary by bioregion, which allows the standards to reflect local conditions. Sarasota Bay is in the Peninsula bioregion, with thresholds of 1.65 mg/L for TN (Figure 4-26) and 0.49 for TP. These criteria are applicable only to freshwater streams. TN and TP levels in freshwater reaches of the Hudson Bayou Basin met the criteria in all years (2007–2010).

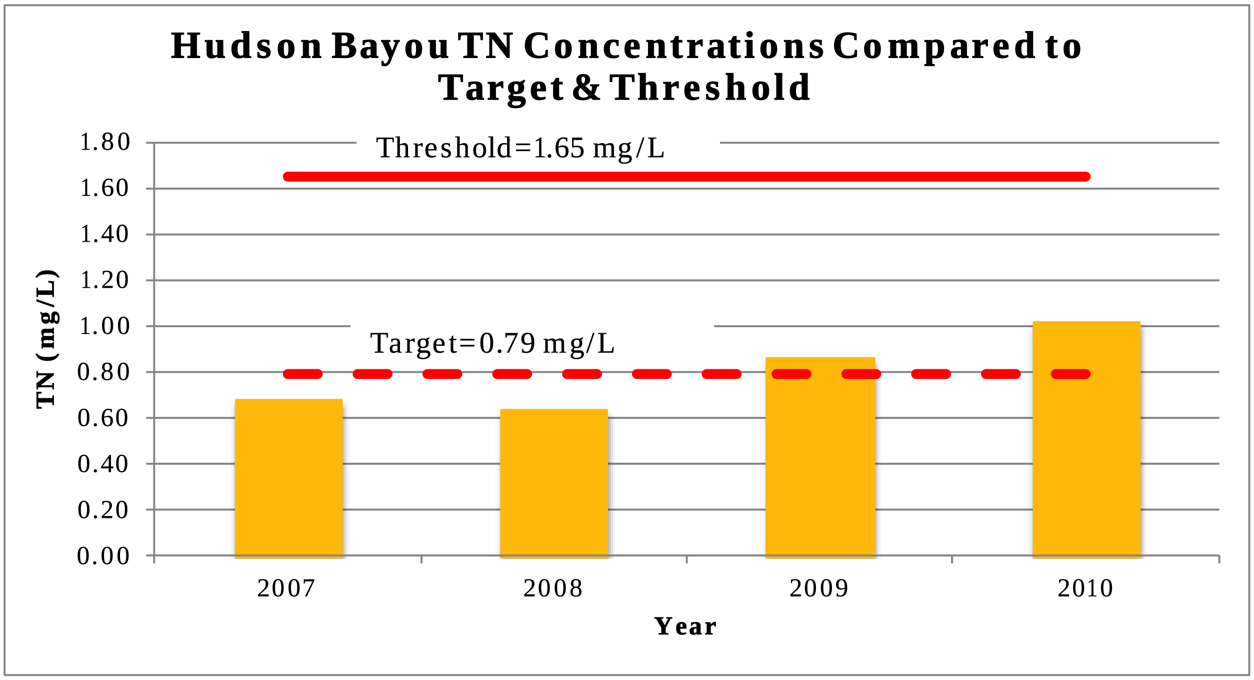


Figure 4-26 Comparison of the Freshwater TN Threshold and Target to TN Concentrations in Hudson Bayou

❖ In Florida DO has traditionally been held to a standard based on concentration. The current State DO standard for freshwater requires that DO remain above 5.0 mg/L at all times, and the current minimum concentration for marine waters is 4.0 mg/L. Recognizing that the standard does not allow for variability in natural conditions based on water temperature or salinity, FDEP has proposed DO criteria based on percent saturation, which is the expected amount of DO in aquatic environments given ambient conditions. For predominantly marine waters (Class II and III, which includes Sarasota Bay), those standards are:

- The daily average percent DO saturation shall not be below 41.7%.

and

- The 7- and 30-day average percent DO saturations shall not be below 51.0 and 56.5%, respectively.

The proposed State DO standards for Class III freshwater is:

- The daily average percent DO saturation shall not be below 67% in the Panhandle West bioregion or 34% in the Big Bend, Northeast, and Peninsula bioregions. (The entire Sarasota Bay system is within the Peninsula bioregion.)

DO in the freshwater sites exceeded the proposed FDEP DO standard during 2006 through 2011, and DO in marine waters in Hudson Bayou exceeded the standard during 2007 through 2009. The period of record was 2003 through 2011. Because the criterion was exceeded in 2 of 3 consecutive years two times in the freshwater segment of the bayou and one time in the marine segment, Hudson Bayou had three exceedances of the proposed DO criterion.

- Impaired Water Bodies—FDEP administers the EPA's TMDL program in Florida. The TMDL program is intended to identify water bodies that are receiving a higher pollutant load than can be assimilated while maintaining the water body's designated use. If a water body does not meet State water quality standards according to the State's IWR protocol, that water body is deemed "impaired." A TMDL may result that identifies excessive pollutant loadings and sources and specifies required reductions in pollutant loads to enable the water body to meet its designated use.

  The marine portion of Hudson Bayou is identified by its WBID number of WBID 1953 (Figure 4-27). The WBID has been deemed impaired for low DO, attributed to elevated BOD concentrations and is included on the FDEP 1998 303(D) List of Impaired Water Bodies. WBID 1953 has also been deemed impaired for fecal coliform based on exceedances of the fecal coliform standard of 400 counts/ 100 milliliters.

Figure 4-27 Impaired WBIDs within the Sarasota Bay Watershed – Whitaker Bayou (WBID 1936) and Hudson Bayou (WBID 1953)

- Basin Loadings—Annual TN, TP, and TSS loadings from the Hudson Bayou Basin for 1989 through 2008 were developed as part of the SIMPLE modeling. Figure 4-28 compares the TN loadings to targets and thresholds that have been developed. The Hudson Bayou Basin loading target (13.9 tons/year) is the average of annual loads for 2001 through 2005. This is consistent with reference period approach used to develop chlorophyll targets. A higher threshold (17.6 tons/year) was also determined to allow for variability within the system. Loads were below the threshold during all except 1 year and were higher than the target during 5 years. To be classified as an exceedance, the annual load must be higher than the threshold for 2 years of a 3-consecutive-year period; thus, no exceedance occurred during this period.

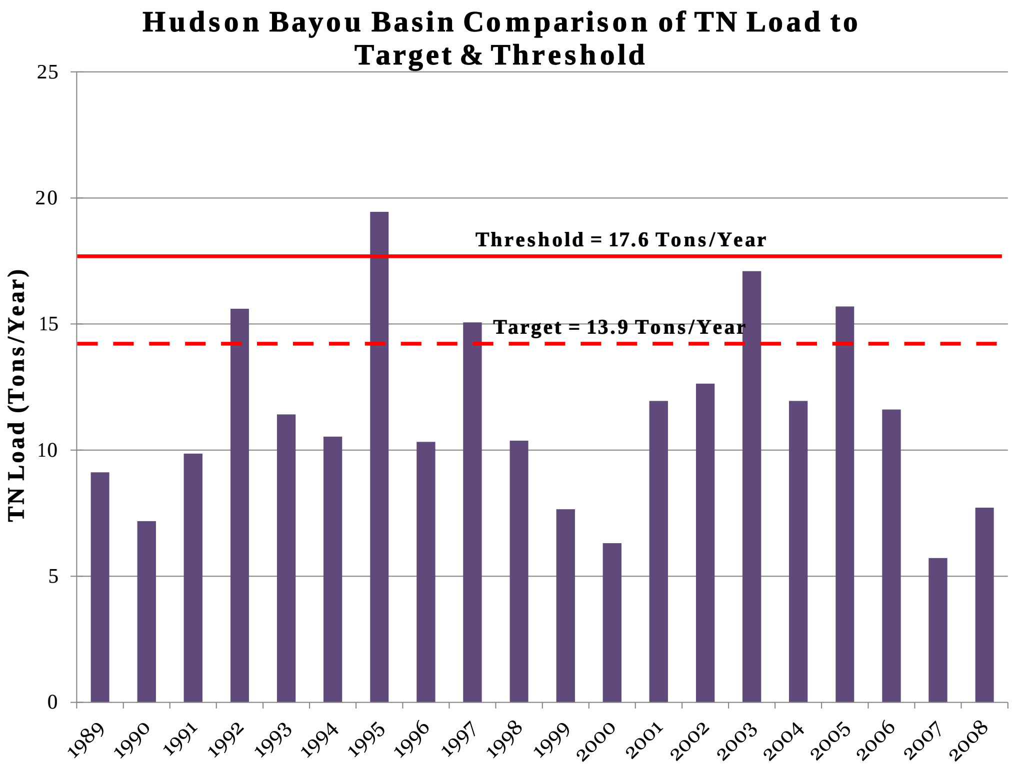


Figure 4-28 Comparison of Annual TN Loads to Target and Threshold – Hudson Basin

Considering the DO impairment, BMPs should target nutrients and other substances contributing to oxygen demand. Four water quality projects identified in this basin could reduce TN by approximately 30 pounds per year and prevent almost 500 cubic yards of sediment and erosion from reaching the waterbodies, thus reducing oxygen demand. The projects and sites are detailed in Appendix C, Water Quality and the conceptual plans and cost estimates are in Appendix G, Recommendations.

4.3.4 Natural Systems

The Hudson Bayou Basin is also a highly urbanized with only approximately 5% of the basin being comprised of undeveloped uplands and less than 1% of the basin is wetlands, which vary in size and quality. A majority of these undeveloped uplands are parks such as Arlington or Payne Park, which lack intact natural vegetation communities. However, three natural system improvement projects were identified and developed within Hudson Bayou Basin: Arlington Park, Payne Park, and Hudson Bayou Oak Street Canal. This project proposes stream enhancement, wetland creation, stream enhancement to enhance downstream water quality and create additional much needed wildlife and fish habitat. Two of the projects also propose educational features due to the high public use of Arlington and Payne Park (Figure 4-29). These natural system improvement projects are presented in detail in Appendix D, and conceptual plans and cost estimates are provided in Appendix G.

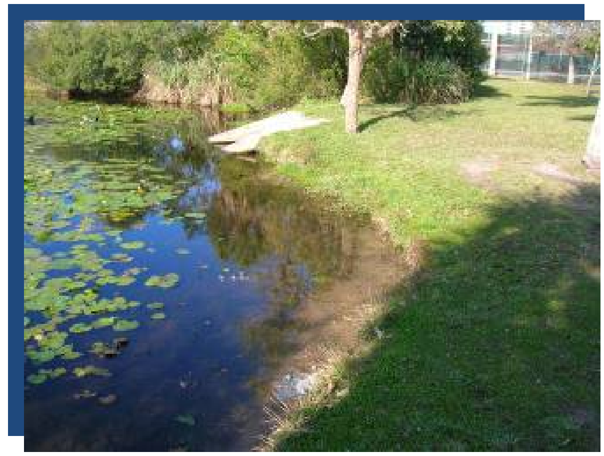


Figure 4-29 Payne Park Northwest Pond

4.3.5 Flood Protection

The 1987 City-Wide Master Drainage Plan identified 15 flood-problem areas within the Hudson Bayou Basin. The flooding problems are primarily described as street, driveway, and yard flooding. None of the 15 problem areas references house flooding. The causes of the problem listed in the Master Drainage Plan in these 15 areas are either undersized storm sewer pipes or constricted channel sections. The projects recommended in this study primarily address nuisance flooding areas or drainage complaints and do not necessarily address the City stormwater LOS for the project area. The 1994 Basin Master Plan for Hudson Bayou indicates a deficient LOS area within the Outfall No. 3 drainage area. The LOS analysis indicates that 30 buildings within the 25-year floodplain of the Arlington Drainage Canal, the Fruitville Drainage Canal, and the Euclid Drainage Canal would have flooding on the lowest floors. Deficiencies are also seen within Outfall No. 1 and No. 2 of the Hudson Bayou Basin. However, no attempt was made to quantify the location or number of structures that might be flooded during a 25-year, 24-hour storm event due to the lack of lowest floor elevation and the inaccuracy in predicting flow depths of the closed conduit system. Table 5-1 in Appendix E – Flood Protection lists CIP projects that address deficient LOS in the Hudson Bayou Basin.

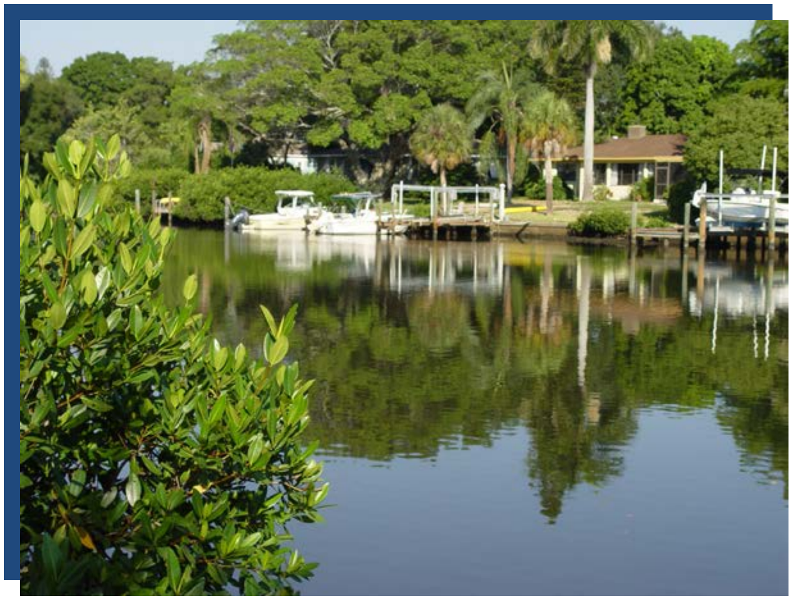
4.3.6 Sediment Management

The Hudson Bayou Basin is almost entirely developed; more than half occurred before stormwater regulations were implemented. As such, sediment management BMPs and bank stabilization measures were not incorporated, making these developed areas likely contributors of sediment to the Bayou and Sarasota Bay.

As discussed above, Hudson Bayou has areas of polluted sediments. Many areas throughout the basin exhibited higher TSS levels, as estimated by SIMPLE, than the average across the watershed. Additionally, many areas with erosion or sediment build-up were identified. Three sediment management projects are recommended in the Hudson Bayou Basin. SMP7 is shown in Figure 4-30. General sediment management measures throughout the basin are also recommended to minimize the amount of sediment, debris, and pollutants reaching Hudson Bayou and the bay. Source control activities such as LID redevelopment projects, street sweeping, and construction-area silt fencing should be implemented. Additionally, maintenance activities including cleaning out baffle boxes, removing vegetation debris resulting from maintenance activities from swales and roadside ditches, replacing or repairing damaged infrastructure, and maintaining control structures and weirs should be done regularly.

Figure 4-30 SMP7-Hudson Bayou near Sarasota High School has a History of Lead-Contaminated Soils and In-Stream Erosion

4.3.7 Hudson Bayou Summary and Recommendations



Hudson Bayou is a highly urbanized basin that has changed in land use and hydrology since the mid-1900s. These changes have impacted flood control, water quality, and natural habitat.

Hudson Bayou has areas of polluted sediments. Studies reveal lead concentrations as high as 510 ppm in sediment throughout the bayou, including the tidal portion. Many areas throughout the basin exhibited higher TSS levels, as estimated by SIMPLE, than the average across the watershed. Additionally, many areas with erosion or sediment build-up were identified. Three sediment projects were identified as part of this plan that in total can prevent over 22,000 cubic yards of sediment from reaching the bay.

The basin also has moderate levels of total pollutant loading rates with respect to other basins in the watershed and has among the highest UALs of any basin. The basin is highly urbanized, so little opportunity exists for increases in land use-based pollutant loadings. Hudson Bayou has ongoing low DO levels and has been determined by FDEP to have impaired water quality (low DO) through their TMDL program. . However, insufficient biological data exist to identify any negative effects to aquatic biota resulting from the low DO in Hudson Bayou. Additionally, Whitaker Bayou has met the State's NNC for TN and TP as well as existing and proposed DO criteria.

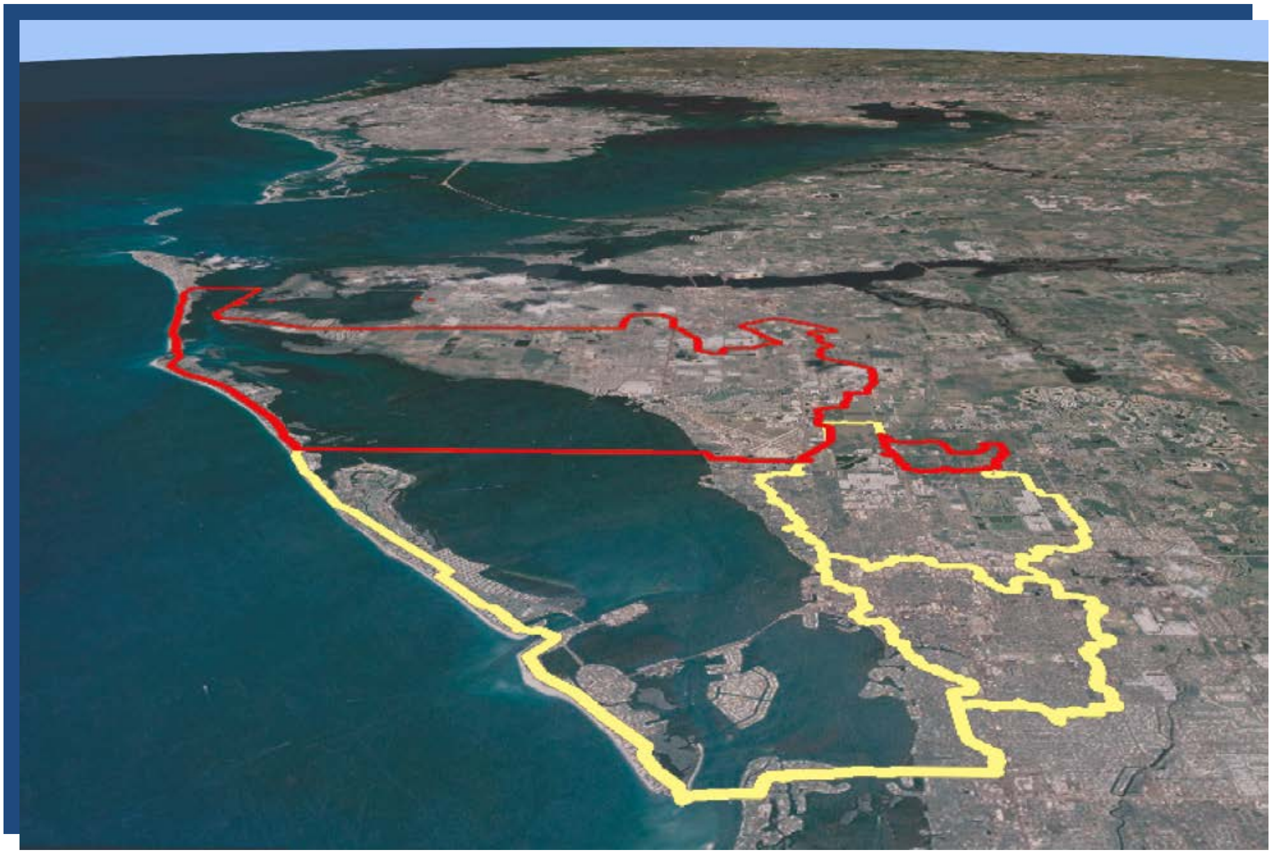
The water body is bounded by concrete seawalls and surrounded by high-density development. Enhancing freshwater inflows and circulation to this water body could have a beneficial effect on DO; therefore, future investigations should explore means of enhancing DO levels in Hudson Bayou.

4.3.8 Project Recommendations

If implemented, twelve projects recommended in the Hudson Bayou Basin could reduce TN by approximately 400 pounds per year and prevent or remove approximately 22,200 cubic yards of sediment and 43 acre-feet of direct runoff from reaching the bay, in addition to providing habitat improvements worth 0.5 UMAM credits. Living shorelines and vegetated buffers will also help reduce runoff, thereby reducing the amount of pollutants reaching the waterbodies and improving natural systems. The County should work with property owners to properly maintain mangroves and implement a 50-foot watercourse setback.

Project ID	Project Name	Flood Protection	Water Quality		Natural Systems		Water Supply	Estimated Value of Major Benefits	Opinion of Probable Cost	Present Value of O & M	Present Value of Costs	Benefits / Costs
		County Flood Control Benefits	Cubic Yards of Erosion Prevention and Sediment Control	Annual Pounds of Total Nitrogen Removal	UMAM Mitigation Bank Credits of Herbaceous Wetlands	UMAM Mitigation Bank Credits of Forested Wetlands	Annual Acre-feet of Beneficially Used Harvested Water					
WS04	Arlington Park and Aquatic Complex	0	0	0	0.00	0.00	33	$397,419	$39,200	$46,444	$85,644	4.64
SMP6	Sarasota High School at Hatton Street	0	21574	105	0.00	0.00	0	$1,366,960	$368,600	$106,543	$475,143	2.88
NS1	Arlington Park	0	0	61	0.12	0.17	0	$329,540	$83,195	$46,444	$129,639	2.54
NS5	Payne Park	0	0	74	0.19	0.05	0	$382,250	$162,152	$46,444	$208,596	1.83
SMP3	Orange Avenue	0	85	90	0.00	0.00	0	$435,400	$226,500	$92,449	$318,949	1.37
WS07	Gillespie Park	0	0	0	0.00	0.00	9	$108,387	$32,300	$59,622	$91,922	1.18
SMP7	Sarasota High School at Tamiami Trail	0	0	16	0.00	0.00	0	$76,800	$48,100	$17,617	$65,717	1.17
NS6	Hudson Bayou Oak Street Canal	0	0	9	0.00	0.02	0	$46,040	$33,094	$9,924	$43,018	1.07
WQ5	Hudson Bayou North Branch	0	0	9	0.00	0.00	1	$55,243	$52,900	$14,094	$66,994	0.82
WQ10	Ringling Blvd. Sidewalks	0	0	20	0.00	0.00	0	$96,000	$396,400	$17,159	$413,559	0.23
WQ1	North Gillespie Park	0	460	0	0.00	0.00	0	$18,400	$103,700	$60,099	$163,799	0.11
WQ9	Hudson Bayou East Branch	0	92	0	0.00	0.00	0	$3,680	$112,900	$60,099	$172,999	0.02
	Hudson Bayou Basin Total	0	22211	384	0.31	0.24	43	$3,316,119	$1,659,040	$576,938	$2,235,978	----

4.4 OTHER BASINS (MANATEE COUNTY)



Evaluating and analyzing the Manatee County portion of the watershed were not included in the scope of work for this plan. However, to properly evaluate the health of the bay, water quantity, and inflows and water quality related to nutrients were analyzed for this basin as they contribute to the bay.

4.4.1 Water Quantity

4.4.1.1 Water Budget

Freshwater inflows from individual basins within the Sarasota Bay Watershed were examined in the same manner as the watershed as a whole to evaluate spatially-specific issues. Current conditions were compared to historical conditions to help understand how watershed-based activities have altered freshwater inflows to the bay from the basins over time. Current and future conditions were also compared to help identify any potential problems that may arise in coming years. Using a basin-specific approach also helps identify potential projects to address anticipated future problems.

Approximately one-half of the Sarasota Bay Watershed lies north of Sarasota County in Manatee County. To examine the relationship of the bay to watershed-based freshwater inflows, the entire watershed was assessed as detailed in Appendix B. The basins in Manatee County that were used in the SIMPLE modeling of freshwater inflows have been summarized as a whole in this chapter and are Canal Road Drain, SBC-North, Palma Sola Drain – Bayshore, Cedar Hammock Creek, Bowlees Creek, and part of Longboat Key, as described in Appendix B, Water Quality.

Historical, current, and future freshwater inflows from the SBC-North Basin to Sarasota Bay were estimated using the methods summarized above and detailed in Appendix B. Selected results are presented below. The analyses of these data included examining and comparing the spatial and temporal variation in freshwater inputs from the Manatee County Basins for historical, current, and future conditions.

Rainfall patterns are shown and discussed above in Section 3.2.3.1. Annual precipitation ranges from 43.5 to 54.3 inches per year between 1989 and 2008, with less rainfall occurring closer to the coast.

Total annual freshwater inflows to the bay from the Manatee County Basins for historical, current, and future conditions were compared. Current rainfall was used to develop inflow estimates for all scenarios. Inflows for the current period were approximately 80% higher than during the historical period, a result of higher runoff and baseflow (Figure 4-31). Freshwater inflows from baseflow and direct runoff all increase significantly under current conditions, based on SIMPLE model results. The most likely explanation for this is that urbanization is typically accompanied by a reduction in wetlands and natural vegetation with a subsequent lowering of evaporation and ET rates and reductions in on-site storage. Surface water that once was returned to the atmosphere now flows directly to the bay or infiltrates the remaining soil, where some of the water becomes baseflow. Also, increases in impervious surfaces (e.g., parking lots, roofs) allow more surface water to reach the bay as runoff.

Inflows for the future scenario were virtually unchanged from the current period (about 5% higher). As with the watershed as a whole, existing urban conditions preclude significant future land use.

Seasonal patterns of freshwater inflows for historical, current, and future conditions were also compared. The seasonal patterns remain very similar (Figure 4-32). This demonstrates that, especially for the historical and current conditions, land use changes may alter the volume but not the seasonal patterns of freshwater inflows to the bay.

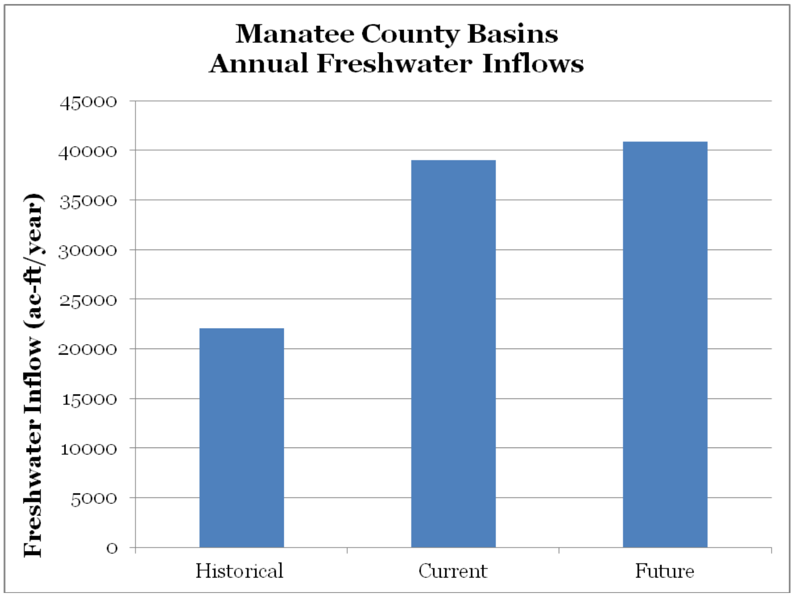


Figure 4-31 Mean Annual Total Freshwater Inflow to Sarasota Bay from the Manatee County Basins for Historical, Current, and Future Conditions

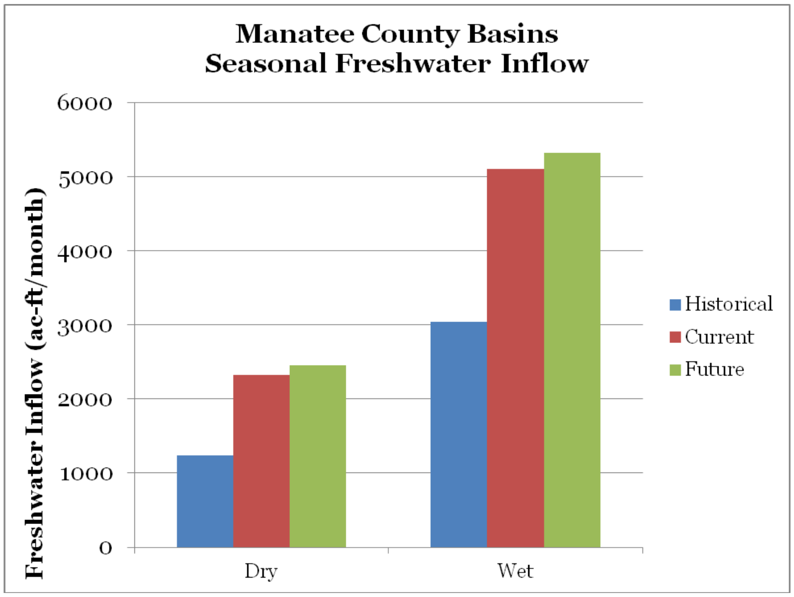


Figure 4-32 Seasonal Variability in Total Freshwater Inflows to Sarasota Bay from the Manatee County Basins for Current and Future Conditions

Although the magnitudes of inflows from individual sources in the Manatee County Basins have changed, their relative contributions have not. Atmospheric deposition includes only rainfall to the bay, so it is not included in basin inflows. Runoff and baseflow are the most significant sources, with irrigation and septic tanks contributing small loads, and no point sources present. This condition is constant for all scenarios. Figure 4-33 compares inflow source relative contributions for the three scenarios.

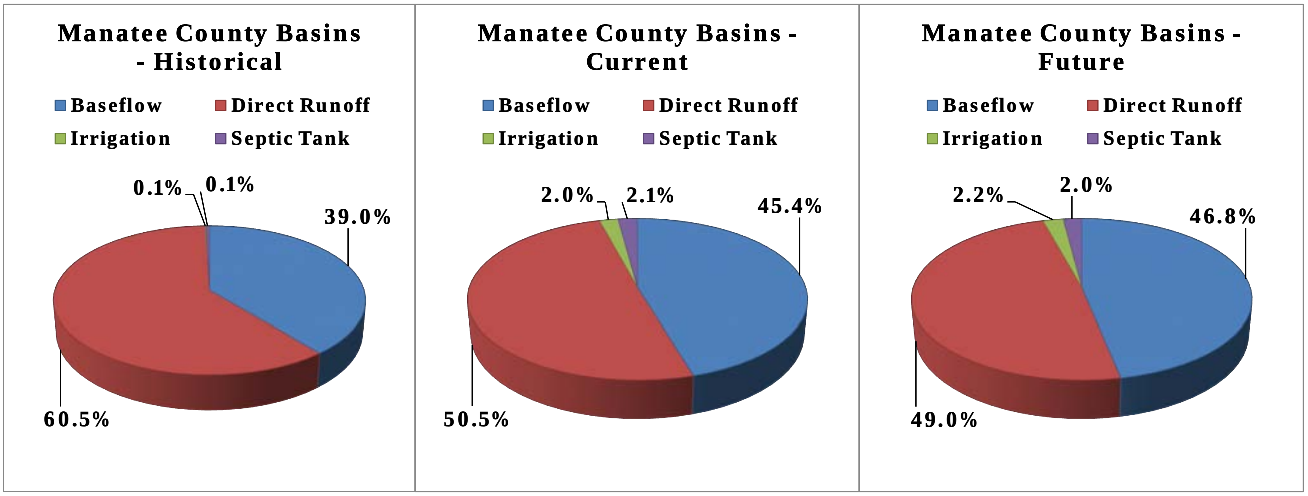


Figure 4-33 Relative Contributions of Sources of Freshwater Inflows to Sarasota Bay from the Manatee County Basins for Historical, Current, and Future Conditions

The spatial and temporal patterns of freshwater inflows in the Manatee County Basins are very similar to those of the watershed as a whole. Total freshwater inflows from the basins have increased from historical to current levels, but very little change exists between current and future inflows. This is a reflection of the current urban nature of the basin. Seasonal patterns have not changed significantly between the scenarios, indicating that changes in land use do not alter the seasonal pattern of inflows to the bay. Additionally, while the magnitudes of inflows from individual sources have changed between scenarios, their relative contributions have not. Because future freshwater inflows should very much resemble current inflows, no adverse effects due to changes to inflows in the future are expected.

4.4.2 Water Quality

Approximately one-half of the Sarasota Bay Watershed is in Manatee County and includes the Canal Road Drain, SBC-North, Palma Sola Drain – Bayshore, Cedar Hammock Creek, and Bowlees Creek Basins. These basins were assessed for current and future loading rates to allow the total watershed load to the bay to be determined.

4.4.2.1 Tributary Water Quality Status and Trends

The only water quality monitoring site in the northern portion of the watershed is in the marine segment of Bowlees Creek. A review of ambient data shows a slightly increasing (not statistically significant) trend in TN, and no trend in chlorophyll or DO during the sampling period of 1998 through 2010.

4.4.2.2 Hydrologic and Pollutant Loading

Hydrologic and nutrient loadings were estimated for the north basins to determine the total loading to Sarasota Bay. Total basin loads ranged from the second largest for current/largest for future (Bowlees Creek) to the second smallest total load (Canal Road Drain). Loads for future conditions were about 4% higher in SBC-North and Bowlees Creek Basins due to increases in developed land in the future. No point sources are in the basins. Figure 4-34 shows the cumulative current and future load from basins in the Sarasota Bay Watershed that are in Manatee County. Direct runoff and baseflow are by far the dominant sources of TN loading to the bay.

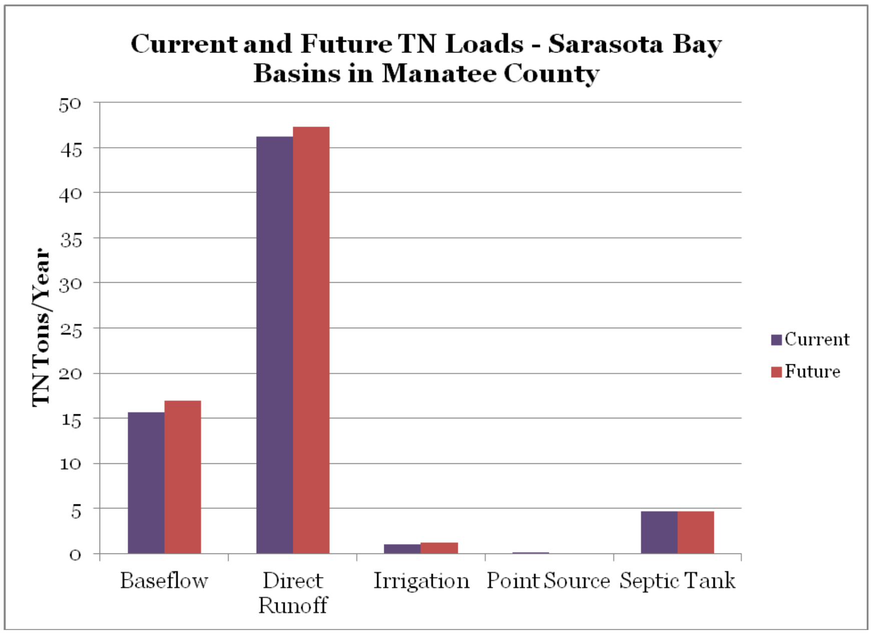


Figure 4-34 Current and Future TN Load from Sarasota Bay Basins in Manatee County

4.4.2.3 Comparison of Ambient Water Quality to Regulatory Criteria and Management Levels of Service (LOS)

Ambient water quality was compared to several regulatory limits and management criteria to assess the ecological health of the north basins. Results of the assessments include the following:

- FDEP Freshwater NNC—No water quality sampling sites are in the freshwater portion of this basin; thus, this LOS is not applicable.

- In Florida DO has traditionally been held to a standard based on concentration. The current State DO standard for freshwater requires that DO remain above 5.0 mg/L at all times, and the current minimum concentration for marine waters is 4.0 mg/L. Recognizing that the standard does not allow for variability in natural conditions based on water temperature or salinity, FDEP has proposed DO criteria based on percent saturation, which is the expected amount of DO in aquatic environments given ambient conditions. For predominantly marine waters (Class II and III, which includes Sarasota Bay), those standards are:

- The daily average percent DO saturation shall not be below 41.7%.

and

- The 7- and 30-day average percent DO saturations shall not be below 51.0 and 56.5%, respectively.

The single water quality monitoring site in these basins is within the marine segment of Bowlees Creek. DO at the site met both the current and proposed freshwater DO standard.

❖ Impaired Water Bodies—FDEP administers the EPA's TMDL program in Florida. The TMDL program is intended to identify water bodies that are receiving a higher pollutant load than can be assimilated while maintaining the water body's designated use. If a water body does not meet State water quality standards according to the State's IWR protocol, that water body is deemed "impaired." A TMDL may result that identifies excessive pollutant loadings and sources and specifies required reductions in pollutant loads to enable the water body to meet its designated use.

West Cedar Hammock Creek is identified as WBID 1885. The WBID has been deemed impaired for DO due to elevated BOD, TN, and TP concentrations, and for fecal coliform based on exceedances of the fecal coliform standard of 400 counts/100 milliliters.

❖ Basin Loadings—Annual TN, TP, and TSS loadings from the basin outside Sarasota County for 1989 through 2008 were developed as part of the SIMPLE modeling. Table 4-5 shows the TN and TP targets and thresholds for each basin.

Table 4-5 TN and TP Loading Targets and Thresholds for Sarasota Bay Watershed Basins in Manatee County

Basin	TN (tons/year)		TP (tons/year)	
	Target	Threshold	Target	Threshold
Canal Road Drain	1.76	2.26	0.31	0.40
SBC-North	18.5	23.3	3.14	3.89
Palma Sola Drain – Bayshore	7.03	8.68	1.28	1.57
Cedar Hammock Creek	16.6	20.3	3.25	3.97
Bowlees Creek	34.0	41.2	6.60	7.98
Longboat/Lido Keys	13.3	17.0	2.60	3.31

For 1998 through 2008, no basin exceeded the threshold during 2 of any 3-consecutive-year period for TN or TP.

4.4.3 Manatee County Basins Summary/Conclusions

The spatial and temporal patterns of freshwater inflows in the Manatee County Basins are very similar to those of the watershed as a whole. Total freshwater inflows from the basins have increased from historical to current levels, but t very little change exists between current and future inflows. This is a reflection of the current urban nature of the basin. Seasonal patterns have not changed significantly between the scenarios, indicating that changes in land use do not alter the seasonal pattern of inflows to the bay. Additionally, while the magnitudes of inflows from individual sources have changed between scenarios, their relative contributions have not.

The results of the water budget analysis suggest that although inflows have increased since the historical period, future freshwater inflows should very much resemble current inflows. No adverse effects due to changes to inflows in the future are expected.

The SBC-North and Bowlees Creek Basins are not as highly urbanized as those within Sarasota County, so some opportunity exists for increases in land use-based pollutant loadings in the future.

The watershed must be managed as a whole to address large-scale water quality issues and identify opportunities for developing achievable, effective management projects.

5.0 WATER QUALITY MANAGEMENT PLAN IMPLEMENTATION

Effective implementation of the Sarasota Bay Water Quality Management Plan will depend upon four elements:

1. Establishment of Levels of Service (LOS).
2. Monitoring to collect the essential data for compliance assessment.
3. Compliance assessment process that "rolls up" the individual LOS.
4. Decision framework for a comprehensive compliance assessment that scales the response to the number of LOS that may be exceeded.

5.1 ESTABLISHMENT OF LEVELS OF SERVICE

LOS for the bay and basins have been proposed in the previous sections. More detailed information on each LOS can be found in the Appendices by AOR:

- Water Quality LOS (chlorophyll *a*, nutrient criteria and loading, and DO) – Appendix C.
- Sediment LOS – Appendix C.
- Natural Systems LOS – Appendix D.
- FPLOS – Appendix E.

Where possible, these LOS have been refined and expressed as targets, i.e., the levels of each of these metrics that are desirable, or the levels of each of these metrics that beyond which management responses will be necessary.

5.2 ENVIRONMENTAL MONITORING

Sarasota County conducts extensive monitoring of natural systems in Sarasota Bay including:

- Estuarine and tributary water quality.
- Stage, flow, and rainfall.
- Monthly water quality in several tributaries.
- Biannual oyster bed health survey.
- Annual synoptic tidal creek index sampling.
- Annual volunteer-assisted seagrass characterization and validation survey.

Together these monitoring programs represent a concerted effort on the part of Sarasota County to provide proper stewardship of the natural resources of Sarasota Bay.

The County's overall strategic monitoring plan was reviewed in detail (Janicki Environmental, 2009) in conjunction with the development of the Roberts Bay North and Lemon Bay Watershed Management Plans. The monitoring plan provided a detailed review of the routine monitoring elements conducted by Sarasota County and evaluated how the monitoring programs may be optimized to provide the highest return on the resources invested. That review found that the current monitoring design was sufficient to track changes in many aspects of ecosystem health over time and report in a timely fashion for the development of a watershed report card. Data gaps were identified with respect to the evaluation of some key elements in evaluating ecosystem health and recommendations were made for minor improvements in the overall design for several aspects of the overall program. The following summarizes the recommendations in the document.

- Continue ambient estuarine water quality monitoring at its current intensity.
- Coordinate with FDEP to optimize data collection in support of the TMDL program.
- Periodically review tidal creek water quality data to refine the data collection network if needed.
- Re-locate ARMS stations currently at tidally-influenced sites upstream to areas above tidal influence.
- Continue the current County oyster monitoring program.
- Complete an inventory of oyster habitat in the bay (now underway).
- Support State-sponsored seagrass monitoring activities in the bay and continue its own validation efforts to quantify the extent of seagrass in the bay using volunteers.
- Conduct a one-time synoptic benthic sampling effort to characterize the benthos in Sarasota Bay's open waters.
- Use the results of a current 1-year study documenting the temporal variability in fisheries catch in Sarasota County estuaries to explore the efficacy of developing an index to use for incorporating a fisheries score into a report card.
- Encourage additional fisheries sampling through the FWC Fisheries Independent Monitoring (FIM) Program.
- Periodically assess the health of mangroves in the bay.

5.3 COMPLIANCE ASSESSMENT AND REPORTING

Successful management of coastal ecosystems requires accurate quantitative tools for managers, scientists, and the public at the local and regional levels to easily understand and apply basic principles of ecosystem management. Our current scientific knowledge allows us to understand the complexity and variability found in the marine environment and its associated watershed. Taking the data and applying them to compliance assessment can be difficult based on the wide range of audiences to whom information must be conveyed. Environmental programs can be ineffective because the translation of data through analysis and subsequent conveyance to decision makers and the public are inadequate or confusing. Therefore, a clear process that reports on the current status of the environment and assesses whether management action is warranted is critical. The following describes how this can be achieved for the Sarasota Bay WQMP.

Clearly, each LOS can and should be assessed individually. This is especially critical for LOS tied to a regulatory requirement such as floodplains and NNC and DO criteria. These LOS should be assessed annually to provide an "early warning" since the FDEP assessments occur on a 5-year cycle.

Reporting of this compliance assessment will be critical and it is recommended that this be achieved by producing an annual watershed report card and a Bay Conditions Report for the County Water Atlas.

5.3.1 Decision Framework for Comprehensive Water Quality Compliance Assessment

The necessity of management response to lack of compliance with the LOS becomes more evident when more than one LOS is in non-compliance. Figure 5-1 presents a proposed process for "rolling up" the individual LOS compliance assessments to identify the need and justification for varying degree of management responses. As the number of non-compliance assessment results increases, the degree of response increases, i.e., the Outcome increases.

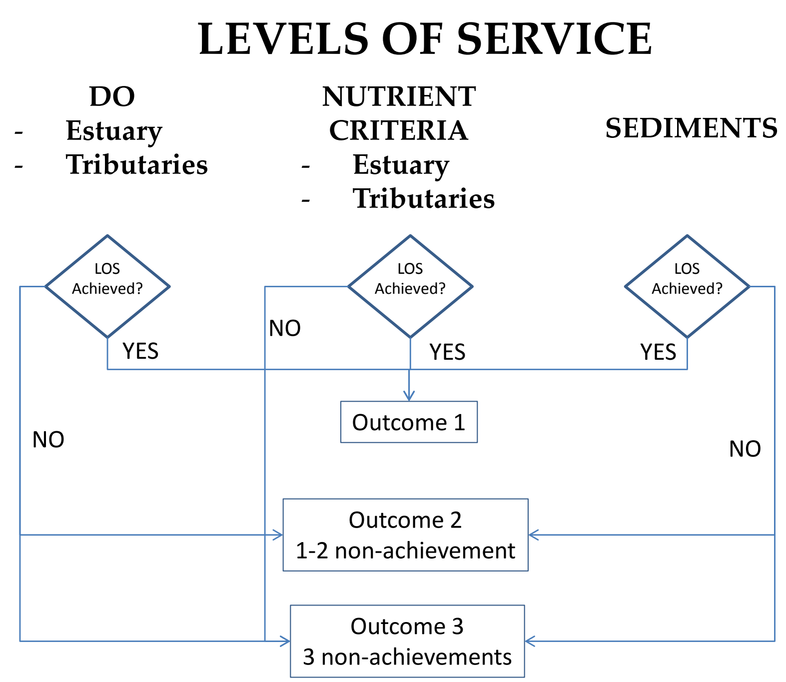


Figure 5-1 Framework for "Rolling Up" LOS Compliance Assessments

The following responses to the three potential outcomes are proposed:

- ❖ Outcome 1 – “All is good” – keep up the good work.
- ❖ Outcome 2 – Review data, investigate potential cause(s), and identify alternatives to address cause(s).
- ❖ Outcome 3 – Review data, investigate potential cause(s), identify alternatives to address cause(s), estimate costs for response(s), and examine feasibility.

6.0 RECOMMENDED ACTIONS FOR THE WATERSHED

This section summarizes some of the recommended program and actions from previous sections and formulates them as tools that may be implemented by the County or other partners. These recommendations are geared toward increasing public understanding and stewardship of these vital components of a healthy bay system.

6.1 SEAGRASS PROTECTION

6.1.1 Seagrass Protection Strategy


Photo credit: Sarasota County

Seagrasses provide numerous values and functions, including but not limited to primary estuarine refuge and food production, nutrient conversion, stabilization of bottom sediment, significant recreational fishing habitat, and forage areas for the West Indian Manatee.

The Sarasota Bay LOS target is 7,269 acres. The 2008 and 2010 surveys indicate that seagrass coverage has been significantly above the LOS target acreage since 2008. This equates to approximately 1,700 acres of seagrass in excess of the LOS target acreage. While the trends in seagrass coverage in Sarasota Bay are certainly very promising, the ongoing identification and implementation of water quality and quantity improvement projects in the watershed is still critical to ensure that this trend continues.

Numerous tools and protection measures have been implemented to protect seagrasses by the state and Sarasota County. In addition to implementing these tools and protection measures, monitoring efforts should continue and opportunities should be sought to enhance the value and function of this resource through the following recommendations.

6.1.2 Seagrass Protection Recommendations

- Implement water quality improvement projects.
- Implement water quantity improvement projects.
- Continue seagrass monitoring.

What can you do to help Seagrasses?

- *Avoid boating in shallow areas.*
- *Pole or walk out of seagrass beds.*
- *Reduce yard-fertilizer use.*
- *Eliminate soil erosion by laying mulch over exposed earth or planting groundcover.*

6.2 OYSTER MONITORING

6.2.1 Oyster Monitoring Strategy

Oysters are an important indicator of estuarine health, and their status can help identify water-management problems. Oyster reefs serve several valuable ecological functions, providing habitat for estuarine fauna including conch, mud crab, fish, and other bivalves and helping improve water quality through filtering as they feed.

Because the bay-wide areal extent of oysters is not known and the historical mapping data are not of comparable accuracy to modern mapping, establishing an LOS target expressed as acres of oyster bars is not feasible at this time. A target based on acres could be established when the Sarasota County mapping is completed and a similar inventory is made of Manatee County oyster habitats.

6.2.2 Oyster Monitoring Actions

- ❖ Continue Oyster Monitoring Program.
- ❖ Map oysters.
- ❖ Develop oyster LOS to help gauge the health of the bay.

6.3 MANGROVE PROTECTION

6.3.1 Mangrove Protection Strategy

Mangroves provide numerous values and functions, including but not limited to nursery habitat, shoreline protection, wind buffering, nutrient uptake, and recreation and ecotourism opportunities.

Sarasota Bay experienced a substantial loss of mangrove acreage before State legislation and Sarasota County standards were enacted that halted the major loss of this natural habitat. While mangroves are afforded protection today by both the State and the County, numerous threats still remain that can decrease the value and function of this resource, including shoreline stabilization, cultural trimming, and nuisance and invasive plants.

In addition to implementing the State and local standards, this resource's stewardship should be promoted and its values and functions should be optimized through the following recommendations.

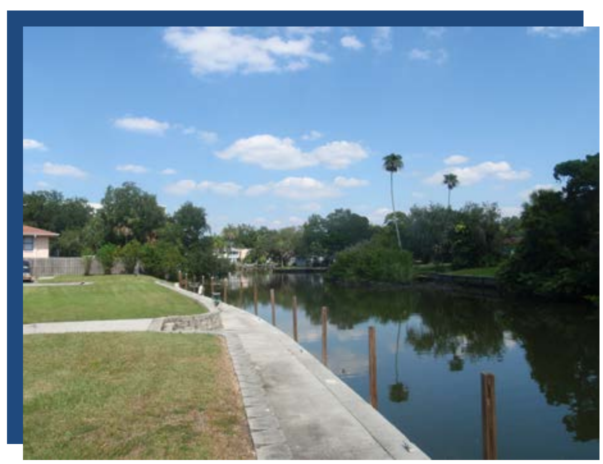
6.3.2 Mangrove Stewardship Recommendations

- ❖ Provide education and outreach to property owners, residents, and visitors, identifying the multiple beneficial functions of mangroves. Related actions include:
  - Identify neighborhood associations and individual property owners in locations willing to plant mangroves.
  - Hold mangrove planting workshops.
  - Present the importance of mangroves and planting methodologies at HOAs and encourage planting mangroves where such opportunities exist.
  - Promote additional benefits of untrimmed mangroves in educational materials and at presentations.
  - Schedule and hold tours with property owners who have trimmed and untrimmed mangroves to show homeowners the expected results.
- ❖ Coordinate with the IFAS Sarasota County Extension Office and identify collaborative opportunities.

6.4 HABITAT

6.4.1 Native Vegetation

Planting native vegetation and removing non-native, invasive species is a key strategy to meet watershed goals. Vegetation plays a significant role in the hydrologic process by intercepting, storing, and absorbing rainfall and through ET. These functions influence the rate, timing, and volume of stormwater runoff. Wetland, riparian area and understory vegetation filter pollutants and nutrients from stormwater runoff. Removing invasive species is critical to preserving biodiversity.



As the watershed developed, buildings and streets replaced green spaces and wetlands. Revegetation restores habitat and provides food and cover for native wildlife and restores the functions of once plentiful soils and organic layers.

One of the greatest impacts of urbanization on aquatic and terrestrial wildlife is habitat fragmentation. Urbanization leaves remnant patches of habitat, which are disconnected, isolated, or fragmented segments of land or riparian area. Revegetation connects and expands habitat areas to increase their function and value and can be accomplished as land redevelops. The implementation of these recommendations would further the goals and intent described in the Environmental Policies 1.1.2 and 4.2.1 and Management Guideline Principles IV.A.2.d, IV.A.2.f, IV.B.2.d, IV.C.2.e, VI.A.2.d, and VI.B.2.g of the Sarasota County Comprehensive Plan.

6.4.2 Native Vegetation Actions

- Increase the extent of canopy and other vegetative cover.
- Improve the quality and composition of vegetative cover.
- Work with homeowners to convert waterward portions of their backyards dominated by turf grass to native, low-maintenance species.
- Maintain existing natural shoreline extents while working to increase extents over time, even at a parcel-by-parcel level.

6.5 HABITAT ENHANCEMENT

6.5.1 Habitat Enhancement Strategy

In developing watershed protection and restoration strategies, focusing on both terrestrial and aquatic areas and processes that connect them within watersheds is essential. River, stream, wetland riparian, and upland enhancement projects improve natural watershed processes and fish and wildlife habitat functions.

Aquatic and terrestrial enhancement improves hydrologic functions. Restoring channel complexity, natural stream meanders, off-channel wetlands, and riparian and upland vegetation buffers helps normalize stream flows, recharges groundwater, provides flood storage and reduces high flows that can erode stream banks and degrade stream channels and aquatic habitat. Protecting upland vegetation soil conditions is critical for flow storage and erosion prevention.

What can you do to help Freshwater Wetlands?

- *If you live on a lake, encourage native emergent vegetation around the lake edge*
- *Encourage your governments to enact rules that require local mitigation.*
- *Vote in favor of programs designed to purchase land for environmental protection and parks. Much freshwater wetland acreage has been protected through these programs.*
- *Support private land trusts.*

Aquatic and terrestrial enhancements improve water quality. Restoring stream depth, increasing complexity with large wood, varying stream width, and meandering channels help manage aquatic plant growth. Over-production of aquatic plants leads to fluctuations in DO concentrations and pH, which damage aquatic species. Restored aquatic and terrestrial natural areas filter nutrients, sediment, and toxics from stormwater that is not discharged before reaching the waterway. Through filtration, upland vegetation and wetlands capture and treat nutrients and pollutants, stabilizing pH and the DO concentration of the receiving waterway.

Aquatic and terrestrial enhancement improves habitat and protects and biodiversity. Restoring connectivity by removing or retrofitting impassable culverts, installing road undercrossings for wildlife, or planting vegetated wildlife corridors promotes the natural movement of aquatic and terrestrial species. These pathways restore critical areas for feeding, nesting, roosting and migrating. Restoring native vegetation, managing invasive plant and animal species and removing development from the riparian and floodplain area also increases connectivity between stream corridors and their associated uplands.

6.5.2 Habitat Enhancement Actions

- ❖ Restore channel and floodplain function and stability.
- ❖ Restore or create stream, wetland, and terrestrial habitat structure and function.
- ❖ Restore habitat connectivity and access.
- ❖ Manage for appropriate native species.

6.6 STORMWATER MANAGEMENT

6.6.1 Stormwater Management Strategy

Stormwater management is fundamental to improving hydrologic function and watershed health. Development creates streets, rooftops, and other impervious surfaces that can increase the volume and velocity of stormwater runoff. Proper stormwater management controls runoff flow and protects property, infrastructure, and natural resources. Site design or retrofits of existing development that reduce impervious area also reduce the amount of stormwater runoff. Ponds, oversized pipes, greenroofs, and swales can all reduce runoff. Properly designed swales, planters, greenroofs, and other vegetated facilities also filter stormwater pollutants, protect water quality, and provide habitat.

6.6.2 Stormwater Management Actions

- ❖ Modify the storm drainage system to increase reuse or detain stormwater.
- ❖ Modify the storm drainage system to treat stormwater pollutants.
- ❖ Maintain stormwater management systems to ensure the efficient function of existing stormwater conveyances.

- Continue to develop floodplain models to identify areas of flood concern and potential improvement projects.
- Regularly maintain and update floodplain models.
- Continue the Community Rating System program.
- Perform outreach annually for residential mitigation projects, grants, and insurance.
- Ensure that modifications to drainage systems/stormwater management systems do not result in adverse impacts to maximum flood stages resulting from the 100-year design storm event.

6.7 OPERATIONS AND MAINTENANCE

6.7.1 Operations and Maintenance Strategy

Effective operations and maintenance practices are critical to watershed health. Stormwater maintenance has traditionally played an active role in maintaining the flood capacity of the stormwater system throughout the County. A more robust maintenance program will play a larger role in improving the quality of the runoff reaching the estuaries and bays of Sarasota County. The recommendations below are intended to expand and enhance the existing stormwater maintenance process to include water quality in addition to flood protection as part of the focus. The implementation of these recommendations would further the goals and intent described in the Water Policy 2.1.1 and Management Guideline Principles V.C.2.f of the Sarasota County Comprehensive Plan.

Storm and sanitary infrastructure need to be maintained to operate properly.

- Both public and private facilities that remove sediment, oil, grease and debris from stormwater need routine cleaning to remove accumulated sediment and pollutants.
- Industrial permits need to be monitored.
- Regular street sweeping prevents debris and pollutants from washing into the storm system and streams.
- Greenspace enhancement projects that aren’t properly designed and maintained lose effectiveness and could actually harm watershed health.
- Monitoring and maintenance of revegetation projects protects new plantings and prevents the return of non-native, invasive plants.

6.7.2 Operations and Maintenance Actions

- Implement and update the 1999 Strategic Maintenance Plan.
- Achieve the inspection and maintenance frequency required in the MS4 Permit.

- Operate and maintain the storm sewer system, public rights-of-way, greenspaces, and other city facilities and infrastructure to remove and prevent pollutant discharges

6.8 EDUCATION, INVOLVEMENT, AND STEWARDSHIP

6.8.1 Education, Involvement, and Stewardship Strategy

Promoting community education, public involvement and watershed stewardship benefits watersheds by:

- Helping County employees understand how their projects affect watershed conditions.
- Showing residents and businesses how their individual behavior and actions can promote healthy watersheds.
- Increasing stewardship of County-owned natural areas.
- Increasing community interest in watershed stewardship grants and volunteer restoration projects that improve watershed health. Education, involvement, and stewardship raise awareness of watershed issues and the importance of healthy watersheds.

Public involvement encourages property owners to get involved and protect natural resources, prevent pollution, and creatively integrate stormwater into the built environment. This strategy increases awareness of watershed health issues and acceptance of innovative stormwater management projects such as green streets and greenroofs on public property.

6.8.2 Education, Involvement, and Stewardship Actions

- Promote watershed awareness with County staff, schools, the business community, organizations, and general public.
- Provide pollution prevention education to County staff, the business community, organizations, and general public.
- Provide technical assistance and incentives to city staff, schools, the business community, organizations, and general public.

6.9 LINKING ACTIONS AND GOALS

Table 6-1 indicates actions that directly link to the Goals from Section 2.0.

Table 6-1 Watershed Protection Strategies and Actions

✓ Indicates action directly contributes toward achieving goal. Actions without a direct link to a goal may still indirectly contribute to achieving that goal.

STRATEGIES	ACTIONS	Improve water quality.	Restore the historic natural hydrologic regime.	Protect, enhance, and restore natural communities and habitats	Identify potential sustainable surface water supply options
Seagrass Protection	Implement water quality improvement projects	✓		✓	
Seagrass Protection	Implement water quantity improvement projects	✓	✓	✓	
Seagrass Protection	Continue seagrass monitoring	✓		✓	
Oyster Monitoring	Continue Oyster Monitoring Program			✓	
Oyster Monitoring	Map Oysters			✓	
Oyster Monitoring	Develop Oyster LOS			✓	
Mangrove Protection	Conduct mangrove trimming surveys	✓	✓	✓	
Mangrove Protection	Identify neighborhood associations and individual property owners willing to plant mangroves	✓		✓	
Mangrove Protection	Hold mangrove planting workshop	✓		✓	
Mangrove Protection	Present the importance of mangroves and planting methodologies to HOAs	✓		✓	
Mangrove Protection	Promote, in educational materials and at presentations, additional benefits of untrimmed mangroves	✓		✓	
Mangrove Protection	Hold tours with property owners who have trimmed and untrimmed mangroves to show homeowners the expected results	✓		✓	
Mangrove Protection	Partner with IFAS for grant funding and participation	✓		✓	
Native Vegetation	Increase the extent of canopy and other vegetative cover	✓		✓	
Native Vegetation	Improve the quality and composition of vegetative cover	✓		✓	
Native Vegetation	Work with homeowners to convert waterward portions of their backyards dominated by turf grass to native, low-maintenance species	✓	✓	✓	
Native Vegetation	Maintain existing natural shoreline extents while working to increase extents over time, even at a parcel-by-parcel level	✓	✓	✓	
Habitat Enhancement	Restore channel and floodplain function and stability		✓	✓	
Habitat Enhancement	Restore or create stream, wetland, and terrestrial habitat structure and function		✓	✓	

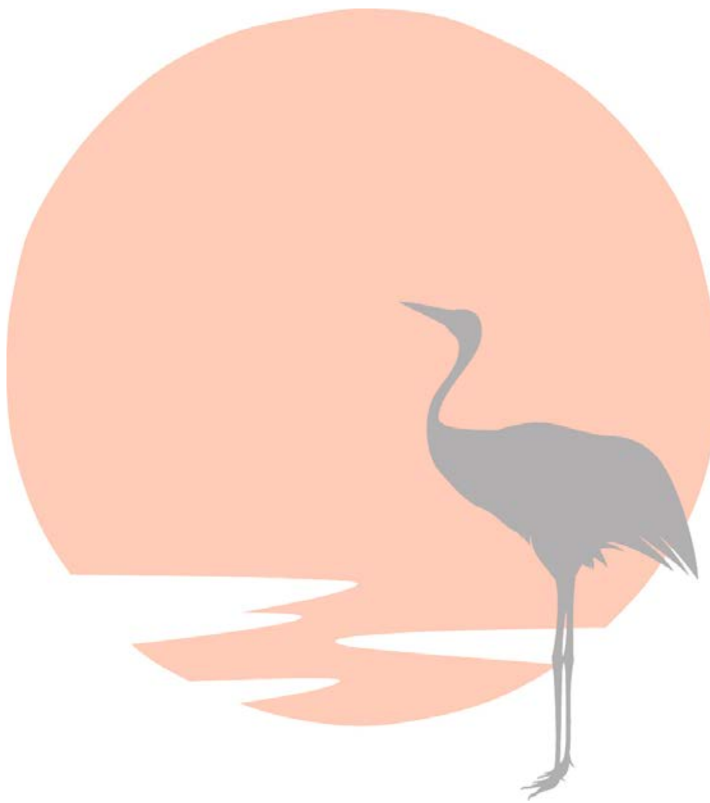
✓ Indicates action directly contributes toward achieving goal. Actions without a direct link to a goal may still indirectly contribute to achieving that goal.

STRATEGIES		ACTIONS	GOALS: Improve water quality.	Restore the historic natural hydrologic regime.	Protect, enhance, and restore natural communities and habitats	Identify potential sustainable surface water supply options
		Restore habitat connectivity and access			✓	
		Manage for native species			✓	
	Stormwater Management	Modify the storm drainage system to increase reuse or detain stormwater		✓	✓	✓
	Stormwater Management	Modify the storm drainage system to treat stormwater pollutants	✓			
	Stormwater Management	Maintain stormwater management systems to ensure the efficient function of existing stormwater conveyances			✓	
	Stormwater Management	Continue Community Rating System program			✓	
	Stormwater Management	Perform outreach annually for residential mitigation projects, grants, and insurance.	✓	✓	✓	
	Stormwater Management	Ensure that modifications to drainage systems/stormwater management systems do not result in adverse impacts to maximum flood stages resulting from the 100-year design storm event.	✓	✓	✓	✓
	Stormwater Management	Continue to develop floodplain models to identify areas of flood concern and potential improvement projects	✓	✓	✓	
	Stormwater Management	Regularly maintain and update floodplain models			✓	
	O&M	Implement and update the 1999 Strategic Maintenance Plan.	✓		✓	
	O&M	Achieve the inspection and maintenance frequency required in the MS4 Permit.	✓			
	O&M	Operate and maintain the storm sewer system, public rights-of-way, greenspaces and other city facilities and infrastructure to remove and prevent pollutant discharges	✓			
	Public Education	Promote watershed awareness	✓			
	Public Education	Provide pollution prevention education	✓			
	Public Education	Provide technical assistance	✓	✓	✓	✓

Appendix A

Project Background and Physical Setting

Appendix A
Project Background and Physical Setting



December 2012

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1.0 BACKGROUND

Sarasota County has six major watersheds located wholly or partially within its limits: Sarasota Bay, Roberts Bay North, Little Sarasota Bay, Dona and Roberts Bay, Lemon Bay, and Myakka River (Figure 1-1). To manage these watersheds, Sarasota County has implemented the Comprehensive Watershed Management Program to address water quality, water quantity, flooding, and natural resources in a comprehensive manner within each of these watersheds. This program is consistent with the Sarasota County Comprehensive Plan (Chapter 4, Goal, Objective 2.2, Policy 2.2.1) and employs an approach consistent with the Southwest Florida Water Management District's (SWFWMD) areas of responsibilities related to water resource management: Water Quality, Water Supply, and Flood Protection, and Natural Systems. One component of this Comprehensive Watershed Management Program is to develop a Water Quality Management Plan (WQMP) for each of these six watersheds. The Lemon Bay Watershed Management Plan and the Roberts Bay North Watershed Management Plan were completed in early 2011.

The coast of Sarasota Bay spreads across two counties, Manatee and Sarasota. The bay is home to a wide variety of marine life, including dolphins, manatees, loggerhead turtles, black mullet, red drum, spotted seatrout, snook, blue crab, stone crab, oysters, and bait shrimp. Sarasota Bay is bound to the west by stretches of barrier islands, principally Longboat Key, and to the east by the mainland of Manatee and Sarasota Counties. The bay is a subtropical estuary with tidal tributaries and small creeks, coves, inlets, and passes. Sarasota Bay is currently classified as an Estuary of National Significance, Outstanding Florida Water (OFW), and SWFWMD Surface Water Improvement and Management (SWIM) Priority waterbody and is designated as a Florida priority estuarine conservation area by the Fish and Wildlife Conservation Commission (FWC).

Sarasota Bay is divided into four unique segments for planning purposes: Palma Sola Bay, Sarasota Bay, Roberts Bay North, and Little Sarasota Bay (Figure 1-2). The southern portion of Sarasota Bay, Roberts Bay North, and Little Sarasota Bay are in Sarasota County.

The County and SWFWMD are partnering on cooperative funding projects to develop a management plan for the Sarasota Bay, Roberts Bay North, and Little Sarasota Bay segments. While cooperative-funding is provided by SWFWMD's Manasota Basin Board, the inclusion of proposed projects, corrective actions, and best management practices (BMPs), in this plan does not confer any special status, approval, permitting, standing, or funding from SWFWMD. All proposed projects are subject to regulatory review and permitting. Requests for funding assistance will have to meet the requirements of funding programs and be subject to the SWFWMD's Governing and Basin Boards appropriating funds. This WQMP is for the segment of Sarasota Bay that is within Sarasota County and the watershed area that drains to the Sarasota County portion of Sarasota Bay (Figure 1-3).

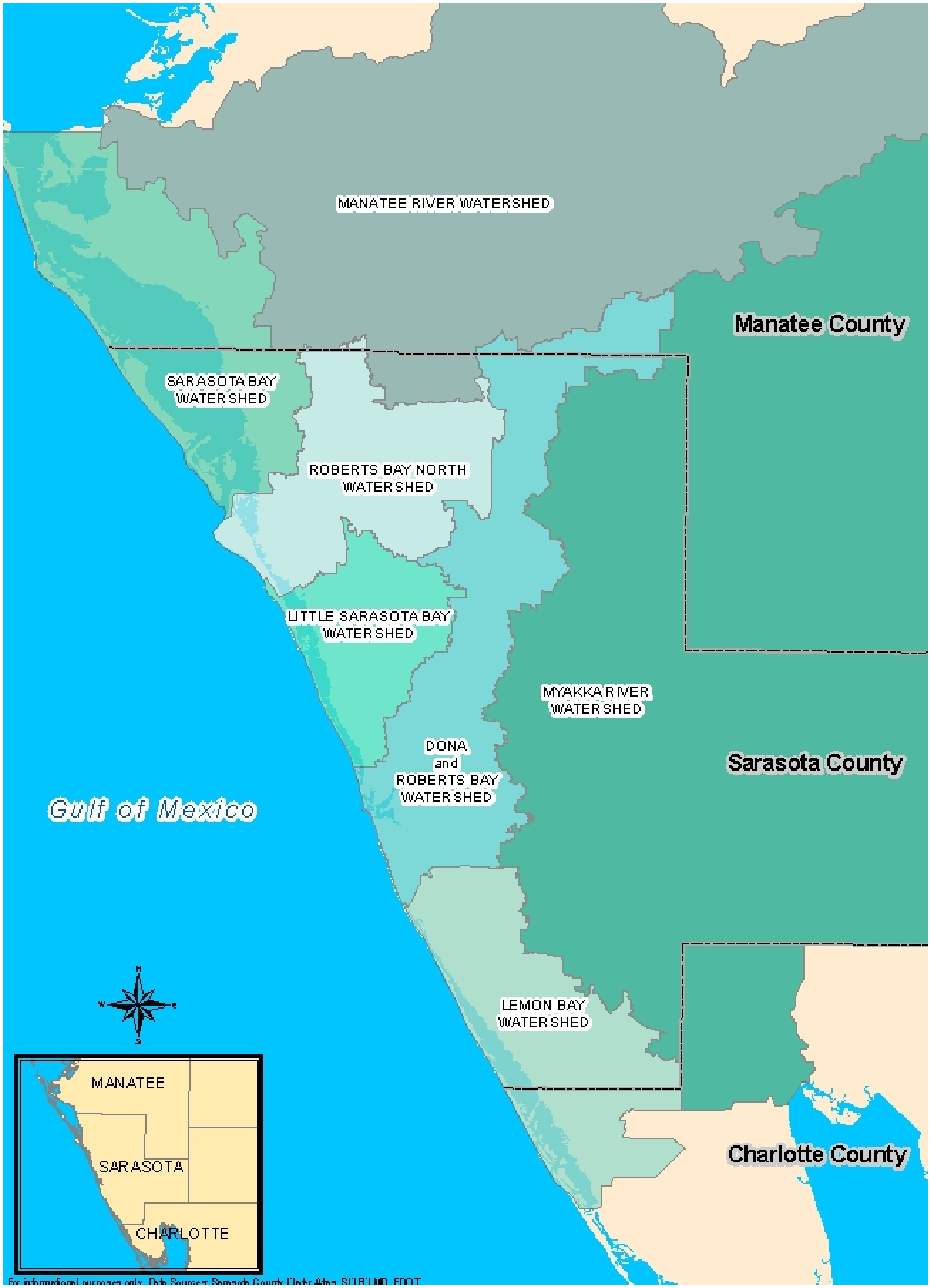


Figure 1-1 Sarasota County Major Watersheds

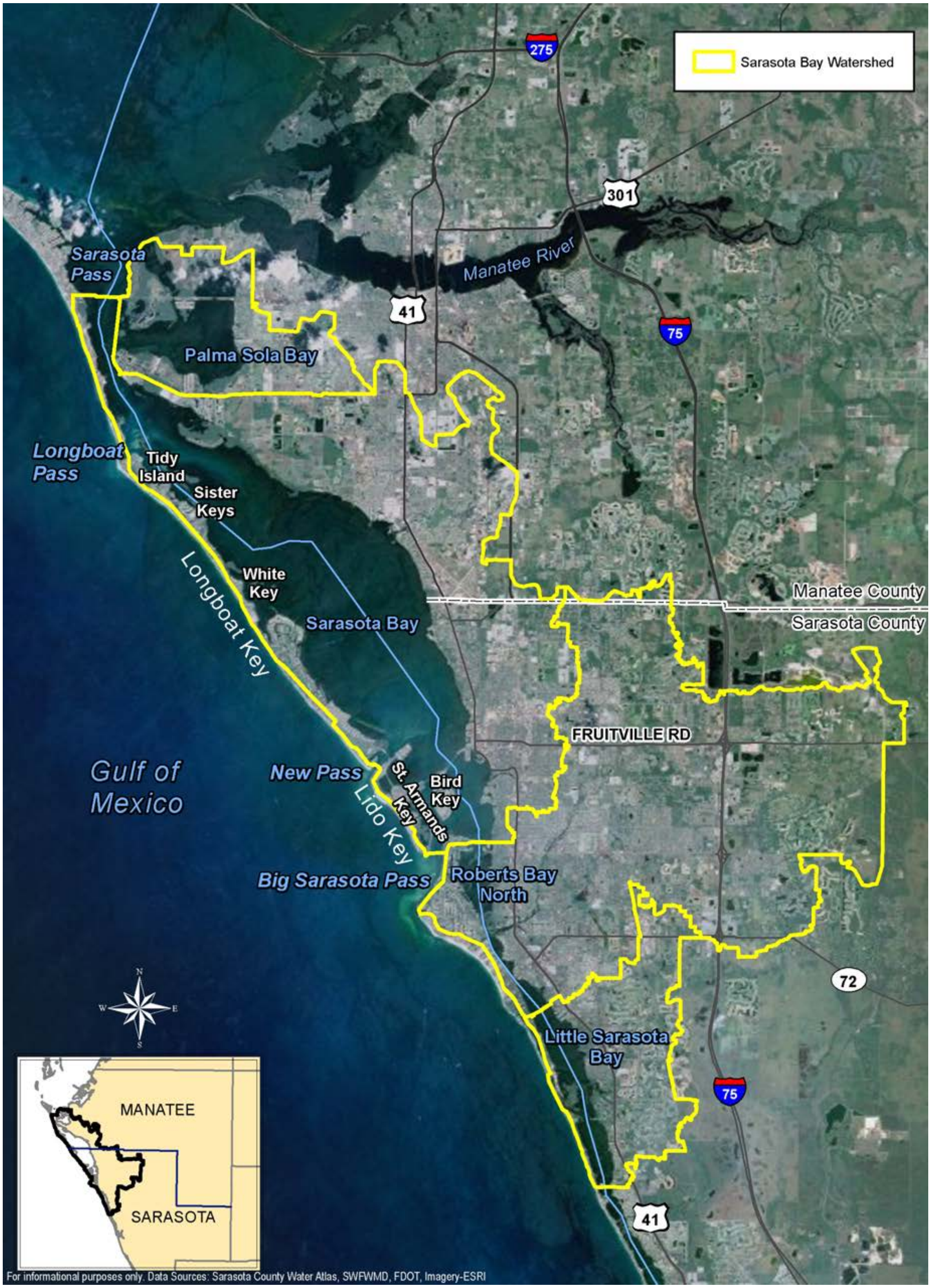


Figure 1-2 Sarasota Bay Watershed Segments

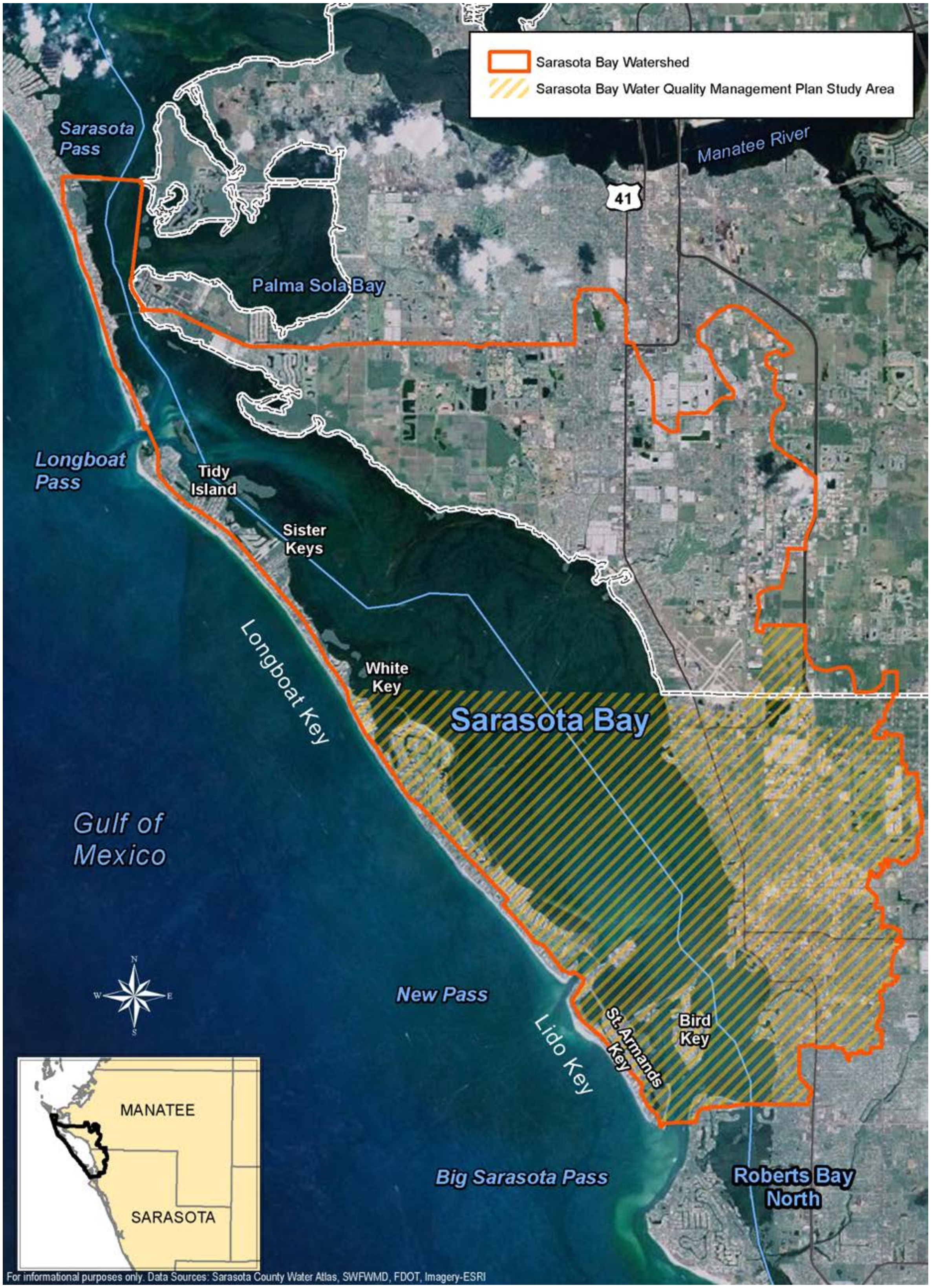


Figure 1-3 Sarasota Bay Water Quality Management Plan Study Area

2.0 PURPOSE AND OBJECTIVE

The Sarasota Bay WQMP is a regional initiative that promotes and furthers implementation of the *Sarasota County Comprehensive Plan*, the Sarasota Bay Estuary Program's (SBEP) *Comprehensive Conservation and Management Plan (CCMP)*, and the SWFWMD's *Southern Coastal Comprehensive Watershed Management Plan*, and the SWFWMD's *Sarasota Bay Surface Water and Improvement (SWIM) Plan*.

The purpose of this initiative is to develop and implement a watershed management plan for Sarasota Bay and its watershed to help achieve the following objectives:

- Improve water quality.
- Restore to the greatest extent possible the historic natural hydrologic regime.
- Protect property owners from flood damage.
- Develop ecosystem goals and targets based on the needs of environmental and biological indicators.
- Investigate potential sustainable surface water supply options consistent with and in support of the Goals, Objectives, and Policies of the Sarasota County Comprehensive Plan, SWFWMD's Regional Water Supply Plan, and the Southern Water Use Caution Area (SWUCA) Plan.

Sarasota County has embarked on a proactive approach to develop the proper science and community-based vision as a foundation for formulating, evaluating, prioritizing, and implementing watershed management actions. The following sections summarize physical and societal characteristics of the Sarasota Bay Watershed.

3.0 WATERSHED

Figure 3-1 View of Sarasota Bay from Bayfront Park (source: Jones Edmunds, 2010)

Located on the west-central coast of Florida, the Sarasota Bay Watershed is famous for its sandy beaches, keys, and sparkling blue water (Figure 3-1). The watershed spans from Anna Maria Sound in Manatee County, south to Roberts Bay North in Sarasota County, and includes the City of Sarasota to the east (Figure 3-2). The bay is bounded to the west by the barrier islands of Longboat Key and Lido Key, which are separated by New Pass. New Pass and Big Sarasota Pass, south of Lido Key, unite the bay with the Gulf of Mexico. Sarasota Bay is a highly productive coastal lagoon that hosts over a thousand different native species, including manatee, mullet, dolphin, spotted sea trout, snook, red drum, stone crab, blue crab, great blue heron, snowy egret, brown pelican, osprey, wood stork, roseate spoonbill, white ibis, and blue heron (SBEP, 2006; SWFWMD Watershed Excursion, n.d.).

3.1 POLITICAL JURISDICTIONS

The Sarasota Bay Watershed is regulated by the Florida Department of Environmental Protection (FDEP), SWFWMD, two counties (Sarasota and Manatee), the City of Sarasota, and the Town of Longboat Key. Approximately 55% of the watershed drainage area is in Manatee County and 45% is in Sarasota County. The bay itself is also divided about equally between the counties. Figure 3-2 shows the political boundaries, and Table 3-1 gives the acreage breakdown for each jurisdiction in the study area. Typically, the regulatory agencies with jurisdiction in the watershed coordinate their efforts to comprehensively manage the system.

As of 2000, the total watershed population was almost 110,000. About 40% of this population resided in the Sarasota County portion of the watershed (U.S. Census Bureau, 2000).

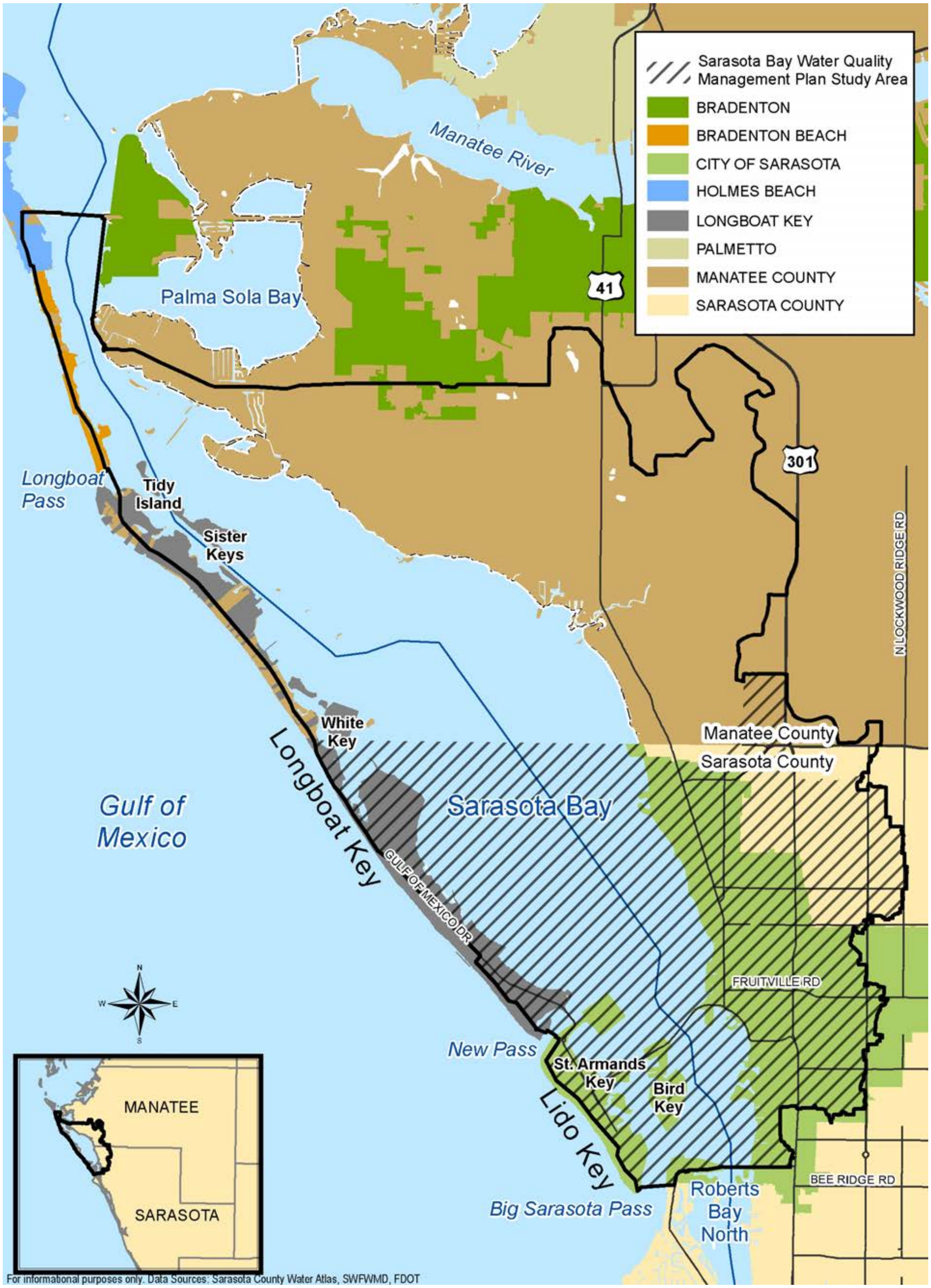


Figure 3-2 Political Boundaries in the Sarasota Bay Watershed

Table 3-1 Political Jurisdictions

	Sarasota Bay Watershed Study Area (21,413 acres)		Sarasota Bay Watershed Total Area (49,913 acres)	
	Acres	Percent	Acres	Percent
Bradenton	0	0%	192	0%
Bradenton Beach	0	0%	180	0%
City of Sarasota	6,634	31%	6,634	13%
Holmes Beach	0	0%	140	0%
Longboat Key	1,102	5%	1,926	4%
Manatee County	440	2%	28,504	57%
Sarasota County	20,974	98%	21,409	43%

Each regulatory agency is responsible for the health of the bay and can regulate specific activities throughout the watershed. In general, State regulations should be followed unless one of the counties has adopted a more stringent rule. The same policy applies to cities within a county boundary; the more stringent regulations always take precedence.

Although each agency is responsible for the health of the bay, each agency's level of responsibility varies by the level of the agency's governing body. At the county level, Sarasota County has taken responsibilities that include:

- Teaching its citizens what they can do to improve the health of the watershed (Figure 3-3).
- Funding and implementing projects to improve water quality, water supply, natural systems, and flood protection.
- Researching new methods and practices for watershed management.
- Enforcing existing ordinances and passing additional ordinances to lessen the impacts caused by new developments.

Figure 3-3 Sarasota County Citizens Install a Monofilament and Recovery Recycling Bin

This WQMP discusses the goals and objectives for Sarasota County and the measures the County is taking to meet these goals. This plan does not encompass the portion of the Sarasota Bay Watershed in Manatee County; however, Manatee County is also taking measures to meet similar goals for Sarasota Bay.

3.2 WATERSHED HISTORY

Figure 3-4 Ancient Shell Mound 1 Mile North of Sarasota circa 1907 to 1908 (USGS)

Archaeological evidence suggests more than 10,000 years of occupation in the watershed by native peoples. Large mounds of fish bones and shells indicate that the fish in Sarasota Bay sustained these prehistoric human settlements (Figure 3-4). The first records of the Sarasota Bay Watershed date back to the European explorers in the early 1500s (Figure 3-5). Eventually, fishing camps called *ranchos* were established along the bay by American and Cuban fish and marine traders. These initial settlers were likely attracted to the area by the climate and the bounty of Sarasota Bay. Although the natural resources of the Sarasota Bay Watershed continued to attract some inhabitants to the coast, the Armed Occupation Act brought a multitude of European settlers to Florida in the late 1840s.

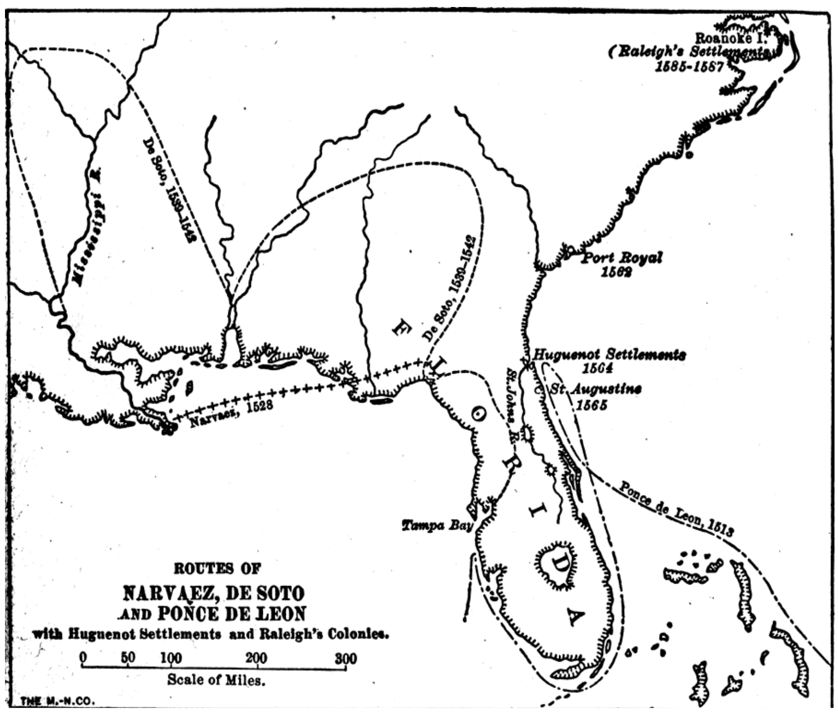


Figure 3-5 Routes of European Explorers
(Map Credit: Courtesy the private collection of Roy Winkelman)

By 1845 Florida had become a state and the U.S. Army had established Fort Armistead on the Sarasota Bay coast at what is known today as Indian Beach. In 1855, the settlers won their war with the Seminole Indian Tribe, and the small rural town of Sarasota, with its nearby ranches, farms, and fishing industry, continued to grow. By the late 1800s, hotel resorts were built and Sarasota Bay was advertised as a place for recreation in the northern states as well as in Scotland. By the beginning of the 20th century, paved streets, sidewalks, an electric plant, water and sewer services, and the Florida West Shore

Railway attracted even more settlers. The Town of Sarasota was incorporated in 1902 with John Hamilton Gillespie, a Scottish immigrant who built the first golf course, as mayor. By the early 1920s, John Ringling had purchased Bird Key, St. Armands Key, and a collection of small islands, which he filled with bay bottom dredging to create Lido Key (Section 3.3.3). He also had a bridge connecting the islands to the mainland constructed.

Originally part of Manatee County, Sarasota Bay and its watershed were divided at the current county line into Manatee County and Sarasota County in 1921 (Figure 3-6). The area experienced a period of rapid growth, namely along the coast and tributaries, in the early 1920s, tripling the population. As development continued, natural mangrove shoreline was replaced by concrete sea walls, destroying nursery areas essential to many marine species in Sarasota Bay. Ditching within tidal areas, a common mosquito control technique at the time, were constructed. Inland in the watershed, the natural tidal creeks of Hudson and Whitaker Bayous were dredged and extended and wetlands were filled to accommodate agriculture, businesses, and residences.

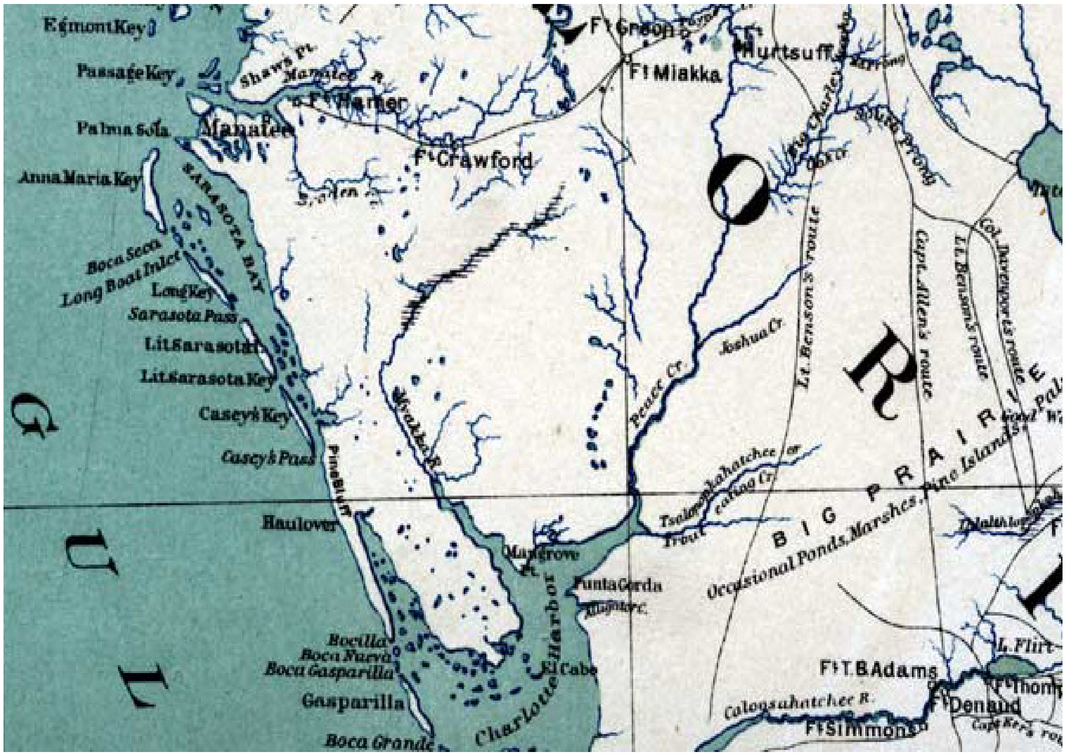


Figure 3-6 Manatee County circa 1865

(source: Julius Bien and Co., General Topographical Map Sheet XI, Atlas to Accompany the Official Records of the Union and Confederate Armies (New York, NY: US Government Printing Office, 1865)) (Florida Center for Instructional Technology, Retrieved 12/01/2010)

As development in the watershed continued, more mangroves, wetlands, and flatwoods that once provided habitat, flood control, and improved water quality were altered and degraded (Figure 3-7). By the mid-1950s, most of the coastal mainland was developed and growth persisted inland and across the barrier islands. Today, the watershed is almost entirely developed (Figure 3-8 and Figure 3-9).

Figure 3-7 Whitaker Bayou circa 1910 (Credit: Sarasota Historical Society) vs Whitaker Bayou circa 2004 (Credit: R T Clapp, Sarasota County Water Atlas)

Figure 3-8 Sarasota Bayfront, looking southwest circa 1935 (Credit: George I. Pete Esthus) vs circa 2000 (Sarasota County Water Atlas)

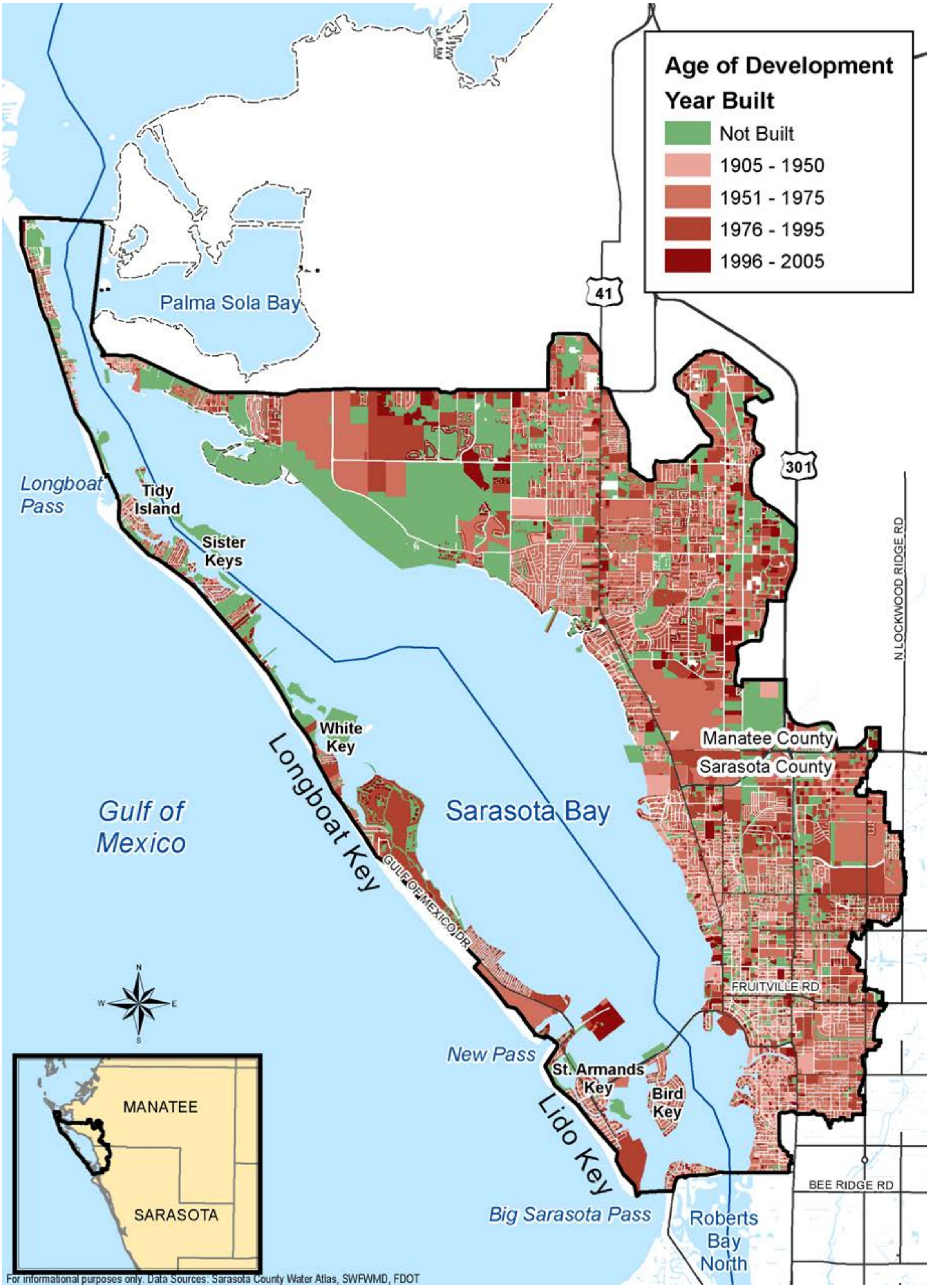


Figure 3-9 Sarasota Bay Watershed Age of Development

Early efforts at watershed management focused solely on flood control wherein the common practices of ditching, channelizing streams, and the use of structural measures hasten drainage. In addition, most of the development in the Watershed occurred before stormwater regulations were implemented in 1982, so stormwater from most of the Watershed's developments flows into the bay without treatment.

In 1989, Sarasota Bay was designated an "estuary of national significance" by the U.S. Congress as part of the Water Quality Act of 1987 and the SBEP was initiated. The SBEP was initially tasked with characterizing the environmental conditions of Sarasota Bay and formulating a comprehensive restoration and protection plan based upon this analysis. The CCMP was formally approved by the Governor of Florida and Administrator of the U.S. Environmental Protection Agency (USEPA) in 1995. The CCMP recommends that specific actions be taken by local governments and State and Federal agencies to improve and protect the bay.

One of the main challenges of protecting the water quality in the Watershed is to decrease the amount of stormwater runoff to limit the amount of freshwater, sediments, and nutrients entering the streams and bay.

Since the late 1980s, wastewater pollution in the watershed has decreased as a direct result of the development of reclaimed water in combination with removing decrepit sewage treatment facilities and replacing leaking septic tanks. As a result, water quality, seagrass beds, and habitat for birds and fish have improved in Sarasota Bay; improvements include decreases in nitrogen levels, fewer impaired areas, and thousands of acres of new or improved seagrass beds. Although the entire bay currently meets State water quality standards, the Watershed still has numerous listed impairments. Appendix C (Water Quality) of this WQMP details the water quality conditions throughout watershed.

The challenge now is maintaining that progress, especially as development and redevelopment throughout the watershed continues. This plan will explore opportunities to implement stormwater treatment in already-developed areas throughout the watershed. Advances in stormwater system technology and building techniques, combined with today's more stringent building codes, can better help balance the needs of the environment with those of the community.

3.3 BOUNDARIES

For the purpose of this plan, the Sarasota Bay Watershed has been divided into four basins: the Whitaker Bayou basin, the Hudson Bayou basin, the Sarasota Bay Coastal basin, and the Sarasota Bay—Manatee County basin (Figure 3-10). The entire watershed covers an area of 49,913 acres in the southwest portion of Manatee County and the northwest portion of Sarasota County including most of the City of Sarasota. The Sarasota Bay Watershed is generally bounded by Roberts Bay North to the south, Anna Maria Sound to the north, Longboat Key to the west, and Beverly Terrace in Sarasota County and U.S. 301 in Manatee County to the east.

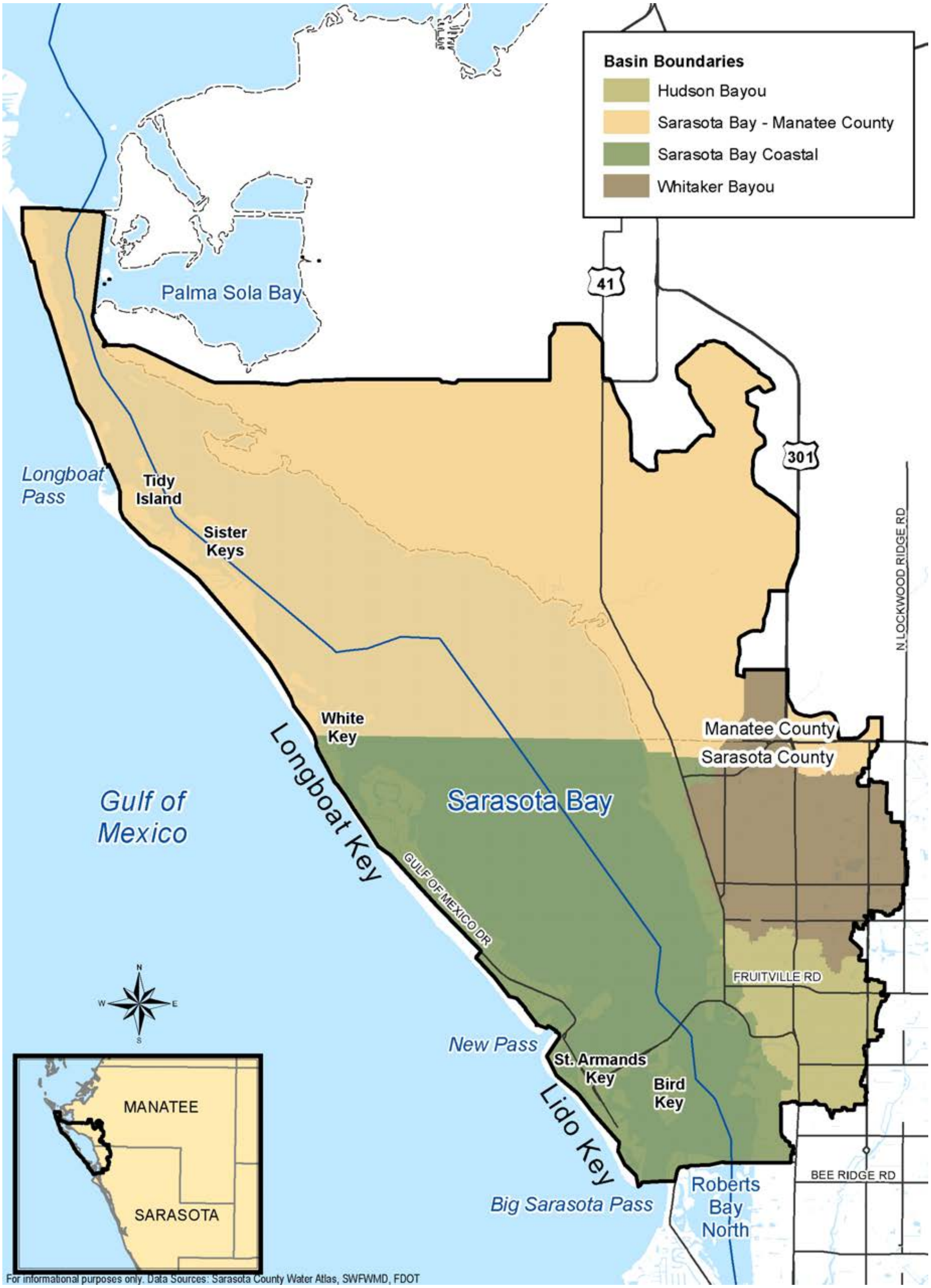


Figure 3-10 Sarasota Bay Watershed Basins

The focus of this WQMP is the Whitaker Bayou, Hudson Bayou, and Sarasota Bay Coastal Basins. The Whitaker Bayou basin consists of Whitaker Bayou, one of three major tributaries to Sarasota Bay, and its drainage basin, which extends from Sarasota County slightly north into Manatee County. The Hudson Bayou basin includes Hudson Bayou, another major tributary, and its drainage basin, which is entirely within the Sarasota City limits in Sarasota County. The Sarasota Bay Coastal basin includes the Sarasota County portion of the barrier islands, such as Lido Key, Bird Key, and southern Longboat Key. This basin also includes the Sarasota County coastal mainland and the Sarasota County portion of Sarasota Bay.

The following three subsections describe the three basins that are the focus of this WQMP—Whitaker Bayou, Hudson Bayou, and Sarasota Bay Coastal Basin.

3.3.1 Whitaker Bayou Basin

The Whitaker Bayou basin covers about 4,667 acres. Its surface water system has undergone significant alteration over the past century. The Sarasota County 1847 General Land Office Survey indicates that Whitaker Bayou only extended about a quarter of a mile inland from the bay (Figure 3-11). The survey also displays a separate waterway that extends inland from 0.25 mile northeast of the head of Whitaker Bayou. The 1959 U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS) Soil Survey Map (Figure 3-12) shows an area of moderately drained soil associated with scrubby flatwoods at the historical extent of the bayou. This survey also shows the second waterway that is illustrated on the 1847 survey extending northeast toward a poorly drained hammock soil, typically found adjacent to ponded areas or sloughs. Between these waterways is a somewhat poorly drained soil associated with flatwoods. Infiltration in this soil is affected by the seasonal fluctuation of the water table. These systems, therefore, could possibly have been joined during the wet season.

The 1944 Corps of Engineers, U.S. Army Map service topography map of Sarasota indicates that much of the watershed was already developed at the time the survey was done. Whitaker Bayou is shown to extend beyond the approximate 1847 location, possibly to include the second 1847 waterway. The bayou continues inland, branching off into several smaller waterways that go on several miles throughout the watershed (Figure 3-13 and Figure 3-14). Although there are far more ditches and canals today, this demarcation of the basin's major waterways very much resembles many current waterways (Figure 3-15).

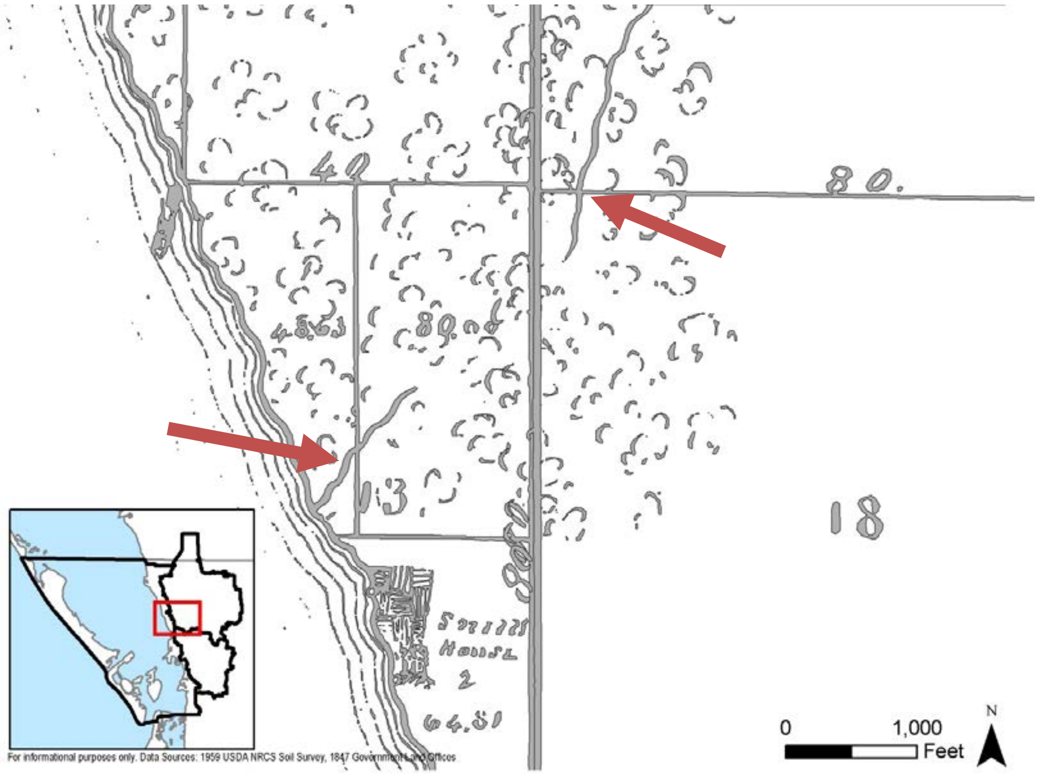


Figure 3-11 Whitaker Bayou Area Survey Circa 1847

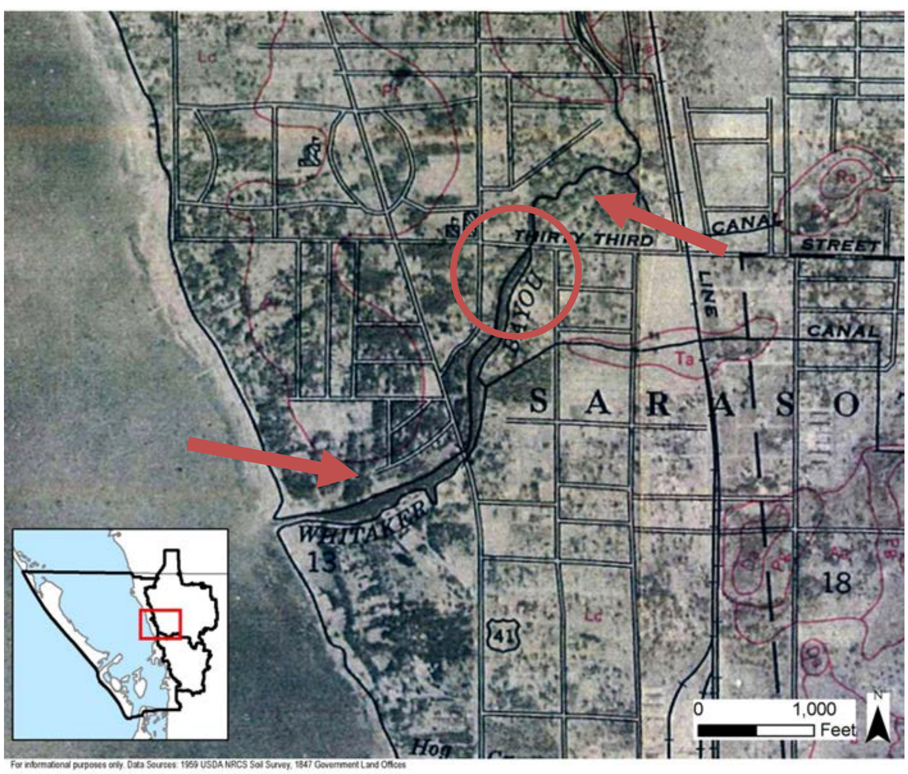


Figure 3-12 Whitaker Bayou Area 1959 USDA NRCS Soil Survey Map

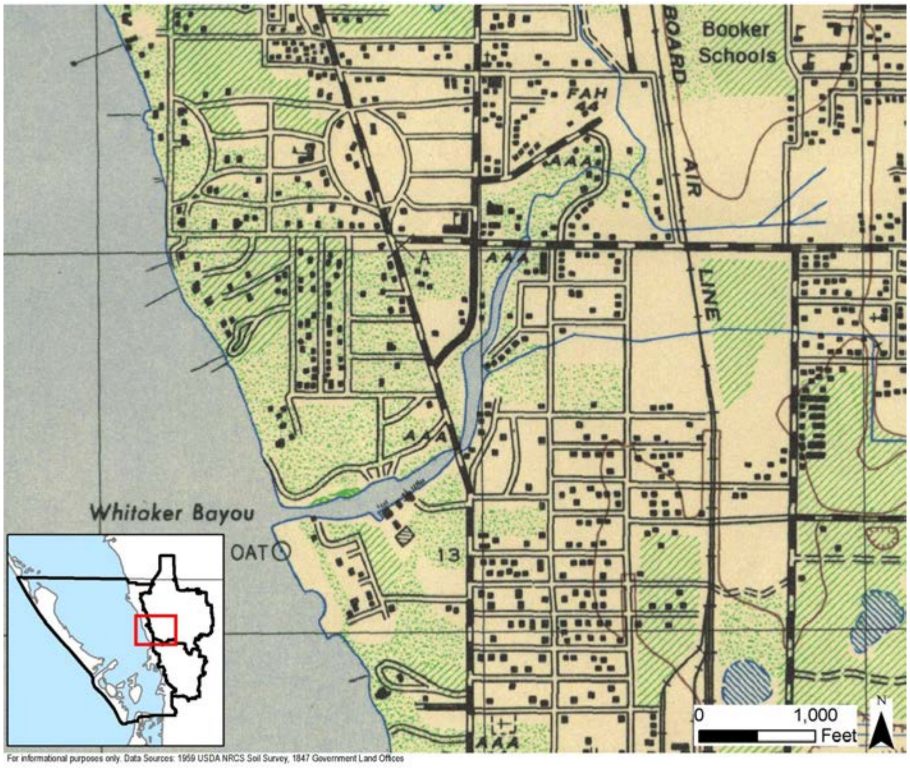


Figure 3-13 Whitaker Bayou Area Topography Circa 1944
(for figure legend see Figure 3-14)

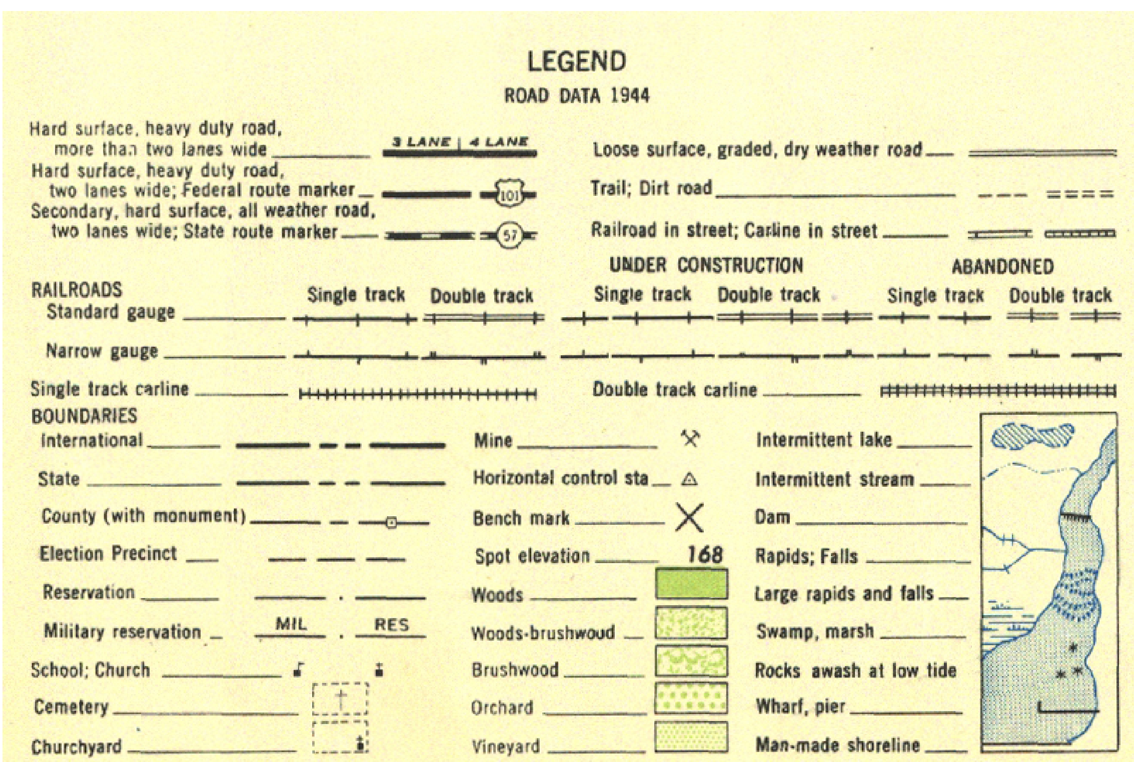


Figure 3-14 1944 Corps of Engineers, U.S. Army Map Service Topography Map Legend

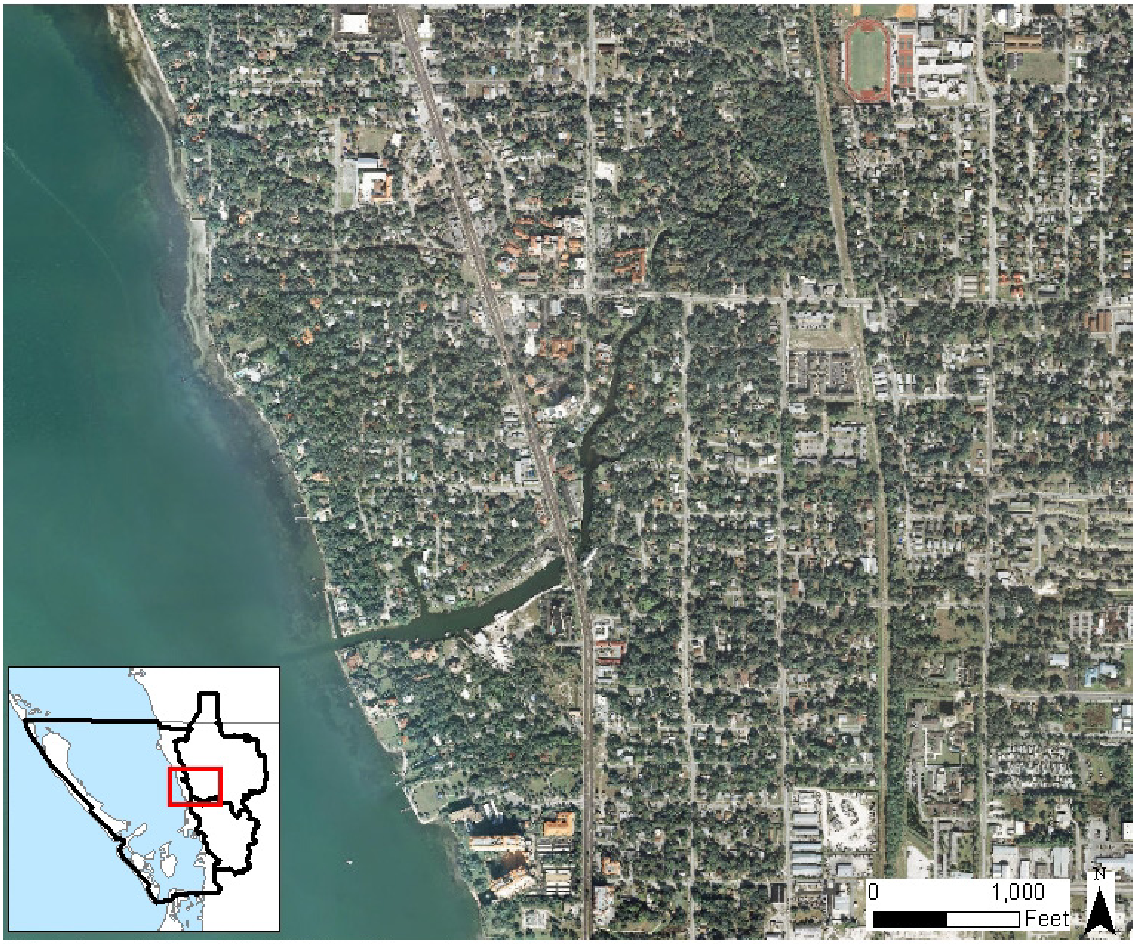


Figure 3-15 Whitaker Bayou Area Circa 2010

3.3.2 Hudson Bayou Basin

The Hudson Bayou basin covers an area of 2,392 acres and is entirely within the bounds of the City of Sarasota. Its surface water system has undergone significant alteration over the past century. The Sarasota County 1847 General Land Office Survey does not confirm Hudson Bayou but does show a few inland waterways (Figure 3-16). The 1959 USDA NRCS Soil Survey Map shows that Hudson Bayou extended about 1 mile inland from the bay through somewhat poorly drained soil associated with flatwoods (Figure 3-17). The survey also shows an area of well-drained soil likely consisting of scrub land north of the bayou, which continues north along the coast.

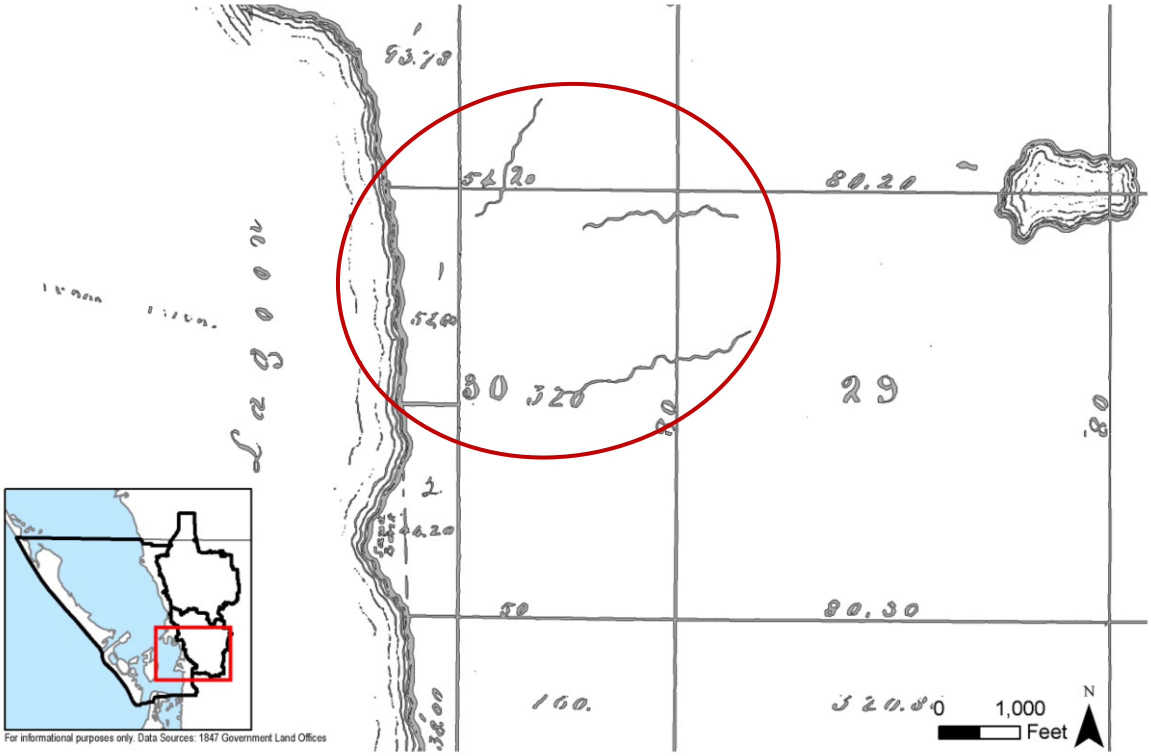


Figure 3-16 Hudson Bayou Area Survey Circa 1847

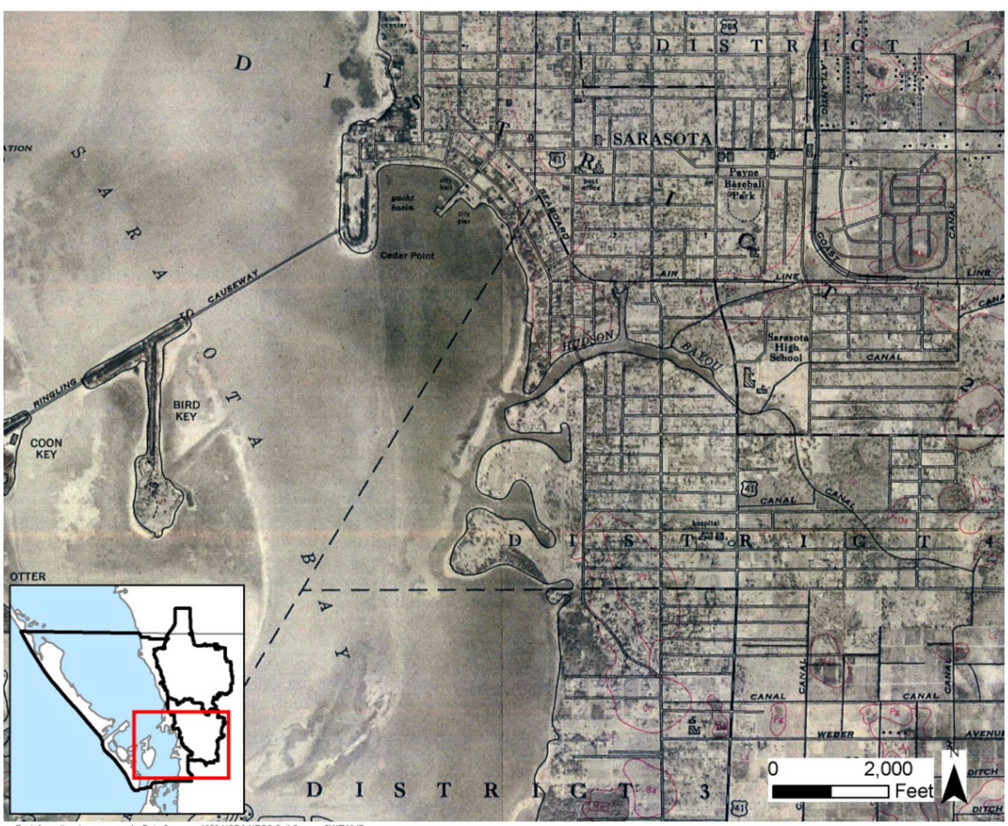


Figure 3-17 Hudson Bayou Area 1959 USDA NRCS Soil Survey Map

The 1944 U.S. Corps of Engineers, U.S. Army Map service topography map of Sarasota indicates that much of the Hudson Bayou basin was already developed at the time the survey was done. The bayou is shown to extend inland from the bay for about 1 mile and then branch out into several smaller waterways that continue several miles inland throughout the watershed (Figure 3-17 and Figure 3-18). This delineation of the waterways very much resembles the current Hudson Bayou basin waterways (Figure 3-19).

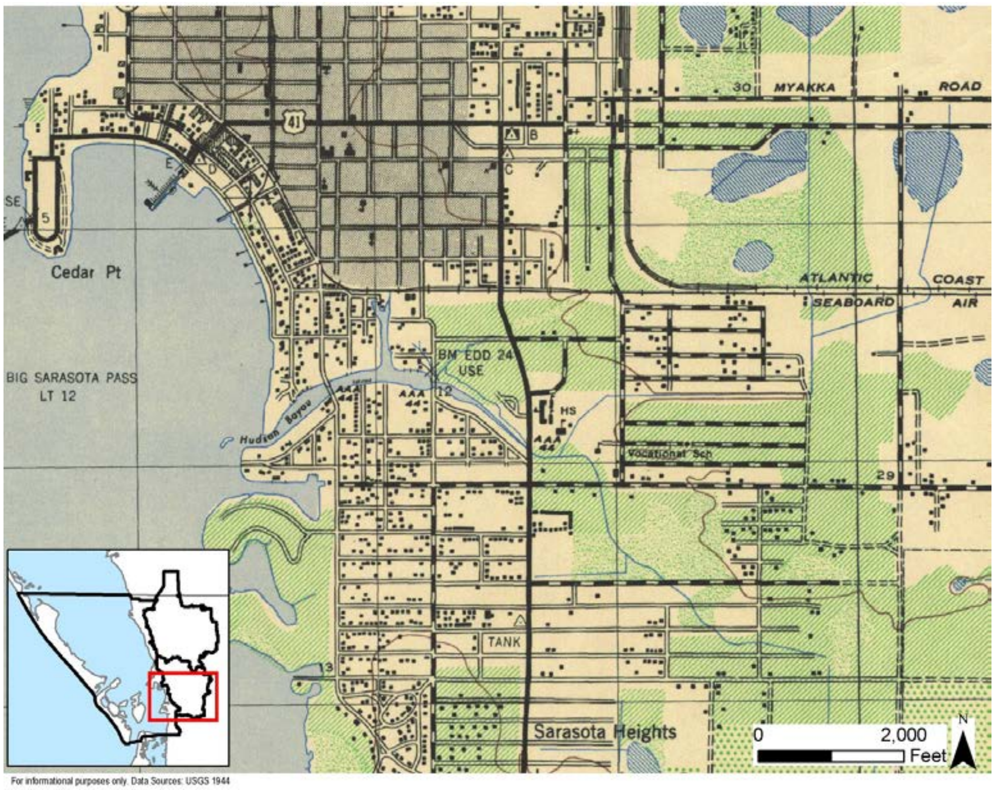


Figure 3-18 Hudson Bayou Area Topography Circa 1944
(for figure legend see Figure 3-14)

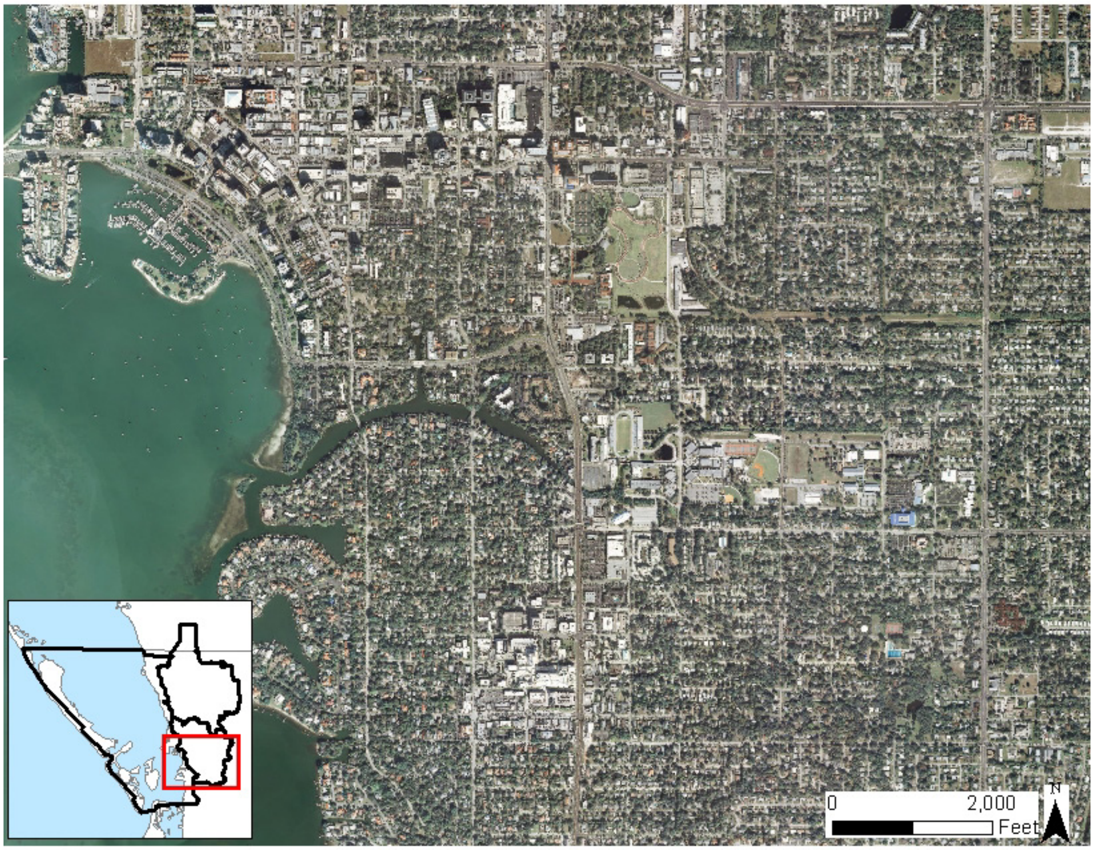


Figure 3-19 Hudson Bayou Area Circa 2010

3.3.3 Sarasota Bay Coastal Basin

The Sarasota Bay Coastal basin covers 14,963 acres. Sarasota Bay makes up roughly 75% of the basin, and the remainder consists of the barrier islands and coastal mainland that drain directly to the bay. The Sarasota County 1847 General Land Office Survey (Figure 3-20) shows a system of many barrier islands separated by two passes connecting Sarasota Bay to the Gulf of Mexico; however, drastic changes have occurred in this basin since that time.

In 1890, the U.S. Army Corps of Engineers began dredging what would eventually become the Gulf Intracoastal Waterway (ICW), which spurred development in the area. Shallow parts of the estuary were dredged and deposited to enlarge existing islands or create new ones. In the early 1900s, Lido Key was created from a collection of smaller islands. Shortly after, a bridge connecting the mainland to the islands was constructed. By the mid 1900s most of the coastal mainland had been developed and barrier islands had been enlarged and platted for development (Figure 3-21). In the late 1950s, the estuary around Bird Key was dredged and filled to create a subdivision more than ten times the size of the original island. These changes can be seen in Figure 3-22 and Figure 3-23.

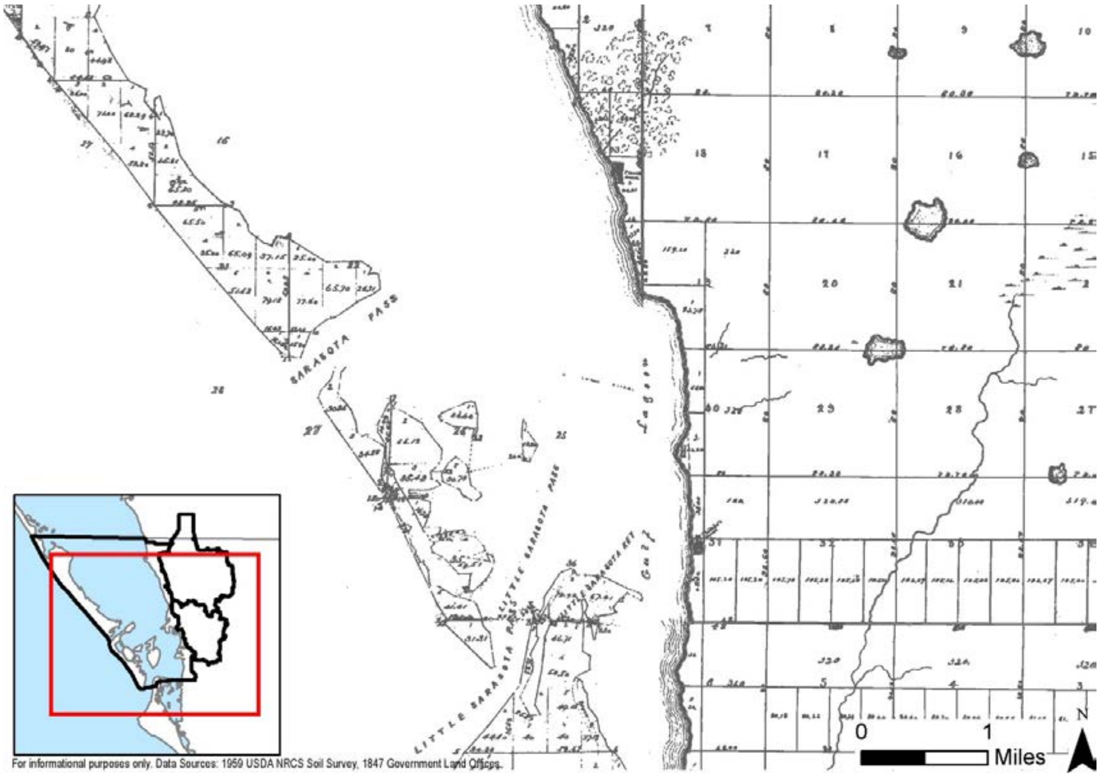


Figure 3-20 Sarasota Bay Coastal Basin Area Survey Circa 1847

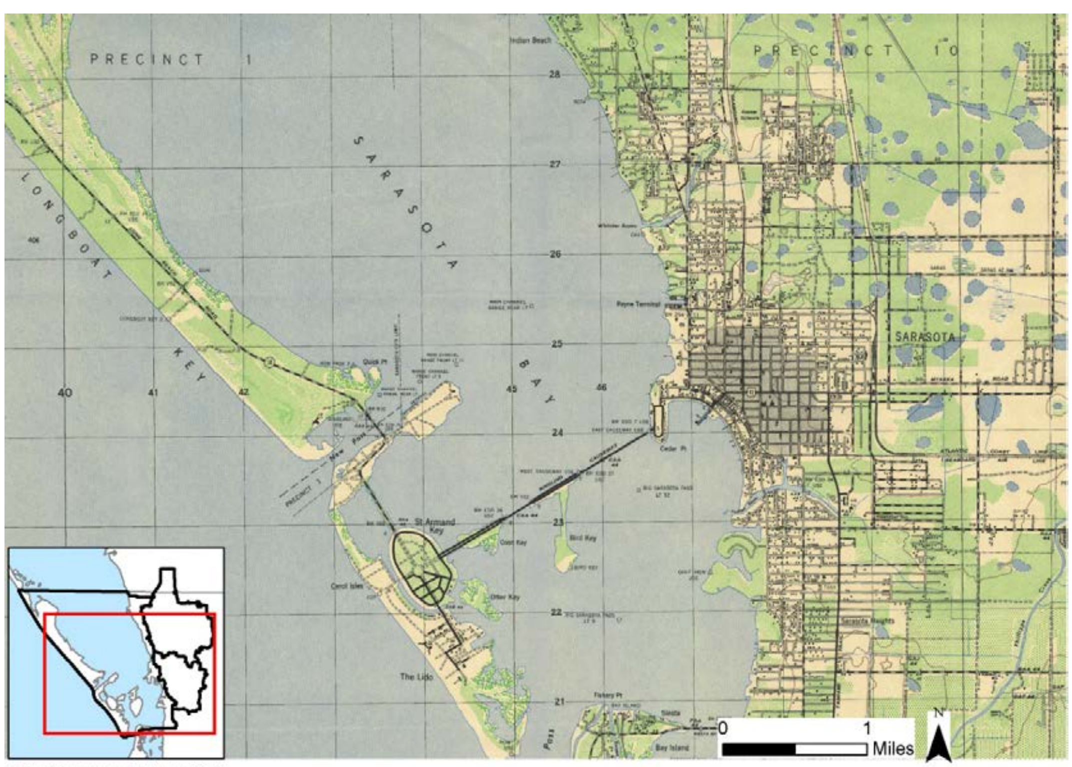
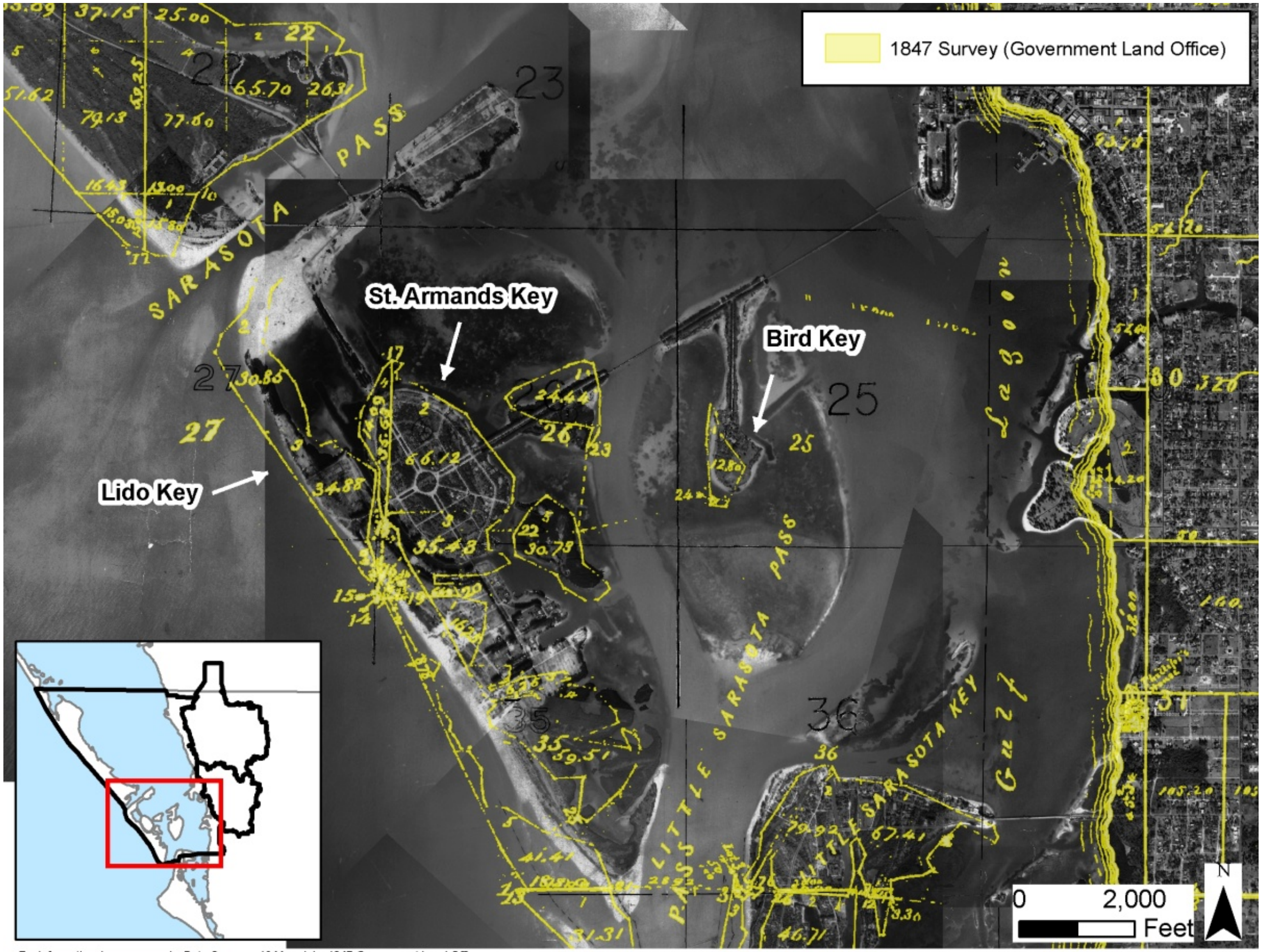


Figure 3-21 Sarasota Bay Coastal Basin Area Survey Circa 1944
(for figure legend see Figure 3-14)



For informational purposes only. Data Sources: 1944 aerials, 1847 Government Land Offices

Figure 3-22 Sarasota Bay Coastal Basin Area 1847 Survey Over 1948 Aerial

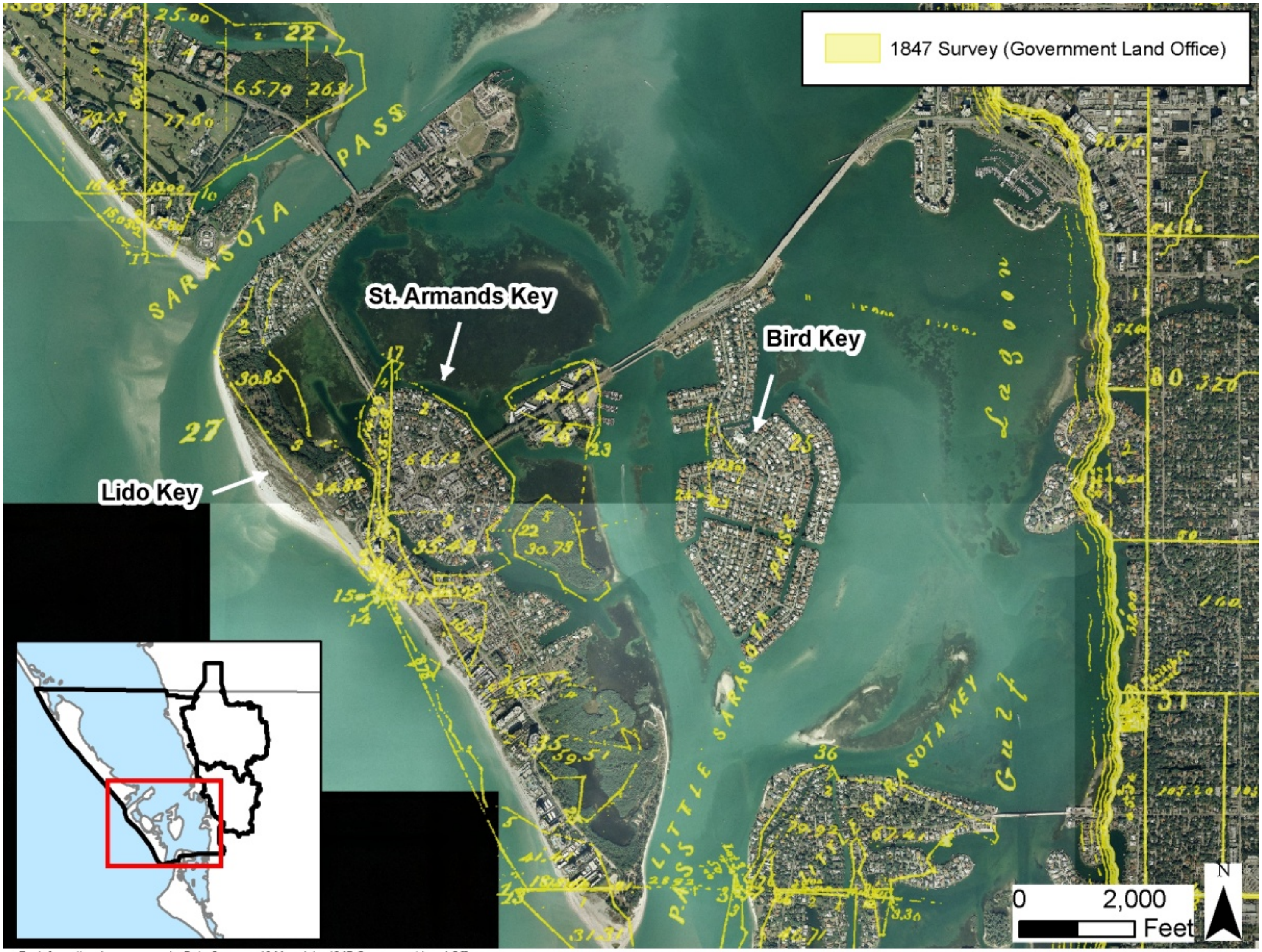


Figure 3-23 Sarasota Bay Coastal Basin Area 1847 Survey Over 2009 Aerial

3.4 LAND USE

Land use characteristics of a watershed significantly affect water quality, water quantity (flow), habitat, and flooding risks. The spatial distribution and acreage of different current land use categories were identified using the SWFWMD's 2008 land use coverage contained in the District's geographic information system (GIS) library. SWFWMD land use data are based on the Florida Department of Transportation (FDOT) "Florida Land Use and Cover Classification System" (FLUCCS). These FLUCCS classes were aggregated into categories, which are presented in Table 3-2. Almost half of the watershed is open water and about a quarter is residential. Only about 10% of the watershed is undeveloped, most of which is in the Manatee County portion of the watershed. Current land use coverage is shown in Figure 3-24 and described in Table 3-2 and Table 3-3.

Table 3-2 Sarasota Bay Current Land Use Classification (FDOT 1999)

Land Use	FLUCCS
Commercial	1400, 1700
Low-Density Residential	1100
Medium-Density Residential	1000, 1200
High-Density Residential	1300
Golf Course	1820
Pasture	2100, 3300, 7400
Agriculture	2200, 2300, 2400, 2500, 2550
Row Crops	2000, 2140
Light Industrial	1500
Transportation/Utilities	8100, 8200, 8300
Forest, Open area, and Park	1800, 1900, 2600, 3100, 3200, 4000, 4100, 4110, 4120, 4200, 4340, 4400
Wetlands	6000, 6100, 6110, 6120, 6150, 6200, 6210, 6300, 6410, 6420, 6430, 6440, 6450, 6600
Water	1600, 5100, 5200, 5300, 5330, 5340, 5400, 5410, 5720, 6530

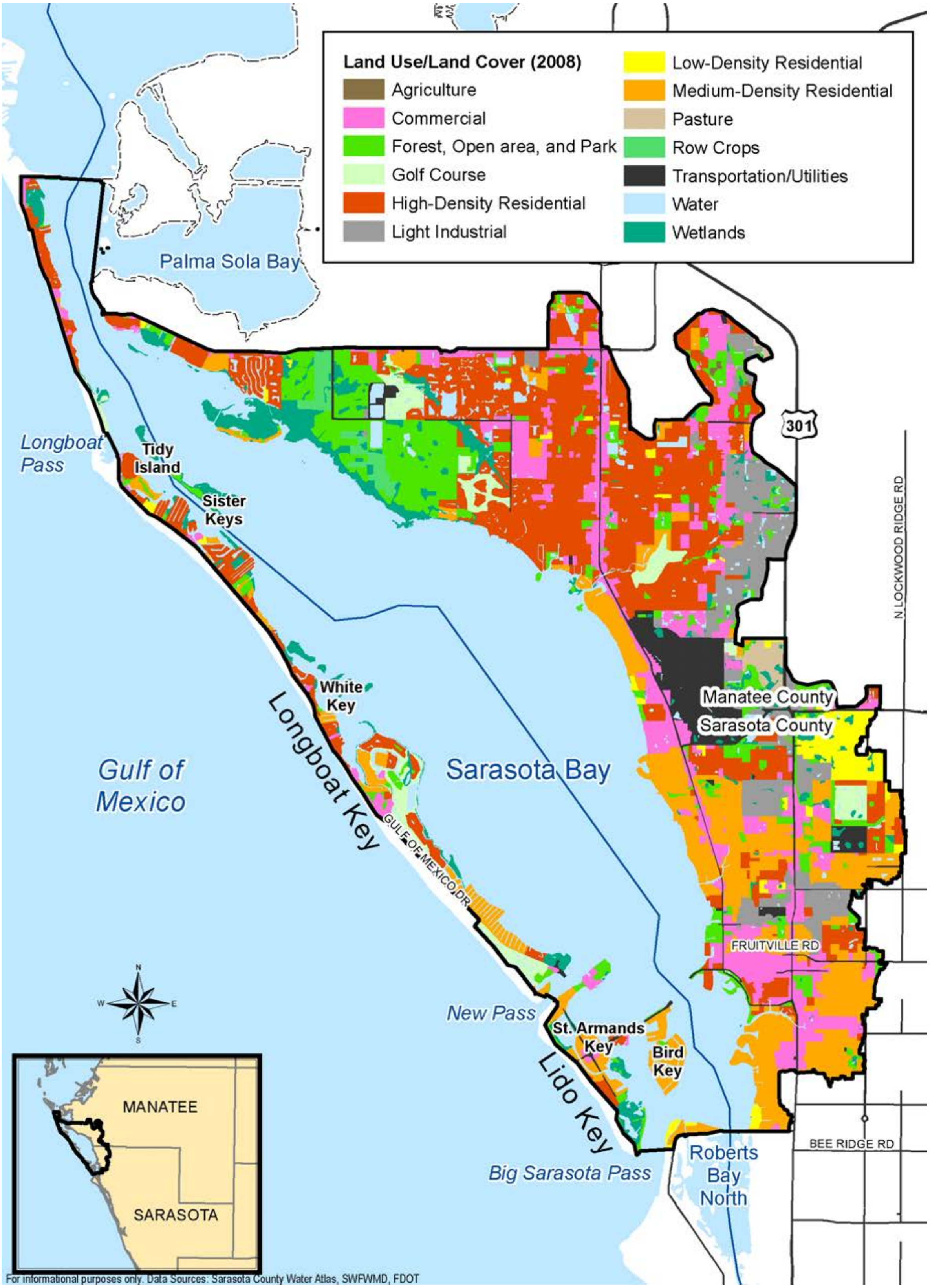


Figure 3-24 Sarasota Bay Watershed Land Use Circa 2008

Table 3-3 Sarasota Bay Watershed Current Land Use (SWFWMD 2008)

Land Use	Basin								Sarasota Bay Watershed	
	Hudson Bayou		Whitaker Bayou		Sarasota Bay Coastal		Sarasota Bay - Manatee County			
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	0	0%	1	<1%	0	0%	23	0%	25	0%
Commercial	768	32%	409	9%	458	3%	2,012	7%	3,647	7%
Low-Density Residential	0	0%	349	7%	63	0%	369	1%	780	2%
Medium- Density Residential	988	41%	1,227	26%	1,619	11%	811	3%	4,645	9%
High-Density Residential	215	9%	651	14%	436	3%	6,103	21%	7,405	15%
Golf Course	0	0%	127	3%	317	2%	461	2%	905	2%
Pasture	0	0%	181	4%	0	0%	24	0%	205	<1%
Row Crops	0	0%	0	0%	0	0%	291	1%	291	1%
Light Industrial	169	7%	673	14%	0	0%	1,168	4%	2,010	4%
Transportation/ Utilities	109	5%	338	7%	148	1%	1,096	4%	1,691	3%
Forest, Open Area, and Park	121	5%	423	9%	284	2%	2,186	8%	3,014	6%
Wetlands	10	0%	184	4%	218	2%	1,437	5%	1,849	4%
Water	26	1%	103	2%	10,800	75%	12,524	44%	23,453	47%

3.5 TOPOGRAPHY

The Sarasota Bay Watershed is relatively flat and ranges in elevation from sea level in the west to a maximum of approximately 35 feet *National Geodetic Vertical Datum (NGVD)* at the northeast watershed boundary (Figure 3-25). The average slope of the watershed land surface is approximately 0.004 feet/foot. The barrier islands are low-lying and do not exceed 5 feet NGVD throughout.

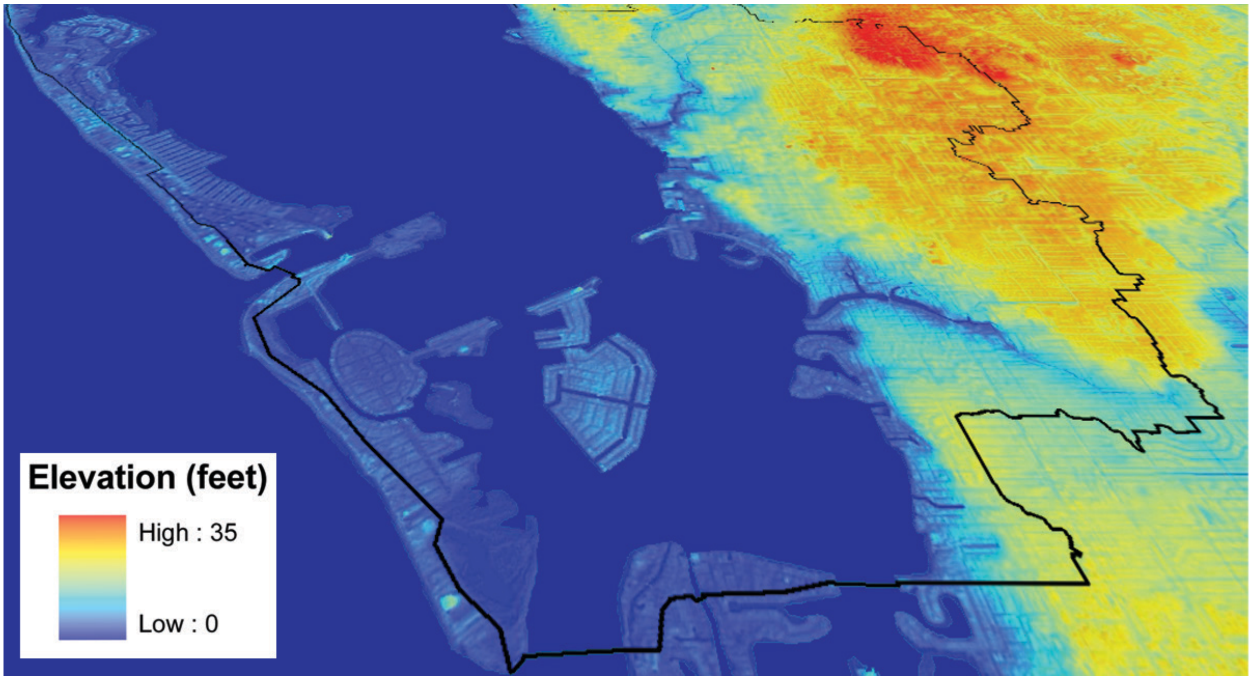


Figure 3-25 Sarasota Bay Watershed Topography

3.6 SURFACE HYDROLOGY

Rainfall and surface water runoff are critical to maintaining the natural resources of any estuarine system and its supporting watershed. Sarasota County's surface water hydrologic setting includes an average annual rainfall of 53 inches, although this depth can vary significantly from year to year (SWFWMD, 2010). Intra-annual variability is also high, with about 61% of a typical annual rainfall occurring during the wet season months of June through September.

The surface water runoff from the rainfall flows across the watershed terrain through ditches, storm drains, creeks, and wetlands, and eventually into Sarasota Bay. Sarasota Bay has three major tributaries that connect to the bay: Hudson Bayou and Whitaker Bayou in Sarasota County and Bowlees Creek in Manatee County.

The Sarasota Bay Watershed once consisted of an expanse of pine flatwoods and other upland systems, numerous wetlands, and marshy tributaries that slowly drained into the bay. These native natural systems provided habitat, flood control, and improved water quality. Many of these natural systems were altered and degraded by urban and agricultural development over the past 100 years, resulting in major changes in the watershed. Drainage activities, flood-control projects, and the construction of impervious surfaces have changed the natural hydrology of the watershed, resulting in higher peaks in the natural flow and increases in the delivery of pollutants to the bay. Hydrologic alterations within the Sarasota Bay Watershed include:

Widespread alterations to the surface hydrology of the watershed have occurred over the past decades, resulting in significant changes to the volume and timing of freshwater inflows to the bay.

- Reducing on-site rainfall storage by filling and ditching natural depressions and wetlands.
- Increasing stormwater runoff rates by channelizing natural streams and creating networks of interconnected ditches that flow to the bay.
- Reducing infiltration by introducing pavement and other impervious surfaces.
- Altering flow patterns by constructing water control weirs and increasing sedimentation in the channel from upland erosion.

3.7 PHYSIOGRAPHIC REGION

The Sarasota Bay Watershed lies entirely within the Southern Gulf Coastal Lowlands subdivision of the mid-peninsular physiographic region of Florida (White, 1970; SWFWMD, 2000). The Gulf Coastal Lowlands is a broad, gently sloping marine plain characterized by broad flatlands with many sloughs and swampy areas (White, 1970). Some of these areas have been drained by ditches and canals, especially near the coast. Soils in the Southern Gulf Coastal Lowlands are generally unconsolidated sands that increase in clay content with depth. Organic soils are found underlying wetland areas.

3.8 GEOLOGY AND HYDROGEOLOGY

The Sarasota Bay Watershed lies within an area designated by SWFWMD as the Southern Water Use Caution Area (SWUCA) (SWFWMD, 2006). A *Water Use Caution Area* is an area where water resources are or are expected to become critical within the next 20 years. Hydrogeologic features of the SWUCA and the watershed include three distinct aquifer systems: the surficial, intermediate, and the Floridan (Figure 3-26 and Figure 3-27). The *surficial aquifer* is an unconfined system that overlies the intermediate aquifer system and ranges in thickness from a few feet to over 60 feet in the watershed. Hydraulic properties of the surficial aquifer system determined from aquifer tests, laboratory tests, and model simulations vary considerably across the study area (Barr, 1996).

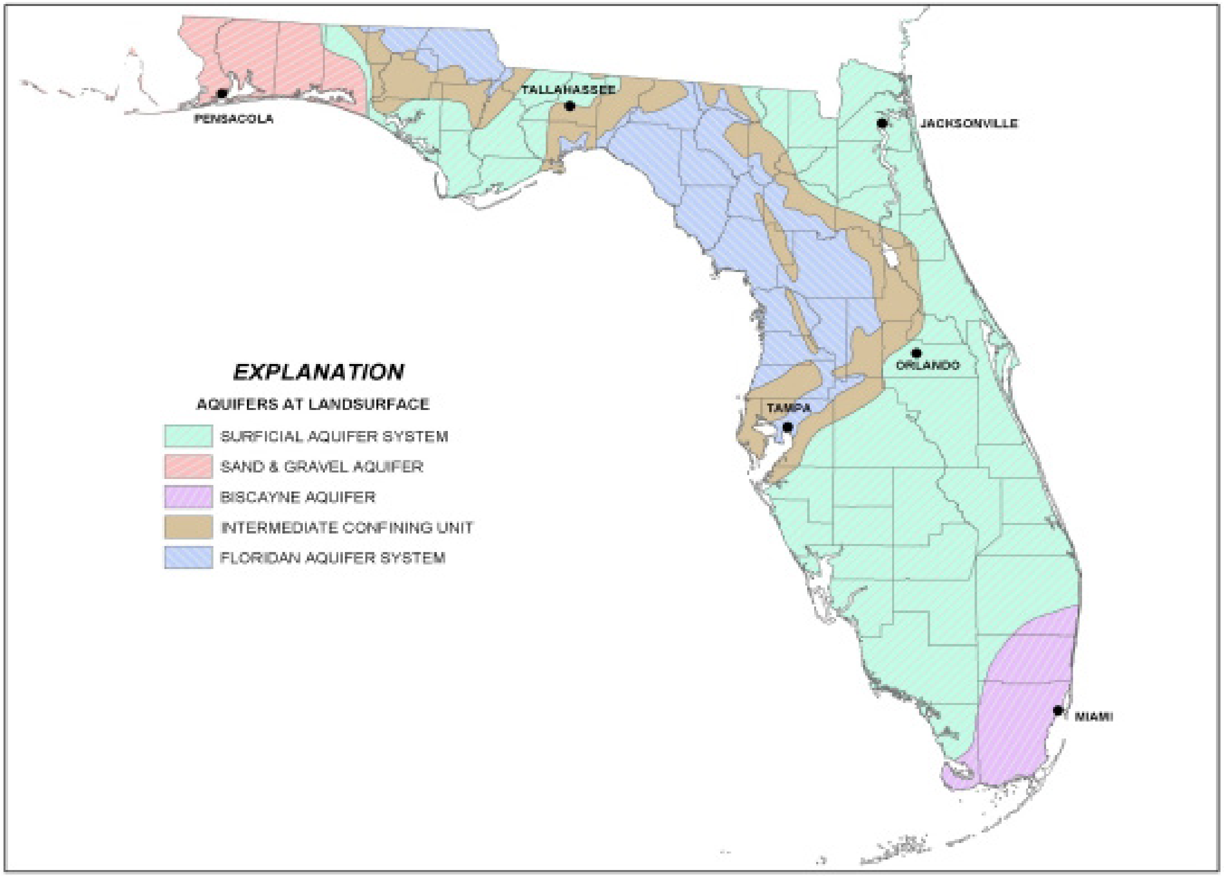


Figure 3-26 Aquifers at Land Surface
(source: http:\\www.dep.state.fl.us, updated 1/3/07)

Series	Stratigraphic unit	Hydrogeologic unit	Lithology
Holocene and Pleistocene	Undifferentiated surficial deposits (including the Caloosahatchee Formation and the Tamiami Formation)	Surficial aquifer system	Undifferentiated sand with some limestone and shell beds.
Pliocene	Undifferentiated surficial deposits (including the Caloosahatchee Formation and the Tamiami Formation)	Intermediate aquifer system: Confining unit; Tamiami/Peace River zone (PZ1)	Sand, limestone, and shell beds. Thick clay near top.
Miocene	Hawthorn Group: Peace River Formation	Intermediate aquifer system: Confining unit	Mostly limestone, sandy limestone and sand. Phosphatic in part. Dolomite beds common. Clayey in middle and lower parts.
Miocene	Hawthorn Group: Undifferentiated Arcadia Formation	Intermediate aquifer system: Upper Arcadia zone (PZ2)	
Oligocene	Hawthorn Group: Undifferentiated Arcadia Formation (Tampa Member / Nocatee Member)	Intermediate aquifer system: Confining unit; Lower Arcadia zone (PZ3); Confining unit	Limestone, sandy limestone and sand. Clay beds in upper and lower parts.
Oligocene	Suwannee Limestone	Upper Floridan aquifer	Granular, fossiliferous limestone, with trace amounts of sand and clay in the upper portions. Dense dolostone and indurated limestone, mostly pelletal
Eocene	Ocala Limestone	Upper Floridan aquifer	
Eocene	Avon Park Formation	Upper Floridan aquifer	

Figure 3-27 Hydrogeologic Framework and Geochemistry of the Intermediate Aquifer System in Parts of Charlotte, De Soto, and Sarasota Counties, Florida (from Torres et al., 2001)

The *intermediate aquifer system* is a confined aquifer system between the surficial and the Upper Floridan aquifers and is composed of alternating confining units and permeable zones. The intermediate aquifer system has three major permeable zones that exhibit a wide range of hydraulic properties. Horizontal flow in the intermediate aquifer system is northeast to southwest. Most of the Study Area is in a discharge area of the intermediate aquifer system, meaning that water pressure is higher at lower elevations, causing net upward flow of groundwater (Barr, 1996).

Under natural conditions, shallow groundwater ranges from fresh in the surficial aquifer system and upper permeable zones of the intermediate aquifer system to moderately saline in the lower intermediate aquifer. Water quality data collected in coastal southwest Sarasota County indicate that groundwater withdrawals from major pumping centers have resulted in lateral seawater intrusion and upconing into the surficial and intermediate aquifer systems (Barr, 1996).

The intermediate aquifer system is underlain by the Upper Floridan aquifer, which consists of a thick, stratified sequence of limestone and dolomite. The Upper Floridan aquifer is the most productive aquifer in the Study Area; however, its use is generally restricted because of poor water quality. Interbedded clays and fine-grained clastics separate the aquifer systems and permeable zones (Torres et al., 2001).

3.9 SOILS AND SEDIMENT

The subsurface geology and subsurface features of Sarasota Bay and its watershed are directly related to historic sea level fluctuations. The underlying geologic formations developed as the result of physical, chemical, and biological processes. These processes included near-shore deposition of sediment, precipitation of chemicals directly from seawater, and accumulation of the skeletal remains of marine organisms. These geologic formations range in age from the Oligocene epoch (38 to 22.5 million years ago) to the Holocene epoch (10,000 years ago to present) (Sarasota County Planning and Development Services, 2007, p. 2-9).

Surface and near-surface sediments consist of quartz sand, consolidated and unconsolidated shell beds, clays, limestone, and dolomite. Stratified layers of relatively pure limestones and phosphatic clays (clays rich in phosphate, salts of phosphoric acid) developed gradually in the watershed. Quartz sands that eroded from exposed higher land were also deposited. These near-surface sediments, which occur within approximately 1,500 feet of ground elevation, were of major importance to settlement because of their capacity to store and/or contain potable water. In addition to supplying water, the marine sediments provide phosphate and other mineral resources (Sarasota County Planning and Development Services, 2007, p. 2-9). The watershed's phosphorus-rich geology and soils significantly influence the total phosphorus concentrations in the Sarasota Bay tributaries and estuary.

Much of the 'soils' in the watershed, generally described as surficial sediments, represent only slightly weathered parent material or modern sediments, some of which are still being formed, rather than layers of mixed mineral and organic materials. The soil types in the watershed include limestone rock, calcareous muds (marls), sands (marine terraces), organic materials (peats and muck), and mixed solids (Duever et al., 1979; SWFWMD, 1980).

An additional substrate is made up of altered or Arent soils, e.g., dredge and fill, shell mounds, and landfills (Herwitz, 1977). Examples are the inland and coastal artificially constructed canals. Modification of natural tidal tributaries to finger canals is prevalent in developments. There is a shift away from autochthonous (local) sediment production in the natural waterways to a primarily allochthonous (transported) source of sediments in the canal system. Marls and sand marls generally range from 6 inches to 3 feet in depth, have low relief, and because of low water permeability are often wet (SWFWMD, 1980).

Each individual soil can be classified into a hydrologic soil group (HSG) based on its runoff-producing characteristics. The most important of these characteristics is the inherent capacity of the soil to permit infiltration when bare of vegetation.
The four major hydrologic soil groups are:

- **Group A** (low runoff potential)—Soils with high infiltration rates even when thoroughly wetted. The soils are composed primarily of sands and gravel that are deep and well to excessively drained. These soils have a high rate of water transmission. Minimum infiltration rate = 0.30-0.45 inch/hour.
- **Group B** (low to moderate runoff potential)—Soils with moderate infiltration rates when thoroughly wetted. The soils are typically moderately fine to moderately coarse in texture and have a moderate rate of water transmission. Minimum infiltration rate = 0.15-0.30 inch/hour.
- **Group C** (moderate to high runoff potential)—Soils with slow infiltration rates when thoroughly wetted, often with a layer of soil that impedes the downward movement of water. The soils typically have a moderately fine to fine texture and a slow rate of water transmission. Minimum infiltration rate = 0.05-0.15 inch/hour.
- **Group D** (high runoff potential)—Soils with very slow infiltration rates when thoroughly wetted. The soils are primarily clay soils with a high permanent water table or shallow soils over nearly impervious materials, such as a clay pan or clay layer. These soils have a very slow rate of water transmission. Minimum infiltration rate = 0.0-0.05 inch/hour.

Some soils are assigned to two soil groups (e.g., B/D). The first letter applies to the drained condition and the second to the undrained condition. The distribution of HSGs for the Sarasota Bay Watershed is mapped in Figure 3-27. This information was developed based on SCS Soil Survey with Geographical Information Systems (GIS) coverages developed by SWFWMD. The majority of the portion of the watershed that is not open water is classified as HSG B/D—well-drained much of the year but poorly drained due to the high water table during the wet season. Only 1% of the soils in the watershed are classified as very well-drained (HSG A), while about 16% are classified as poorly to very poorly drained (HSG C, C/D, or D) (Table 3-4 and Figure 3-28).

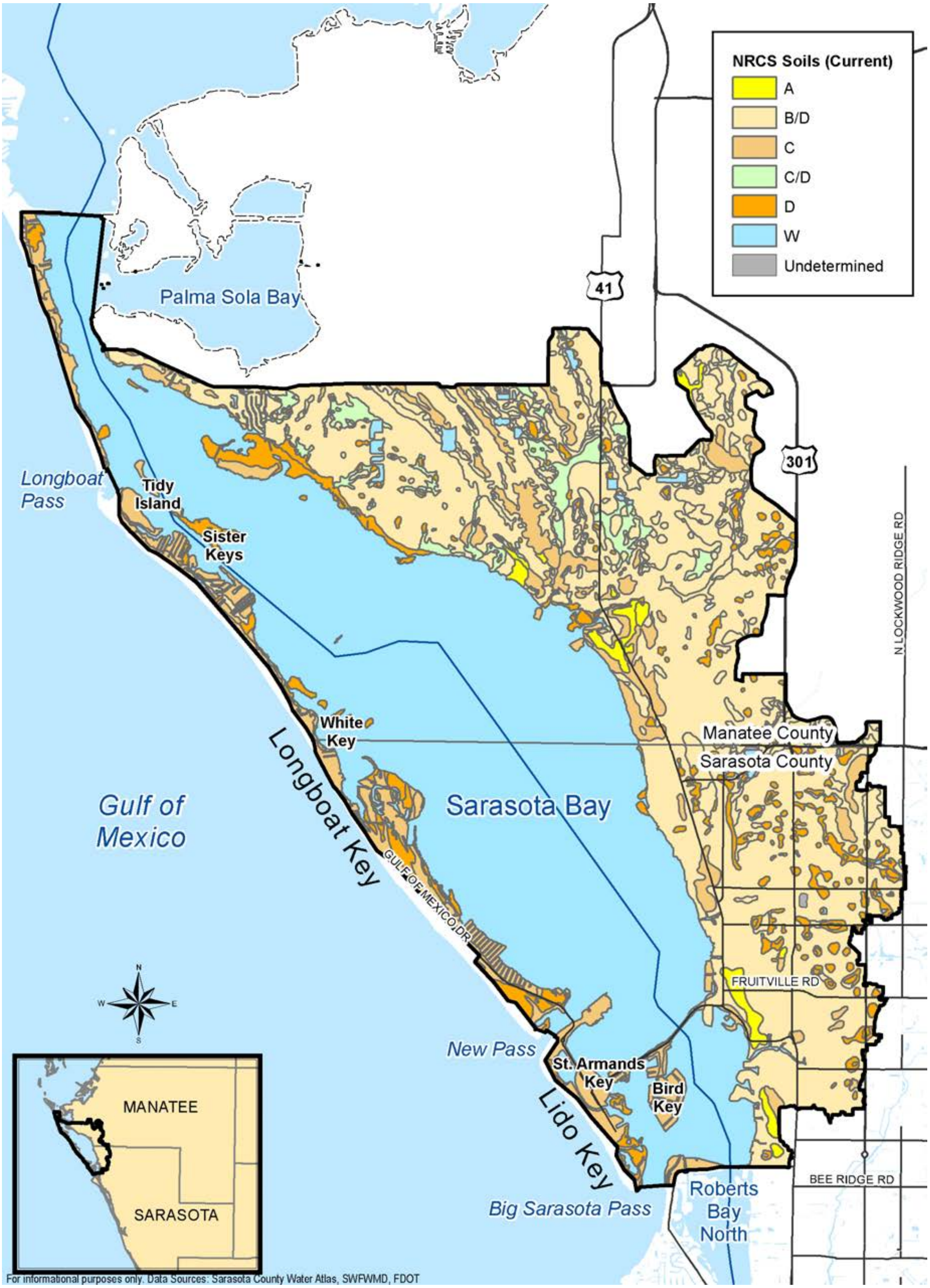


Figure 3-28 Sarasota Bay Watershed Soil Hydrologic Groups

Table 3-4 Sarasota Bay Watershed Current Soils (NRCS)										
HSG	Basin								Sarasota Bay Watershed	
	Hudson Bayou Basin		Whitaker Bayou Basin		Sarasota Bay Coastal Basin		Manatee County Basin			
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
A	84	3%	6	0%	138	1%	291	1%	519	1%
B	0	0%	0	0%	0	0%	5	0%	5	0%
B/D	2,055	85%	3,776	81%	1,115	8%	11,382	40%	18,328	37%
C	66	3%	153	3%	1,713	12%	2,509	9%	4,441	9%
C/D	0	0%	0	0%	0	0%	949	3%	949	2%
D	184	8%	654	14%	628	4%	1,226	4%	2,692	5%
W	18	1%	61	1%	10,742	75%	12,139	43%	22,960	46%
UNDETERMINED	0	0%	16	0%	2	0%	0	0%	18	0%

4.0 ESTUARY

This section summarizes the physical extent and general features of Sarasota Bay. Detailed descriptions of water quality, pollutant sources, and critical habitats and biological communities are provided in Appendices C (Water Quality) and D (Natural Systems).

4.1 PHYSICAL AND POLITICAL BOUNDARIES

The estuary boundaries are set by physical and natural features that in turn determine to a large extent the behavior of water and biota in the estuary. A thorough understanding of these features is germane to the effective management of the estuarine resources.

Sarasota Bay proper is a lagoonal estuary on Florida's southwest coast and extends from just south of Palma Sola Bay at the Cortez bridge south to the northern boundary of Roberts Bay North at the Siesta Drive bridge, just south of Big Sarasota Pass (Figure 4-1), a distance of about 14.5 miles. The surface area of the bay is 22,703 acres.

The bay is approximately evenly divided between Sarasota County and Manatee County to the north. The eastern (mainland) shore of the estuary is within Sarasota and Manatee counties and the City of Sarasota. The western estuary boundary includes barrier islands that are within the jurisdiction of the City of Longboat Key (Longboat Key), Sarasota County (St. Armands Key and Lido Key), and, at the extreme northwest, Manatee County (Anna Maria Island).

The Sarasota Bay estuarine system, including Sarasota Bay and Roberts Bay North, was designated by FDEP as an OFW in 1986 (Chapter 62-302.700, FAC). OFWs are designated for "special protection due to their natural attributes" (Section 403.061, FS). The OFW designation was based on a finding that the waters are of exceptional recreational or ecological significance. The intent of an OFW designation is to maintain ambient water quality, even if these designations are more protective than those required under the waterbody's surface water classification.

Although much of the estuary's watershed has been developed, the estuary itself has been recognized for its abundant valuable natural resources. SWFWMD placed Sarasota Bay on its list of priority waterbodies for the SWIM program in 1987. USEPA designated Sarasota Bay as an Estuary of National Significance and authorized the Sarasota Bay National Estuary Program (SBEP) in 1989 (USEPA, 2005).

Sarasota Bay west of the ICW is designated as Class II (suitable for shellfish propagation or harvesting), and the bay east of the ICW is Class III Marine (suitable for recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife).

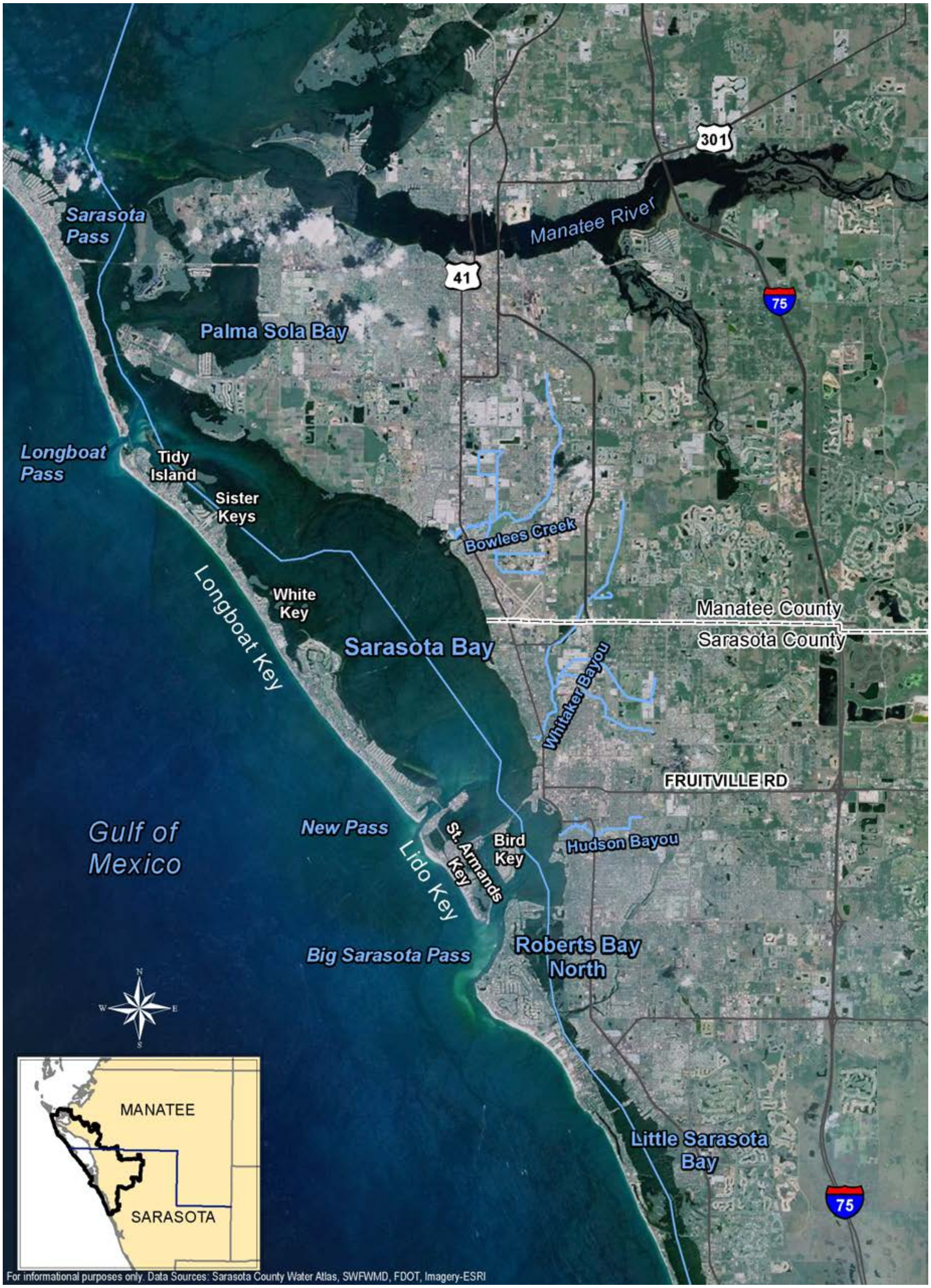


Figure 4-1 Sarasota Bay Estuary Location and Boundaries

4.2 BATHYMETRY

Bathymetric data for the estuary were obtained from the National Geophysical Data Center (NGDC). These data are used by the National Ocean Service to produce nautical charts. The bathymetry data used by NGDC were obtained from numerous sources including U.S. National Ocean Service Hydrographic Center, U.S. Geological Survey (USGS) 3 arc-second Digital Elevation Models (DEMs), U.S. Army Corps of Engineers, and other institutions (Jones Edmunds, 2010).

Sarasota Bay bathymetric information is contained on the National Ocean Services chart #11425 dated September 2007 and is presented in Figure 4-2. Sarasota Bay has an average depth of 6.5 feet with a maximum depth of >20 feet, based on a vertical datum referenced to mean lower low water (MLLW). The horizontal datum is the North American Datum of 1983 (NAD 83).

In the northern extreme of the estuary, water depths are shallow, mainly 5 feet or less with the exception of the ICW that bisects the bay longitudinally. The design controlling depth of the ICW through Sarasota Bay is 9 feet, although shoaling and scouring can greatly alter local conditions. Water depth in the center of the bay exceeds 10 feet in places with gradual contours to the shoreline.

Before the ICW was dredged, the generally shallow depths of Sarasota Bay limited excursions of higher saline Gulf of Mexico water into the bay and likely reduced dilution and flushing of the pollutant loads present at that time due to tidal exchange. Deepening the ICW channel allowed better tidal exchange in the bay and increased transport and processing of nutrients and other pollutants. However, at the time of ICW dredging, pollutant loadings were much lower than they are currently, and the extent of water quality problems during that period is not known. Conversely, the shallower depths allow more rapid freshwater-induced flushing when freshwater inputs were high, so that pollutant loads associated with larger loading events may have more rapidly moved out of the system.

4.3 CIRCULATION AND COASTAL PASSES

Circulation in Sarasota Bay is driven primarily by tidal exchange and secondarily by freshwater inflow. The passes connecting Sarasota Bay to the Gulf of Mexico provide avenues for tidal exchange, with the resulting circulation within the estuarine system dependent upon the locations and sizes of these passes. Circulation is a major determinant of water quality, including salinity, nutrients, and algal biomass in the bay. Circulation also affects sediment movement and can cause shoaling or scour in inlets and passes.

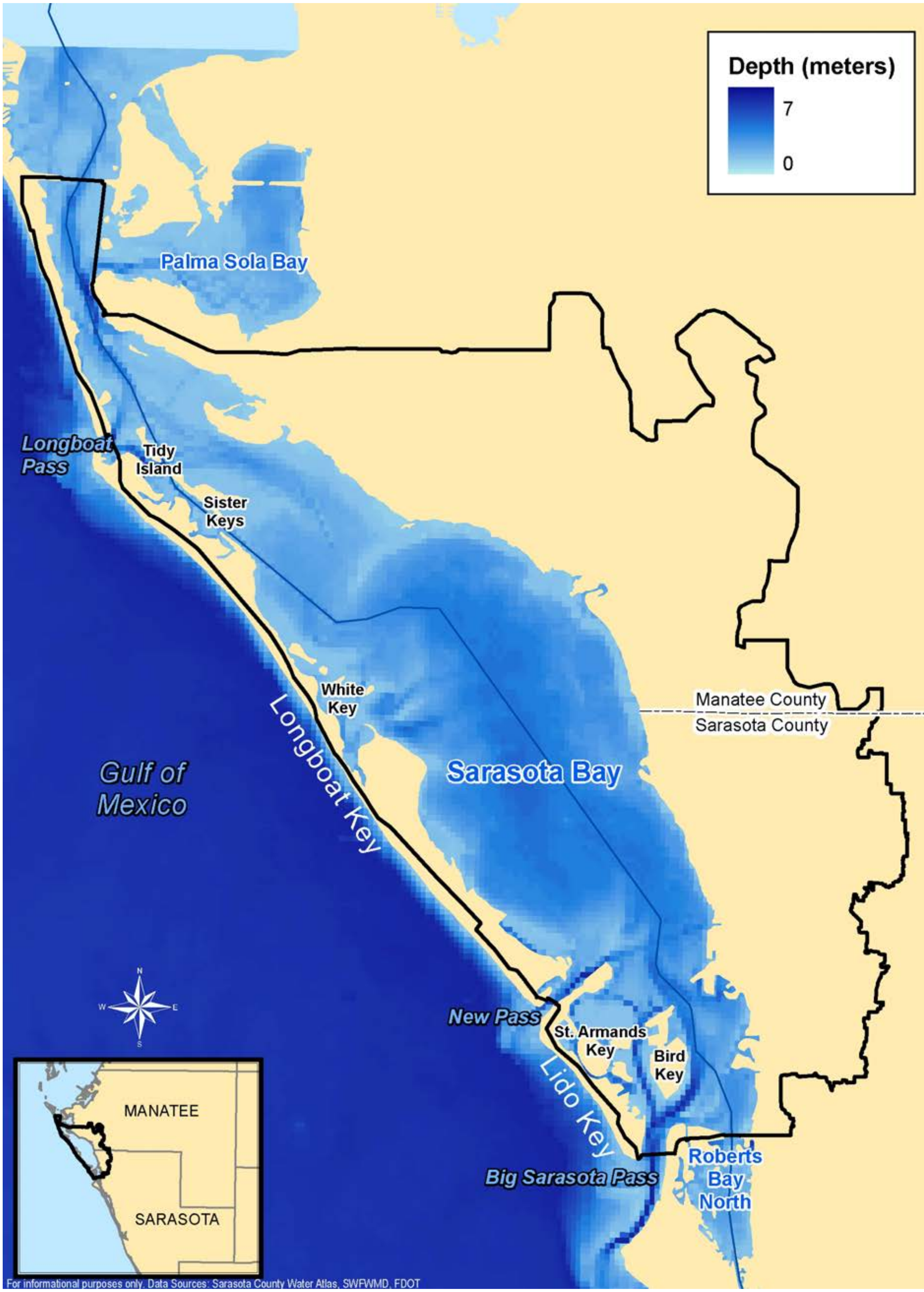


Figure 4-2 Bathymetry of Sarasota Bay and Roberts Bay North (NGDC, 2010)

Sarasota Bay receives runoff from the Hudson Bayou, Whitaker Creek, Bowlees Creek, and coastal drainage areas. The freshwater inflows result in a net outflow from the estuary, generally on a tide-driven basis. Circulation in Sarasota Bay is governed in part by flows north to Anna Maria Sound and south to Roberts Bay North. These narrow flow paths are relatively shallow except for the deeper ICW channel. The ICW enhances circulation and flushing and reduces retention time of water in the bay, reducing the accumulation of pollutants.

Tidal communication between the bay and the Gulf of Mexico is via Anna Maria Pass north between Anna Maria Island and Longboat Key, New Pass between Longboat Key and Lido Key, and Big Sarasota Pass at the south end of Lido Key north of Siesta Key (Figure 4-1). Of the three passes, Big Sarasota Pass is the largest, with a reported maximum depth of 27 feet. Anna Maria Pass also has a maximum depth of 27 feet charted but is not as wide. New Pass has a maximum reported depth of 13 feet and is reportedly the most prone to severe shoaling of the three (Davis et al., 2007).

The strongest currents in the system are found in the passes during incoming and outgoing tides, with the areas between the passes generally experiencing much weaker currents (Sheng, 1992). Modeling of tidal circulation in the Sarasota Bay system showed that the areas between the passes, where the tidal signals entering from adjacent passes meet, are areas of very small current velocities (Sheng and Peene, 1991). Consequently, these areas have relatively lower flushing rates.

A hydrodynamic model developed by ATM and ECE (2004) was used to investigate fluxes into and out of Roberts Bay North for existing conditions (Janicki Environmental, 2010). These fluxes were across the boundary between Roberts Bay North and Sarasota Bay to the north and across the boundary between Roberts Bay North and Little Sarasota Bay to the south. Over a 2-year simulation period, water mass transfers between Roberts Bay North and Sarasota Bay to the north were about twice as large as those between Roberts Bay North and Little Sarasota Bay to the south. This is to be expected given that Big Sarasota Pass is adjacent to the northern end of Roberts Bay North, so that the influence of the tidal signal is stronger across the northern boundary of Roberts Bay North, resulting in more water movement across this boundary.

Modeling was also used to estimate residence times in Sarasota Bay segments (Janicki Environmental, Inc., 2010). Segment-specific residence times ranged from 28.8 days for Sarasota Bay to 2.8 days for Roberts Bay North and represent the median hydraulic residence time within each segment given the observed conditions of 1994–2007. The residence times, which were based on a monthly scale, varied little over the 1994–2007 period with a range of 2-3 days for Sarasota Bay and were virtually unchanged for Roberts Bay North. More variability would be observed using a different time scale that would identify the signature of individual tidal cycles.

Maintenance of the passes enhances circulation in the bay and provides ecological benefits. However other cultural activity has reduced circulation as well as diminished the extent of estuarine habitats. Two examples are Lido Key, which was formed from several small mangrove islands in the late 1920s, and Bird Key, which was constructed of fill material taken from shallow grass beds during the early 1960s. These two artificial uplands near Big Pass have both reduced the benefits of tidal interactions with the Gulf of Mexico and have replaced natural habitats with urban development.

4.4 SEDIMENT CHARACTERISTICS

Sediments in the bay were characterized by Knowles and Davi (1983) and are reported to consist of (1) fine to very fine quartz sand contributed by littoral drift and reworking of older deposits, (2) fine to coarse quartz and phosphatic sand contributed by Tertiary carbonates and Pleistocene terrace deposits, (3) biogenic carbonate debris that is produced within the bay and/or derived from the nearby Gulf of Mexico, and (4) clay minerals derived from weathering of nearby carbonates and shales. These findings were corroborated by Cutler and Leverone in 1993. Bedrock beneath the bay ranges from 0 to 25 feet below present sea level and is largely responsible for the present aerial configuration of Sarasota Bay (Knowles and Davi, 1983).

Sediments are an important component of the estuarine ecosystem. Sediment characteristics can affect habitat type by providing stable substrate for vegetation and benthic organisms. Local flora and fauna can in turn change sediment characteristics, for example by the accumulation of organic detritus around mangrove roots and the cycling of material caused by burrowing benthos. Sediments also influence the fate of chemicals released into the water column, e.g., clay particles binding metals, phosphorus, and organic compounds.

Physical transport of sediment also influences circulation and flushing, which can affect water quality and navigation. Dredging activities in the bay, including dredge and fill projects and channel excavation and maintenance, have resulted in deep holes that act as sediment traps, especially for fine-grained particles. Channel dredging has also created spoil islands, some of which have become vegetated with mangroves. These created habitats include Sister and Jewfish Keys south of Anna Maria Pass along the ICW.

5.0 PUBLIC LANDS

The majority of the Sarasota Bay Watershed has been altered, leaving only isolated natural and conservation areas, most of which are under public ownership (Figure 5-1 and Table 5-1). Fortunately, since 1999 the County's Environmentally Sensitive Lands Protection Program (ESLPP) has been protecting the remaining natural lands through acquisition and less-than-fee simple methods by willing sellers. Designated natural and conservation areas make up only 7% of the entire watershed area and include Priority Sites, Protected Lands, Public Lands, and Developed Properties Preserves (Figure 5-1).

Priority sites are unprotected lands identified by ESLPP as priorities for future protection. Priority sites within the County are ranked on environmental criteria, including connectivity, water quality, habitat rarity, land quality, and manageability. The County's ESLPP continually works to acquire and protect natural lands.

Protected lands are those lands protected through the ESLPP program, which is funded by a 0.25-mill ad valorem tax that passed by referendum in March 1999 and was extended through 2029 by a second referendum in November 2005 (includes fee simple acquisitions, conservation easements, and lands protected through partnerships between ESLPP and other agencies/authorities).

Public lands are the major public (State, County, City) natural areas in Sarasota County as defined by Sarasota County Resource Management. Some portion of the area has been identified as having conservation, preservation, or mitigation uses. The Florida Natural Areas Inventory (FNAI) has also identified public lands in the watershed as having natural resource value. These lands are therefore being managed by the State, Local, or Federal government for conservation purposes.

Developed properties preserves are preservation, conservation, and mitigation areas in private developments in Sarasota County as depicted in Land Development Regulation site development plans or Sarasota County plat books.

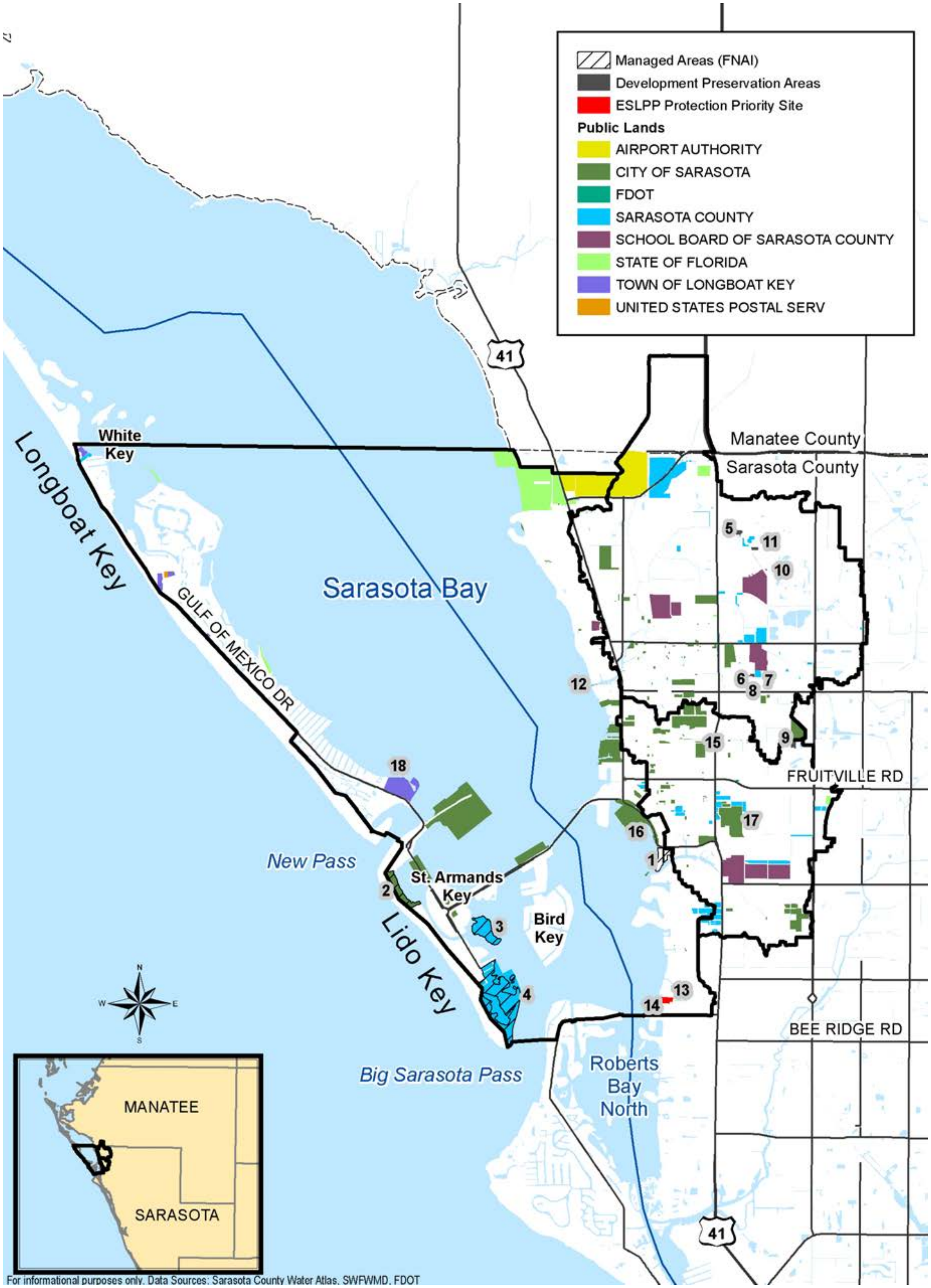


Figure 5-1 Sarasota Bay Watershed Public Lands

Table 5-1 Sarasota Bay Watershed Public Lands			
Map ID	Name	Managing Agency	Type
1	Marie Selby Botanical Gardens	Marie Selby Botanical Gardens	FNAI
2	North Lido Public Beach	City of Sarasota	FNAI
3	Otter Key	Sarasota County	FNAI
4	South Lido County Park	Sarasota County	FNAI
5	Anchor Industrial Park of Sarasota Wetland	Community	Preservation Area
6	Harvest Acres Forested Wetland A	Community	Preservation Area
7	Harvest Acres Forested Wetland B	Community	Preservation Area
8	Harvest Acres Uplands	Community	Conservation Easement, Preservation Area
9	Lord's 1st Addition Wetland	Community	Preservation Area
10	Spring Oaks Wetland	Community	Preservation Area
11	Spring Oaks Wetland	Community	Preservation Area
12	Whitaker's Landing Wetland	Community	Conservation Easement
13	Private	ESLPP	Priority Site
14	Private	ESLPP	Priority Site
15	Gillespie Park	City of Sarasota	Park
16	Island Park	City of Sarasota	Park
17	Payne Park	City of Sarasota	Park
18	Quick Point Preserve	Town of Longboat Key	Park

Some of the areas important to sustaining natural resources include South Lido Park, Otter Key, North Lido Beach Park, and Quick Point Nature Preserve.

South Lido Park (Figure 5-2) is 159 acres of mangrove forests, pine flatwoods, and coastal hammocks at the southern tip of Lido key. The park is bordered by the Gulf of Mexico, Big Pass, Sarasota Bay, and Brushy Bayou. This County-owned park boasts natural beaches, birding opportunities, and a paddling trail through a rich and diverse ecosystem. The substantial seagrasses in this lagoonal area provide food and protection for channeled whelk, hermit crabs, and mullet among other marine animals. The area is rich in coastal mangroves and mangrove islands, providing habitat for juvenile fish and large nesting water birds such as brown pelicans, great blue herons, and great egrets. This park is well-known for scenic landscapes and wildlife viewing.

Figure 5-2 South Lido Park
(photo credit: Simona Duque, Sarasota County Water Atlas)

Otter Key, a 30-acre mangrove island east of Lido Key, is another County park. This island also accommodates a number of waterfowl and juvenile fish and is frequented by kayakers and wildlife enthusiasts (Figure 5-3).

Figure 5-3 Kayak and Canoe trails in the Mangrove Tunnels near South Lido Beach and Otter Key
(photo credit: Bruce Maloney, Sarasota County Water Atlas)

North Lido Beach Park was purchased in 1977 by the City of Sarasota to be preserved as a natural wildlife habitat and is one of the finest examples of a natural coastal dune system in public ownership. The park's 77 acres of natural beach is host to many local and migratory shore birds. A great horned owl as well as an occasional bald eagle has been spotted in the park. The park is also an important sea turtle nesting site. Bordering the bayside of North Lido Beach Park is Pansy Bayou, which is frequented by manatees. North Lido Beach Park is within walking distance from St. Armands Circle and offers visitors a white sandy beach, fishing, swimming, and a nature trail (Figure 5-4).

Figure 5-4 North Lido Beach Park
(photo credit: Deborah Zeilman, Sarasota County Water Atlas)

Quick Point Nature Preserve is 34 acres of grassflats, mangrove forest, salt marsh, natural and man-made lagoons, and upland coastal hammock on the southern tip of Longboat Key. This preserve has approximately 3,000 feet of shoreline on Sarasota Bay and New Pass (Figure 5-5). Home to whelks, conchs, juvenile crabs, and many kinds of small fish, including mullet and black drum, the lagoon also attracts wading birds such as the snowy egret, white ibis, and great blue heron. This preserve, owned

Figure 5-5 Quick Point Nature Preserve Natural Mangrove Lagoon
(source: http:\\longboatkey.org)

and maintained by the Town of Longboat Key, offers nature trails, boardwalks, a canoe or kayak launch, and fishing docks, as well as educational signage (Figure 5-6 and Figure 5-7).

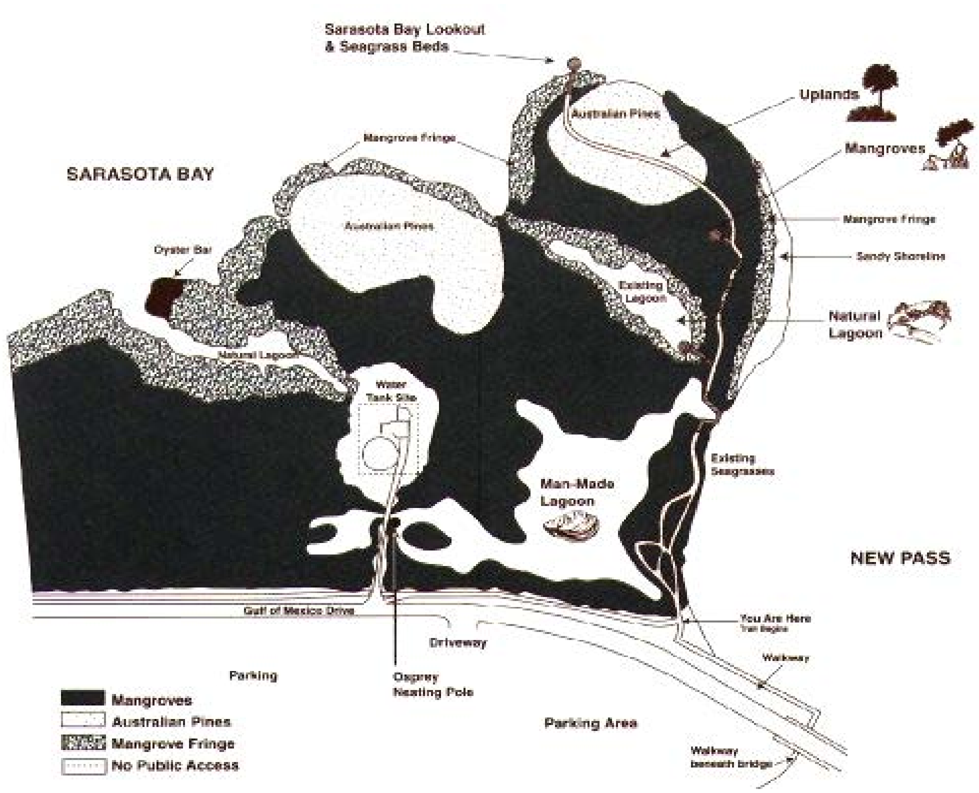


Figure 5-6 Quick Point Nature Preserve Habitats
(source: http:\\longboatkey.org)

Figure 5-7 Entrance to Quick Point Nature Preserve
(photo credit: http:\\discovernaturalsarasota.org)

6.0 THREATENED AND ENDANGERED SPECIES

Preservation lands preserve habitat for many threatened and endangered native species, including Florida scrub jays, eagles, gopher tortoises, manatees, and sea turtles.

Figure 6-1 Florida Scrub Jay

The Florida scrub jay was added to the State threatened species list in 1975 and the Federal threatened species list in 1987 (Figure 6-1). Named for its habitat, the scrub jay prefers the sandy, arid Florida scrub. Unfortunately, Florida scrub is also attractive for its high development potential, which threatens the Florida scrub jay's habitat and existence. Protection of the Florida scrub jay and its habitat is enforced by U.S. Fish and Wildlife Service (USFWS). Development proposals are reviewed by USFWS to determine how impacts may be avoided, minimized, or mitigated. USFWS must release a property before the County can issue any development permits for a parcel. Coordination with the Florida Fish and Wildlife Conservation Commission is also required.

Although removed from the Federal list of Threatened and Endangered Species in August 2007, the bald eagle is still protected by Federal (Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act) and State law (Florida Statute 372.0725) (Figure 6-2). Eagles are very sensitive to human activity and require nesting areas free from human activity. There are approximately 1,133 bald eagles in Florida and 41 reported active nests in Sarasota County (scgov.net). If a nest has been sighted or reported on or near a property, Sarasota County requires proof of coordination with the U.S. Fish and Wildlife Service (USFWS) before a building permit can be issued.

Figure 6-2 Bald Eagle

Figure 6-3 Gopher Tortoise (source: fws.gov)

The gopher tortoise (Figure 6-3) is another endangered species that lives in Sarasota County. Like the scrub jay, the tortoise prefers dry/xeric habitats, such as scrubs, coastal dunes, and pine flatwoods. Habitat destruction from development has reduced the tortoise's habitat area and diminished the overall gopher tortoise population throughout the state and Sarasota County. The ESLPP lands provide a much-needed haven for many species, including this reptile. In turn, the tortoise's burrow is used by several other threatened species for shelter, such as the indigo snake, gopher frog, and the Florida mouse.

Figure 6-4 Loggerhead Turtle
(source: fws.gov)

Sarasota County and the City of Sarasota protected lands also provide a safe nesting habitat for sea turtles. Sarasota County has the highest density of sea turtle nesting on the Gulf Coast of Florida and has supported nesting of the Kemp's ridley, loggerhead (Figure 6-4), leatherback turtle, and green sea turtles. The ridley and the leatherback are two of the most endangered species of sea turtles. The Sarasota County Comprehensive Plan requires that special measures be taken to protect sea turtles and their habitats (scgov.net).

Sarasota County is one of 13 counties designated as a priority protection site for the West Indian Manatee (Figure 6-5), which is protected by State and Federal law. Sarasota County adopted a Manatee Protection Plan in September 2003 (scgov.net). The Sarasota County Government Online website (scgov.net) states that the plan includes:

- An inventory of boat facilities.
- An assessment of boating and activity patterns.
- Manatee sighting and mortality information.
- A boat facility siting plan—to determine the best areas for new marinas, boat ramps, etc.
- Manatee protection measures, such as boating speed regulations in areas with high boat and manatee usage.
- Information on aquatic preserves, OFWs, ports, manatee refuges, etc. within the County.
- An education and awareness program for the public and boaters, divers, and school children.
- A water quality and habitat protection program (including land acquisition and aquatic plant control plans for manatee areas).

Figure 6-5 West Indian Manatee
(source: fws.gov)

More information on threatened and endangered species and critical habitat can be found in Appendix D (Natural Systems) of this plan.

7.0 RECREATIONAL FACILITIES

Sarasota County, the City of Sarasota, and the Town of Longboat Key operate 56 public recreational facilities totaling about 710 acres within the watershed (Table 7-1). These sites include sports facilities, natural areas, neighborhood parks, and beach and boat access parks. The parks range in size and land use from urban sites of under an acre to several large natural area parks. The parks are scattered throughout the watershed, as shown in Figure 7-1.

The recreational facilities provide several public services, including active recreation (softball, golf, boating, etc.) and passive recreation (picnicking, bird watching, etc.). Several of the recreational facilities also protect natural resources. South Lido Park, for example, a 159-acre conservation area wedged between Sarasota Bay and the highly urbanized gulf coast of Lido Key, offers refuge to wildlife.

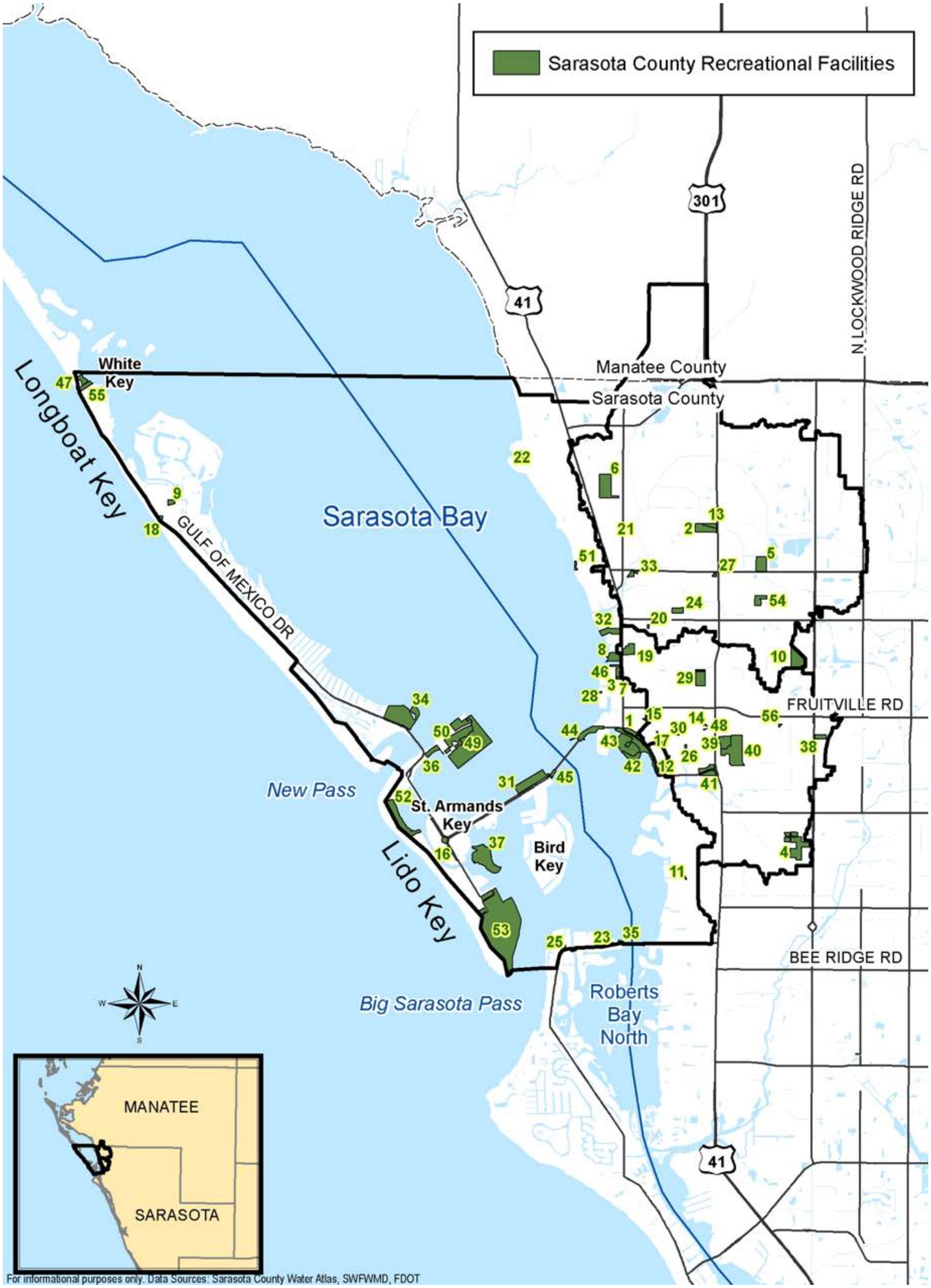


Figure 7-1 Sarasota Bay Watershed Recreational Facilities

Table 7-1 Sarasota Bay Watershed Area Recreational Facilities				
Map ID	Name	Park Class	Acres	Owner
1	Bayfront Park East 41	Community Park	7.8	City of Sarasota
2	Robert L Taylor Community Complex	Community Park	10.2	City of Sarasota
3	Bayfront Community Center	Community Park	0.2	City of Sarasota
4	Arlington Park and Aquatic Complex	Community Park	22.4	City of Sarasota
5	Newtown Estates Park	Community Park	10.5	Sarasota County
6	North Water Tower Park	Community Park	21.4	City of Sarasota
7	Municipal Auditorium at Centennial Park	Community Park	0.5	City of Sarasota
8	Centennial Park Sarasota	Community Park	9.5	City of Sarasota
9	Longboat Key Tennis Center	Athletic Complex	2.4	Town of Longboat Key
10	Ed Smith Sports Complex and Parking	Athletic Complex	50.8	City of Sarasota
11	McClellan Parkway Park	Neighborhood Park	0.2	City of Sarasota
12	Little Five Points Park	Neighborhood Park	0.1	City of Sarasota
13	Cohen Park	Neighborhood Park	3.2	City of Sarasota
14	Links Plaza Park	Neighborhood Park	0.2	City of Sarasota
15	Selby Five Points Park	Neighborhood Park	0.5	City of Sarasota
16	St Armands Circle Park	Neighborhood Park	2.2	City of Sarasota
17	Pineapple Park	Neighborhood Park	0.2	City of Sarasota
18	Bicentennial Park	Neighborhood Park	1.0	Town of Longboat Key
19	Pioneer Park	Neighborhood Park	7.8	City of Sarasota
20	Mary Dean Park	Neighborhood Park	0.5	City of Sarasota
21	Firehouse Park	Neighborhood Park	1.7	City of Sarasota
22	Sapphire Shores Park	Neighborhood Park	0.7	City of Sarasota
23	Norasota Way Park	Neighborhood Park	0.3	City of Sarasota
24	Orange Avenue Park	Neighborhood Park	4.3	City of Sarasota
25	Galvin Park	Neighborhood Park	0.2	City of Sarasota

Table 7-1 Sarasota Bay Watershed Area Recreational Facilities

Map ID	Name	Park Class	Acres	Owner
26	Laurel Park Sarasota	Neighborhood Park	0.5	City of Sarasota
27	Fred Glossie Atkins Park	Neighborhood Park	0.9	City of Sarasota
28	Waterfront Park at Centennial Park	Neighborhood Park	0.4	City of Sarasota
29	Gillespie Park	Neighborhood Park	10.6	City of Sarasota
30	Charles Ringling Park	Neighborhood Park	0.2	City of Sarasota
31	Bird Key Park	Neighborhood Park	19.5	City of Sarasota
32	Whitaker Gateway Park	Neighborhood Park	8.4	City of Sarasota
33	Dr Martin Luther King Jr Park	Neighborhood Park	2.6	City of Sarasota
34	Quick Point Nature Preserve	Preserve	37.4	Town of Longboat Key
35	Bay Island Park North	Reserve	0.6	City of Sarasota
36	Bay Walk Park	Reserve	4.6	City of Sarasota
37	Otter Key	Bay Islands	29.7	Sarasota County
38	Girls Inc Property	Community Park	3.3	Sarasota County
39	Payne Park	Community Park	9.2	City of Sarasota
40	A B Smith Park	Community Park	30.9	City of Sarasota
41	Lukewood Park	Community Park	8.0	City of Sarasota
42	Bayfront Park and Marina	Community Park	21.4	City of Sarasota
43	Bayfront Park and Marina Submerged Lands	Community Park	21.1	City of Sarasota
44	Harts Landing	Community Park	10.0	City of Sarasota
45	John Ringling Causeway Park	Neighborhood Park	1.6	City of Sarasota
46	Lawn Bowling Civic Center	Community Park	2.9	City of Sarasota
47	Bayfront Park Recreation Center	Athletic Complex	4.2	Town of Longboat Key
48	Roberts Memorial Park	Neighborhood Park	0.1	City of Sarasota
49	Ken Thompson Park Submerged Lands	Community Park	63.3	City of Sarasota
50	Ken Thompson Park	Community Park	29.6	City of Sarasota
51	Indian Beach Drive Park	Neighborhood Park	1.0	City of Sarasota

Table 7-1 Sarasota Bay Watershed Area Recreational Facilities

Map ID	Name	Park Class	Acres	Owner
52	North Lido Beach	Beach Access Park	67.6	City of Sarasota
53	South Lido Park	Beach Access Park	151.9	Sarasota County
54	Lime Lake Park	Neighborhood Park	5.7	Sarasota County
55	Longboat Key Site	Water Access Park	3.6	Sarasota County
56	Ringling Blvd Site	Neighborhood Park	0.4	Sarasota County

8.0 PUBLIC EDUCATION

Sarasota County, the City of Sarasota, and other organizations promote environmental stewardship. They help individuals, community-based organizations, businesses, schools, and others undertake watershed restoration initiatives in Sarasota County through public outreach and education. Education regarding topics including natural resources, forestry, watershed management, recycling, and overall county government structure is provided regularly. Keep Sarasota County Beautiful manages several outreach programs including the yearly Coastal Clean-up, Adopt-a-Road, Adopt-a-Park, and Adopt-a-Shore. The County's Neighborhood Services Department offers classes and workshops on how to improve and maintain communities and provides grants to implement what residents have learned to enhance their neighborhoods' character, value, safety, health, and infrastructure.

The County's Neighborhood Environmental Stewardship Team (NEST) is a volunteer organization partnering with residents to increase awareness of the importance of native habitats and watersheds in the community. NEST's primary purpose is to provide constructive and meaningful activities for people to improve the environmental quality of their watershed and neighborhoods while expanding the knowledge base and advocacy for watershed improvements.

The NEST program encourages people to interact with nature through enjoyable and hands-on activities. The NEST idea was initiated during the development of the Lemon Bay Ecosystem Restoration Project in 2001 as an opportunity for residents (neighbors, civic groups, student organizations) to actively work with land managers and restoration ecologists in restoring the native habitats of the preserve. During this initial project, citizens from the surrounding neighborhoods participated in water quality monitoring, fish sampling, a frog listening network, trash and invasive plant removal, native plantings, and a scrub-jay watch program.

In addition to Sarasota County, the City of Sarasota and organizations such as SWFWMD, SBEP, FDEP, Mote Marine Laboratory, University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Extension, and many small non-profit organizations play a key role in educational outreach in the Sarasota Bay watershed area. Table 8-1 summarizes the various organizations and their respective educational outreach programs.

The following describes some of the partner public education programs:

SWFWMD offers a multitude of training, incentives, grants, and educational materials. The SWFWMD educational website, www.swfwmd.state.fl.us/education/, offers free materials and expert speakers, current funding opportunities, and web activities that teach readers about watersheds, conservation, and water quality.

Table 8-1 Public Outreach Programs

Entity	Outreach Programs
Sarasota County	NEST (Neighborhood Environmental Stewardship Team) voluntary association of people - neighbors, civic groups, student organizations, and others who want to improve environmental conditions in their watershed.
	Recycling (publication; community, and school education)
	Discover Natural Sarasota County (publication)
	Keep Sarasota County Beautiful (Adopt-a-Road, -Park, -Pond, -Shore, and -Spot; portable pocket ashtrays, Bag-it-in-Your-Car-Day)
	Public Service Announcements and County Talk (Comcast TV 19 / Verizon 32)
	Improves communications between citizens and government; fosters increased citizen involvement
	Neighborhood, Urban, and Canopy Road Tree Programs (design, selection and planting services)
	Grant Program (helps residents enhance their neighborhoods' character, value, safety, health and infrastructure)
	Neighborhood University Program (classes and workshops designed to inform residents of Sarasota County on how to improve and maintain their communities and neighborhoods)
Florida Department of Environmental Protection	Florida Yards (FloridaYards.org; a project of the Florida Springs Initiative)
	Green Lodging Facilities Program (recognizes and rewards environmentally conscientious lodging facilities)
	Clean Marinas Program (Clean Marina Designation status is awarded to marinas and boatyards that demonstrate continued commitment and protection to the water and marine life.)
Sarasota Bay Estuary Program	Protection, Involvement, Restoration and Education (PIER) – (provides funding and technical assistance to environmental education and research programs.)
	Bay Buddies (established to get everyday people involved in making a difference in their community)
	Funding for Bay-Friendly Projects (Bay Education, Bay Restoration, and Bay-Friendly Landscapes promote environmental education, awareness and stewardship)
	Publications (State of the Bay, A Chronicle of Florida Gulf Coast, Bay Reflections, etc.)

Table 8-1 Public Outreach Programs

Entity	Outreach Programs
Southwest Florida Water Management District	Florida Friendly Landscapes (education program that promotes the use of Florida-friendly landscaping to homeowners, builders, developers and landscape and irrigation professionals; partner to University of Florida's Florida Yards & Neighborhoods Program)
	Training (interdisciplinary water education programs including Project WET; Healthy Water, Healthy People; Great Water Odyssey; etc.)
	Funding (Mini-Grants, Community Grants)
	Web Activities (Learn about watersheds, Splash! Activities, Monitoring)
	Educational materials (free publications and materials for adults and children including Water Matters, Water Matters Hispanic outreach, Florida Waters, Watershed Excursion, etc.)
	FARMS Program (Facilitating Agricultural Resource Management Systems), an agricultural best management practice cost-share reimbursement program involving both water quantity and water quality aspects; developed with the Florida Department of Agriculture and Consumer Services)
	Water Conservation Hotel and Motel Program (Water C.H.A.M.P.) (helps hotels and motels save water and money while practicing more efficient housekeeping and landscaping)
Mote Marine Laboratory	Center for School & Public Programs (on-site learning experiences for schools, families and other professional and social organizations)
	Center for Volunteer & Intern Resources (direct training and active educational experiences)
	Center for Distance Learning (interactive videoconferencing to engage students in interactive live programs)
	Mote TV (educational videos)
City of Sarasota Environmental Management Task Force (EMTF)	Your Green City (yourgreencity.sarasotagov.com) serves as the outreach and public information arm of the City of Sarasota Environmental Services Division. The website is extensive and offers tips on recycling, landscaping, water conservation, jobs, upcoming events, and more.

Table 8-1 Public Outreach Programs

Entity	Outreach Programs
University of Florida IFAS Extension	Florida Yards & Neighborhoods partners with national, state, and local agencies to teach Florida-friendly landscaping
	BMP Training meets the requirements of the Sarasota County Fertilizer Ordinance for landscape company employees who apply fertilizers.
	Master Gardener Program trains volunteer educators to provide information to Floridians about gardening, environmental horticulture, and pest management.
	Rain Barrel Workshops are classes on the construction and use of rain barrels and their environmental benefits. Sarasota County currently sells rain barrels for $37 each after the class.
	The Florida House will re-open in Fall 2010. Florida House is a demonstration facility, which offers education classes and tours.
Other Non-profit Organizations	1000 Friends of Florida, Science and Environment Council of Sarasota County, Florida House Institute

SBEP's Protection, Involvement, Education, and Restoration (PIER) program provides local teachers with a free curriculum about coastal habitats, invasive species, watersheds, and fire ecology as well as free field trips to parks around Sarasota Bay. SBEP also provides many educational publications and grants.

The UF/IFAS Extension program is a partnership between the University of Florida, State, Federal, and county governments to provide scientific knowledge and expertise to the public (UF/IFAS). The UF/IFAS County Extension in Sarasota offers a multitude of free educational courses to community related to natural resource sustainability, such as Florida Yards & Neighborhoods, the Master Gardener Program, and Rain Barrel Workshops.

The UF/IFAS Extension Program has unique demonstration facility in Sarasota County. The Florida House Learning Center is a model home and landscape that demonstrate green building and sustainable living. It was originally conceived as an educational outreach for water conservation after a severe regional drought in the late 1980s and was organized by IF/IFAS and interested citizens. The Florida House features water and energy-conserving designs and devices; Energy Star® appliances; renewable resources such as cork flooring, recycled plastic carpet, and a "Model Florida Yard." The Florida House is believed to be one of the first such educational demonstration facilities in the country (Figure 8-1) (Florida House Learning Center History, 2007—http://sarasota.extension.ufl.edu/FHLC/FLHouseHistory.shtml).

Figure 8-1 Florida House
(http://sarasota.extension.ufl.edu/FHLC/FLHouseHistory.shtml)

9.0 CONCLUSION

The Sarasota Bay watershed provides resources for the economy, recreation, and wildlife. Clean water resources, healthy streams, and safety from flooding are important for residents, businesses, and the local economy. Although the entire bay currently meets State water quality standards, some of the watershed's stream segments have listed impairments. Managing water and other natural resources is necessary to sustain the economy and environmental health of your community. Fortunately, advances in stormwater system technology and building techniques, combined with today's more stringent building codes, can better help balance the needs of the environment with those of the community.

This plan presents a scientific and community-based approach for formulating, evaluating, prioritizing, and implementing watershed management actions. These actions will be holistic in recognition of the relationships and interdependencies of watershed functions as well as the related goals of state, regional, and federal partners.

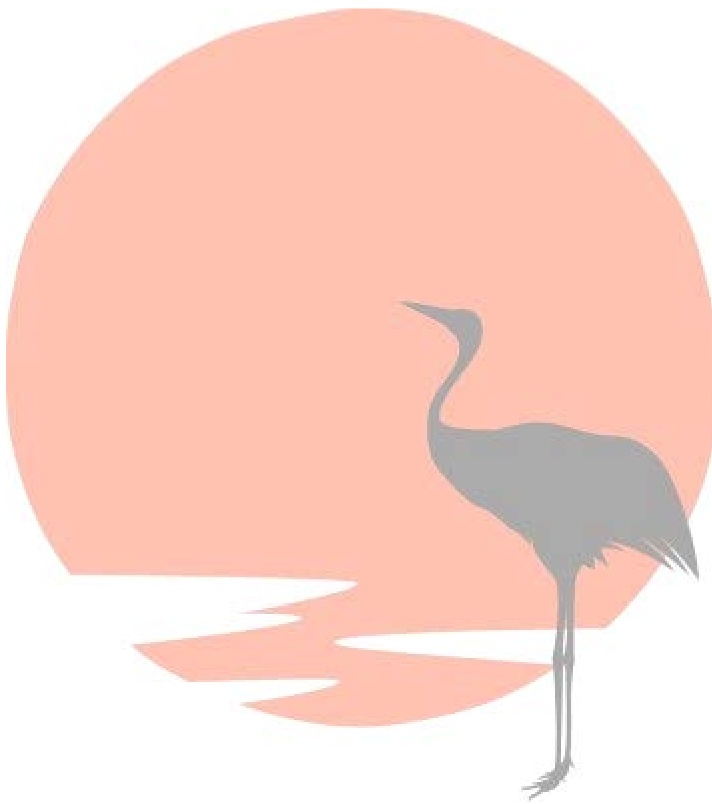
The Sarasota Bay Watershed Water Quality Management Plan balances the goals of restoring natural systems, enhancing water quality, ensuring the sustainability of the water supply, and protecting against floods while expanding recreational and educational opportunities. This plan summarizes past, present, and future watershed conditions and goals. The plan also contains recommendations for activities to help us reach these goals and progress toward sustaining and enhancing the health of our watershed.

Watershed management requires a holistic approach to protecting water resources, one that integrates all of the physical and biological components of the landscape.

Appendix B

Water Quantity

Appendix B
Water Quantity



December 2012

Sarasota County Southwest Florida Water Management District Jones Edmunds Janicki Environmental, Inc.

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1.0 INTRODUCTION

Developing a sustainable water supply is a goal of Sarasota County. The County is committed to providing Sustainable Water Supply through protecting water resources from harm, optimizing the use of alternative water supplies such as reclaimed water and surface waters, providing reliable and cost-effective water supply to the County's residents, and reducing demands on water resources through conservation and low impact development.

Sarasota County meets its water supply needs through several sources. The bulk of the County's annual average daily demand of 19.0 MGD is supplied by the Peace River Manasota Water Supply Authority and Manatee County. Demand on average is expected to increase nearly 6 MGD over the next 6 years with the majority of the new supply coming from existing contracts and its own wellfields. Additional details concerning Sarasota County's water supply and demand are provided in Section 2.

Stormwater runoff is a potential water source for non-potable uses that have been traditionally supplied by groundwater or other potable water sources. Current surface water flows in Sarasota Bay are about 20% higher than historical flows, and future flows are expected to remain near current levels. Section 3 provides details concerning the flow analysis, or water budget, along with results.

Jones Edmunds identified uses for a portion of the excess water in this plan. Section 4 provides specific project and program recommendations to capture and use excess flow. The recommendations focus on stormwater-derived alternative water supplies for irrigation and programs aimed at reducing the potable water supply demand. Potable and reclaimed sources are covered under the County's Comprehensive Plan and water and wastewater master plans.

Sarasota County is aware of the multiple benefits stormwater-harvesting projects can provide and wishes to explore ways to capitalize on stormwater harvesting and reuse opportunities. Stormwater harvesting can provide environmental and cost-savings benefits by reducing:

- Water demand—Using stormwater to supply a portion of water demand reduces groundwater withdrawals and associated environmental impacts and, in the case of potable water, saves treatment costs and differs expansion of existing infrastructure. Transmission costs are also reduced because most stormwater-harvesting projects are located on site.
- Pollutant mass in surface waters—Pollutants carried in the stormwater are removed from the water column and given another opportunity for treatment through natural processes.
- Volume of freshwater discharge—Stormwater harvesting contributes to hydrologic restoration by encouraging aquifer recharge and reducing freshwater pulses that can contribute to less-than-desirable salinities in the estuary.

Water budgets for the Sarasota Bay watershed were estimated for historical, current, and future conditions using the Jones Edmunds SIMPLE (Spatially Integrated Mass Pollutant Loading Estimates) model. The model uses rainfall, land use, and soils data to calculate freshwater inflows to the bay. Selected findings of the water budget investigation include the following and are detailed in following sections.

Rainfall patterns for the bay and watershed were assessed. A distinct spatial trend in rainfall over the watershed was evident, with higher long-term average precipitation in the most inland portions of the watershed and lower precipitation along the coast. The precipitation gradient was significant—more than 10 inches per year difference over a distance of less than 10 miles.

Annual rainfall averaged approximately 49 inches per year for 1989 through 2008 and ranged from about 33 inches/year in 2000 to 66 inches/year in 1995. Spatial variability across the watershed was higher during wet years. Seasonal precipitation followed a pattern typical of peninsular Florida, with rainfall during the summer (June through September) averaging 6 to 8 inches/month and monthly rainfall during the remainder of the year averaging 2 to 3 inches/month.

Atmospheric deposition (direct rainfall on the bay) was the most significant source of freshwater input to the bay for all years under current conditions because the area of the open water estuary is large with respect to the watershed area. Other significant freshwater sources included direct runoff (stormwater) and baseflow (shallow groundwater seepage). Point sources (discharges from wastewater treatment plants and industrial facilities), irrigation (land application of reclaimed water), and septic tank seepage all contributed smaller volumes of freshwater).

The historical and future freshwater budgets were developed using the same 1989 through 2008 rainfall that was used for the current conditions water budget. Using the same rainfall for all scenarios allowed the water budgets to be compared for differences based only on changes to land use and other anthropogenic effects.

Using the SIMPLE model to compare estimated current and historical freshwater inputs indicated that, given the same rainfall, current freshwater inputs to the bay are higher than historical levels. Direct runoff and baseflow were both greater than under historical conditions due to changes in land use within the watershed. Given the similar rainfall used to develop both scenarios, the rates of freshwater inputs for historical and current conditions were similar on both an annual and seasonal basis, with direct rainfall contributing the most freshwater of any single source in both scenarios.

In contrast, there was very little difference between the current and future freshwater inputs. The relative contributions of each of the freshwater sources remained the same. Much of the Sarasota Bay watershed is now highly urbanized, so little opportunity exists for significant changes in land use or other activities that could alter the sources of freshwater inputs to the bay.

2.0 WATER SUPPLY AND DEMAND

W*ater supply planning* is the process by which an agency assesses the projected water demands for a period and the potential sources of water available to meet the demands. The Water Supply Plan helps the County manage one of its greatest resources—water. Water does not have boundaries; it is found in the sky and on, in, and under the ground. Water is seemingly abundant, with a continual supply falling from the sky and stored in the ground and in our bodies. However, recent droughts and the impacts of over pumping have shown us that water is not as abundant as Floridians once thought, and therefore a plan is needed to help neighboring communities share and protect this important resource.

Water supply plans for the region containing the Sarasota Bay Watershed include:

- ❖ Sarasota County Comprehensive Plan (2006).
- ❖ Sarasota County Water Supply Master Plan Update (2005).
- ❖ Sarasota County Wastewater Master Plan Report (2009).
- ❖ Southwest Florida Water Management District (SWFWMD) Regional Water Supply Plan (RWSP) (2010).
- ❖ 10 Year Water Supply Facilities Work Plan, Carollo (2012).

Additionally, Sarasota Bay Watershed is within SWFWMD's Southern Water Use Caution Area (SWUCA). Regulatory requirements stemming from this distinction are described in the SWUCA Recovery Strategy (SWFWMD, 2006)

Jones Edmunds reviewed the County Comprehensive Plan, both master plans, and SWFWMD's RWSP to understand the supply and demand projections for the Sarasota Bay Watershed and help formulate the best alternative water supply recommendations.

2.1 WATER SOURCES

Potable and reclaimed water within the Sarasota Bay Watershed is distributed by Sarasota County Utilities, which falls within SWFWMD's region for supply management.

2.2 WATER SOURCES WITHIN SWFWMD

The following section summarizes information in *A Sustainable Water Supply*, SWFWMD, 2001: http://www.swfwmd.state.fl.us/about/isspapers/watersupply.html.

The average rainfall of West-Central Florida is 53 inches a year, making it one of the rainiest regions in North America. However, most is lost to evaporation and runoff. The remainder replenishes the region's groundwater, which is rainwater that has soaked into the ground to an aquifer, an area of underground rock and sand, where it is "stored." Surface water refers to water on the surface of the earth, such as lakes, rivers, and streams.

Of the approximately 14 inches of rainfall that remain after evaporation SWFWMD-wide, about 9 inches go to surface waters, leaving only an average of 5 inches to resupply Florida's underground water reserves. Water users in the area regulated by SWFWMD use more than 1 billion gallons of water daily. More than 80% of this water comes from groundwater in the Floridan aquifer, the deepest and most productive of the three aquifers in West-Central Florida and one of the most productive aquifers in the world.

In some areas of SWFWMD, aquifers are connected with the lakes, rivers, and wetlands above them. If too much water is withdrawn from the aquifers, the water level of the lake or river above may decline. Excessive groundwater withdrawals can also cause the saltwater that surrounds the Floridan aquifer to move or intrude into freshwater areas, which decreases the amount of available freshwater and increases the cost for providing clean, potable water to residents. In Sarasota County, the Floridan aquifer is confined and the intermediate aquifer system is the main source of water supply.

Groundwater is expected to always be a source of drinking water, but access to other sources is essential. The balance of the region's water supply comes from surface water. Surface water use will most likely increase because the ability of the groundwater system to satisfy an ever-growing need for freshwater is limited, but surface water has limits as well. By 2030, about 84 million gallons per day (MGD) of additional water may be necessary to meet the projected water demand of all current and future water users within SWFWMD. Potential additional water availability is summarized in Table 2-1 (RWSP, SWFWMD, 2010,).

2.3 WATER SOURCES WITHIN SARASOTA COUNTY

Sarasota County Utilities historically purchased its water from Manatee County and blended it with water from the University Wellfields. As the area grew and water demands increased, Sarasota County began developing its own water supplies and participating in the Peace River Manasota Regional Water Supply Authority as a regional partner. Currently, a variety of public and private water service providers meet the water supply demand in Sarasota County. The Cities of Sarasota, Venice, and North Port and the Town of Long Boat Key are primarily served by the local municipal utility. The unincorporated sections of Sarasota County are served by the Sarasota County Utilities Department, Englewood Water District (EWD), independent water treatment and supply systems, and individual wells. EWD and the Cities of Sarasota, North Port, and Venice own and operate the water systems that provide water within their jurisdictional boundaries. The Town of Longboat Key purchases its water from Manatee County (WSMP, Carollo, 2011).

Table 2-1 Potential Additional Water Availability in Southern Planning Region through 2030 (MGD) (RWSP, SWFWMD, 2010)

County	Surficial Water[1]		Reclaimed Water	Desalination		Fresh Groundwater		Water Conservation		Total
	Permitted Unused	Available Unpermitted	Offset	Seawater	Brackish Groundwater	Surficial and Intermediate	Upper Floridan[2] Unused/ Permitted	Non-Agricultural	Agricultural	
Charlotte	3.7	14.6	6.2		5.5	4.7		1.4	0.7	36.8
DeSoto	17.9	80.4	1.3		0.4	1.8		0.3	2.0	104.1
Sarasota	3.2	74.6	14.5	20.0	10.3	6.0	2.7	2.5	0.7	134.5
Manatee	6.2	3.8	17.4	20.0		4.9	0.8	2.8	3.1	59.0
Total	31.0	173.4	39.4	40.0	16.2	17.4	3.5	7.0	6.53	334.4

1 All available surface water from the Peace River is shown in DeSoto County because the calculation was based on flows in DeSoto County; however, future withdrawals from the Peace River in Hardee and Polk Counties are possible.
2 Groundwater that is permitted but unused for public supply. Estimated 2009 use is based on a linear trend for 2000 through 2008. Permitted quantities were current as of October 2009.

Water demand within the Sarasota County Utility service area is met through its groundwater supplies and interlocal agreements with Manatee County and the Peace River/Manasota Regional Water Supply Authority. The agreement with Manatee County expires in 2025. The agreement with the Authority was amended in 2005 and is valid for 35 years with the option to extend for an additional 35 years (WSMP, Carollo, 2011).

The County-owned water system components include groundwater sources and associated treatment and transmission systems. Groundwater sources for Sarasota County include the Carlton, Venice Gardens, and University Wellfields (Figure 2-1), which withdraw groundwater from Production Zone 3 (PZ3) of the Upper Floridan and Intermediate Aquifer Systems (UFAS). The County obtained its current WUP on May 15, 2012 (WUP No. 20008836.010), which consolidated the County's previous three permits for the individual wellfields with no increase in quantities. The current permit expires on August 28, 2017.

2.4 WATER SOURCES WITHIN THE CITY OF SARASOTA

The City of Sarasota operates, maintains, and provides capital reinvestment to their potable water service. All facilities are public and maintained by the City of Sarasota Public Works Department, which serves the corporate limits of the City. Figure 2-2 shows the locations of the existing potable water facilities that provide service within the City of Sarasota. The potable water treatment facility consists of raw water supply facilities, a water treatment plant, distribution system, and storage and pumping facilities.

The existing water treatment plant came online in 1982. The plant's mechanical infrastructure such as pumps and rotating machinery has a design lifespan of 20 years, while that of the piping and tanks is 50 years. A complete renovation of the Reverse Osmosis Treatment System was completed in 2003.

Raw water supplies are regulated through State Water Use Permits issued by SWFWMD. The City is currently allowed an annual average daily withdrawal of 12 MGD. The City's water supply comes from two sources: the Verna Wellfield 17 miles east of the City and the Downtown Reverse Osmosis. (Sarasota City Plan–Utilities Support Document, City of Sarasota, 2008).

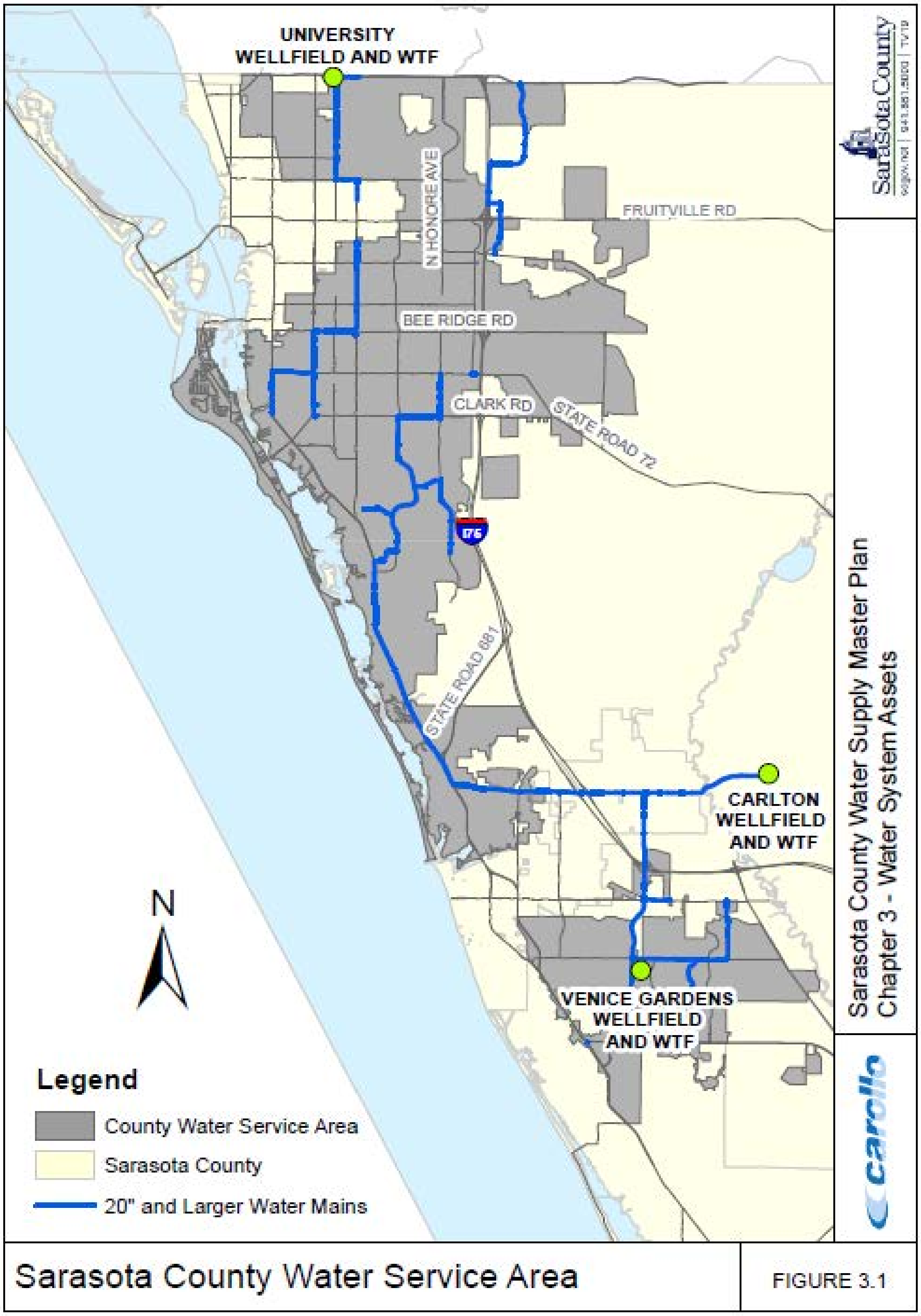


Figure 2-1 Sarasota County Water Service Areas (Sarasota County WSMP, Carollo, 2011)

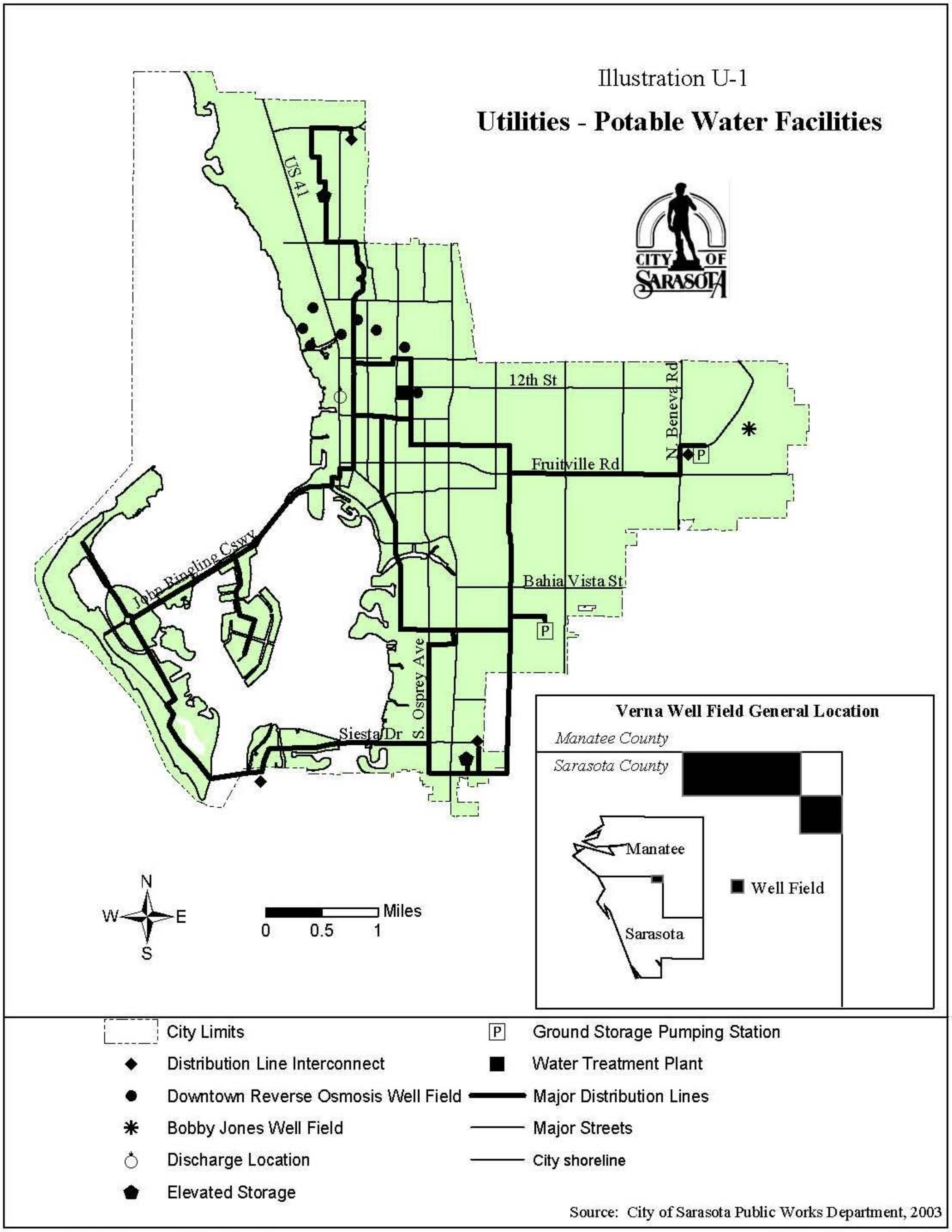


Figure 2-2 City of Sarasota Potable Water Facilities
(Source: Sarasota City Plan and Support Document – The Utilities Plan, City of Sarasota, 2008)

2.5 SARASOTA COUNTY SUPPLY AND DEMAND

Water demand projections were compiled as part of the County's 2011 Water Supply Master Plan. Projected annual average water demands for Sarasota County from the WSMP are shown in Table 2-2.

Table 2-2 Annual Average Water Demands (WSMP, Carollo, 2011)

	2010	2015	2020	2025	2030
Sarasota County	20.81	22.90	25.34	27.46	28.84
City of Sarasota	7.712	7.924	7.959	7.994	8.108
Town of Longboat Key	2.021	2.021	2.021	2.021	2.021

Table 2-3 summarizes average annual and maximum month water demands, facility capacities, and permitted quantities for Sarasota County Utilities. New water supply will need to begin development soon after 2020. The County is working on several options for future supply including the Dona Bay WTF and expansions of existing County-owned facilities, (WSMP, Carollo, 2011)

2.6 AQUIFER RECHARGE AREAS

SWFWMD has identified areas of no or very low recharge in Sarasota County in the vicinity of the City of Sarasota-owned Verna Wellfield. Sarasota County's Comprehensive Plan recommends that the County adopt land development regulations that would guarantee the integrity of these areas; these regulations were adopted.

Table 2-3 Summary of Water Demands, Facility Capacity, and Permits for Sarasota County Utilities (WSMP, Carollo, 2011)

	2011		2016		2021	
	Annual Average	Max Month	Annual Average	Max Month	Annual Average	Max Month
Population Served	218,352	–	245,538	–	276,197	–
Demand (MGD)[1]	21.8	26.2	24.6	29.5	27.6	33.1
Demand per Capita (MGD)	100	140	100	140	100	140
Available Facility Capacity (MGD)	31.83	35.86	33.83	37.98	32.83	36.98
Carlton WTF	5.85	7.7	9.85	1.82	9.85	11.82
Authority	13.225	15.407	13.225	15.407	13.225	15.407
Manatee County	8	8	6	6	5	5
University WTF[2]	2	2	2	2	2	2
Venice Gardens WTF	2.75	2.75	2.75	2.75	2.75	2.75
Future Facility Capacity	–	–	–	–	Note 3	Note 3
Facility Capacity Surplus (Deficit)[4]	9.99	9.65	9.27	8.51	5.21	3.83
Total Permitted/Contracted	34.97	39.91	32.97	37.91	31.97	36.91

Table 2-3 Summary of Water Demands, Facility Capacity, and Permits for Sarasota County Utilities (WSMP, Carollo, 2011)

	2011		2016		2021	
	Annual Average	Max Month	Annual Average	Max Month	Annual Average	Max Month
Amount (MGD)						
Carlton/University/Venice Gardens	13.74	16.50	13.74	16.50	13.74[5]	16.50[5]
Authority	13.225	15.407	13.225	15.407	13.225	15.407
Manatee County	8	8	6	6	5	5
Permitted/Contracted Surplus (Deficit)[6]	13.13	13.70	8.41	8.44	4.35	3.76

Notes:
1. Population and demand projections are based on BEBR Medium projections.
2. Less than 2 MGD may be supplied based on the TDS concentrations of the Manatee County supply and the University Wellfield. The blending ratio is typically 5:1 to meet the TDS limit of 500 mg/L, but blending ratios vary based on the actual TDS concentrations of the source waters.
3. Future supply (expansion of existing facility or new source) to be under development.
4. Calculated by subtracting demand from the available facility capacity.
5. Current WUP expires in 2017. Assume that permit renewal will allow the same withdrawal rate.
6. Calculated by subtracting the demand from the permitted amount.

2.7 SARASOTA BAY WATERSHED SUPPLY AND DEMAND

Developing a sustainable water supply is a goal of Sarasota County.

A general finding from Task II-1, the Water Budget Analysis, is that a significant amount of stormwater in the watershed could be beneficially used while maintaining appropriate flows to the Bay and tributaries. This task (II-4) involves identifying opportunities and developing conceptual alternative water supply plans to reduce excess stormwater runoff. These plans will provide a foundation for developing stormwater-harvesting projects that will help the County meet its sustainable water supply goals.

The Water Budget Analysis (Task II-1 TSDs) found about 20% more freshwater flow to Sarasota Bay (Figure 2-3) today than occurred historically (historical conditions refer to 1948 land use modeled in SIMPLE as part of Task II-1). Additionally, future freshwater flows are projected to be slightly greater than current loads. Higher runoff in the future reflects the increased extent of urban land cover in the watershed compared to the current level of development.

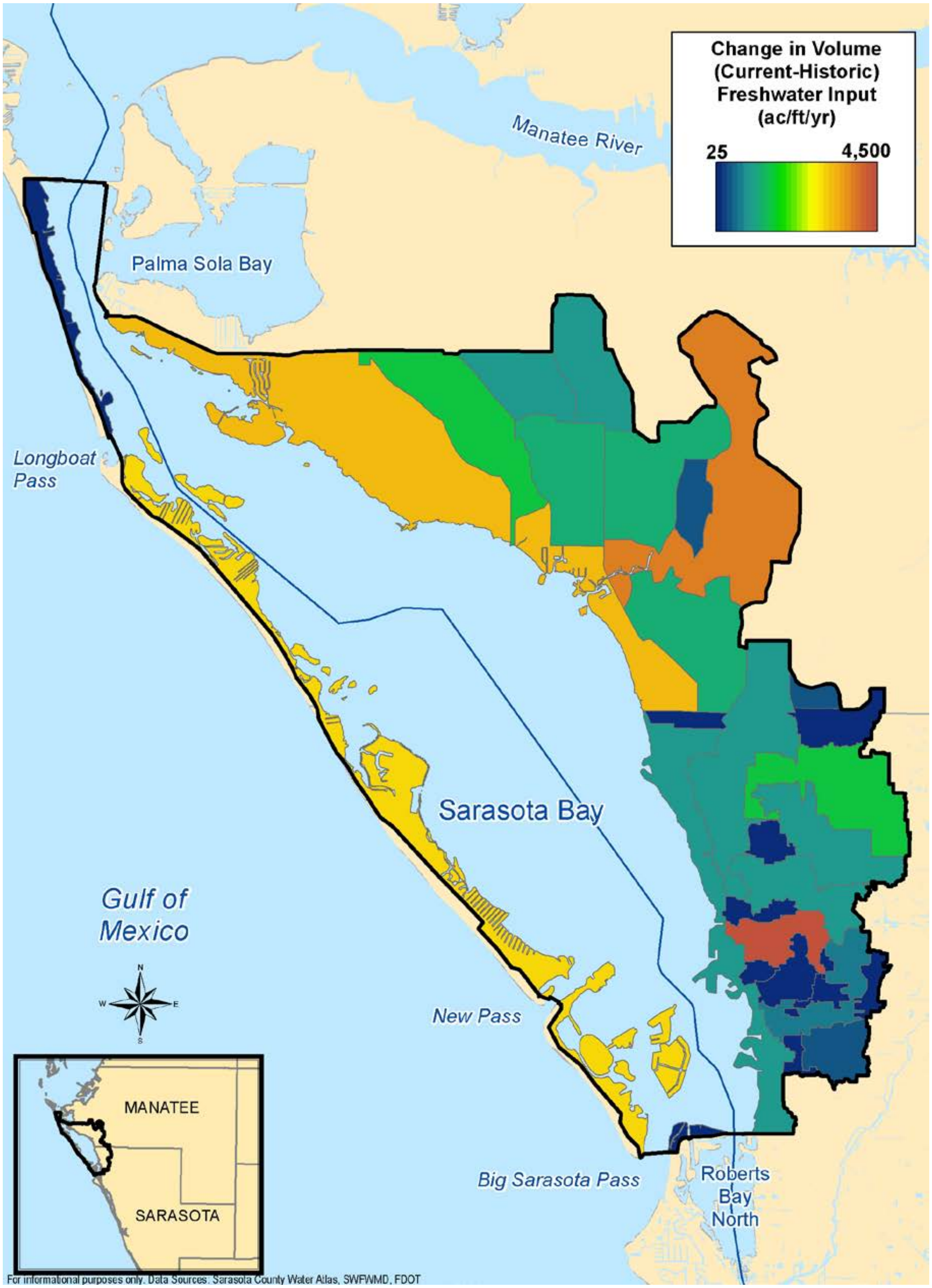


Figure 2-3 Change to Median Annual Freshwater Inputs to Sarasota Bay from Basins within the Watershed from Historical to Current Conditions

2.8 PER CAPITA CONSUMPTION

The average gross per capita water consumption from 2003 through 2007 in Sarasota County was 87 gallons per capita per day (gpcd). This value accounts for water use by commercial and industrial users, as well as for lost and unaccounted-for water. Although the County water system provides approximately 87 gpcd to its customers on average, a demand factor of 100 gpcd was selected to use for planning. This value accounts for any potential changes in water use patterns or shifts in demand. Conservation activities have reduced per capita water use from approximately 110 gallons per capita per day (gpcd) in 1992 (Sarasota County WSMP; Carollo, 2011).

Picture yourself carrying 87 gallons of water in a bucket from a well or stream. Would you still use that much water?

3.0 WATER BUDGET

Water budgets for Sarasota Bay Watershed were estimated for historical, current, and future conditions using the Jones Edmunds SIMPLE (Spatially Integrated Mass Pollutant Loading Estimates) model. The SIMPLE model, co-funded by Sarasota County and SWFWMD, has been applied on numerous projects throughout SWFWMD and elsewhere in Florida. The model uses spatially distributed rainfall, land use, and soils together with constants, mainly defined in lookup tables, to calculate the water budget in six components—atmospheric deposition, direct runoff, base flow, irrigation, point sources, and septic tanks. An in-depth description of the model can be found in Jones Edmunds (2008). Details of the water budget analysis including methodology (Section 3.1) and results (Section 3.2) are provided in the following subsections.

3.1 METHODOLOGY AND DATA USED

The water budgets were prepared by holding rainfall constant at current conditions for all three scenarios and varying the other inputs to simulate historical and future conditions. The results provide a basis for comparison between historical and current conditions as well as current and future conditions. The current conditions were provided by a SIMPLE model run for 1989 through 2008. The modeling was completed for a project funded by the Sarasota Bay Estuary Program (*Numeric Nutrient Criteria for Sarasota Bay*, prepared by Janicki Environmental [2010]). Sources of data and methodologies for current conditions loadings are documented in that report. Data sources and methodologies for historical and future conditions are provided below.

3.1.1 Historical

A Decision Memorandum developed by the Project Team, including the County and SWFWMD, defined the methods used to estimate the historical freshwater inputs as follows. Referenced sources of data and methodologies are documented in *Sarasota County Pollutant Loading Model Development SIMPLE-Monthly Design Report* prepared for Sarasota County and the Southwest Florida Water Management District (Jones Edmunds, 2009).

- Current freshwater inputs were provided by the SIMPLE model run for 1989 to 2008.
- For all modules that require land use/cover data, the historical land use/cover derived from 1948 US Department of Agriculture aerial photographs was used.
- For all modules that require soils data, the soils data used for the current SIMPLE model run were used.
- For all modules that require precipitation and evapotranspiration data, the precipitation and evapotranspiration used for the current SIMPLE model run (1988–2009) were used.

- For the point-source module, the City of Sarasota staff were consulted to develop information regarding the historical loadings from the City's wastewater treatment plant. The plant began operation in 1953 and had a capacity of 4 MGD. The plant has secondary treatment (sand filter, primary settling, biological trickle filter, anaerobic digester, and sludge beds). Effluent was discharged to Whitaker Bayou. The service area generally included some of the south side of the City, the Bayshore area, and downtown (Haas, D. and R. Maikranz, City of Sarasota Utilities Department. Personal communication). However, because sanitary sewer service was not initiated until 1953 and the historical conditions period was 1948 through 1950, to coincide with the land use no point source loadings were included in the historical conditions.
- For the septic tank module, we worked with several individuals (D. Andersen, Hazen and Sawyer, personal communication; Haas, D., City of Sarasota Utilities Department, personal communication) regarding how to address historical septic tanks. We estimated a population density based on census data and photointerpretation of 1948 aerial photographs. Up until the 1940s, most unsewered treatment systems were little more than cesspools. Within the next decade, septic tanks were added to provide initial settling. Because of the lack of design standards, hydraulic failure was common. The US Public Health Service began investigating siting and design guidelines in the late 1940s. Because of the lack of regulation or widespread knowledge of the new guidelines, septic tanks in 1950 could have been built in either lowlands or uplands. Although the technology has not changed significantly, siting requirements to keep the septic tank drainfield 2 feet above the seasonal high groundwater have decreased failure rates and increased efficiency (Anderson and Otis, 2000).

3.1.2 Future

A Decision Memorandum developed by the Project Team, including the County and SWFWMD, defined the methods used to estimate the future freshwater inputs. The future conditions period is not intended to portray any specific yearly envelope but rather to reflect the following assumptions:

- Future land use followed the Jones Edmunds approach used for the Roberts Bay North Watershed Management Plan in which undeveloped uplands were converted to medium-density residential.
- Evaporation and evapotranspiration rates were the same as those used for the historical and current conditions model runs.
- Soil coverage was the same as that used for the historical and current conditions model runs.
- The City of Sarasota Wastewater Treatment Plant is the only point source within the Sarasota Bay Watershed. This facility disposes of treated effluent via deep-well injection during the wet season (June–September) and distribution to reuse

during the dry season. The City of Sarasota was contacted to obtain data to use in estimating future loading rates. Although the plant's direct discharge to Whitaker Bayou is proposed to be taken offline in the future there is no definitive schedule. An assumption was made that all direct surface water discharges will be stopped in the future, so there were no point source inputs for future conditions.

- Septic tank coverage was the same as the current.

3.1.3 Results

The analyses of these data included examining and comparing the spatial and temporal variation in freshwater inputs to Sarasota Bay. Spatial, annual, and seasonal variations in rainfall are described (Section 3.2.1), followed by comparisons of historical and current inputs (Section 3.2.2) and current and future flows (Section 3.2.3) by source (e.g., direct runoff).

3.2 RAINFALL

3.2.1 Spatial Variation

A distinct spatial trend is evident in rainfall over the watershed, with higher median precipitation in the most inland portions of the watershed and lower median precipitation along the coast. The precipitation gradient is striking—over 10 inches per year over a distance of less than 10 miles. Figure 3-1 shows the pixels used by the SIMPLE model to estimate rainfall inputs to Sarasota Bay and its watershed. Each pixel is shaded to reflect the median annual rainfall for 1988 through 2009.

3.2.2 Annual Variation

Figure 3-2 shows the total annual precipitation for the watershed as a whole. Annual rainfall ranged from about 33 inches per year in 2000 to approximately 66 inches in 1995.

Annual precipitation varied significantly spatially (i.e., among locations or pixels) for any year. Each box-and-whisker in Figure 3-3 presents the range of total annual rainfall for all pixels for a year. Figure 3-3 demonstrates that there is significant temporal variability in annual precipitation. The median values range from over 60 inches per year (1992 and 1995) to under 40 inches per year (1990, 1999, and 2000). Total annual precipitation also varied significantly between geographic locations (pixels) for any year. There were at least 10 inches of difference between the highest and lowest pixel in all years, with the difference reaching 30 inches per year in some years.

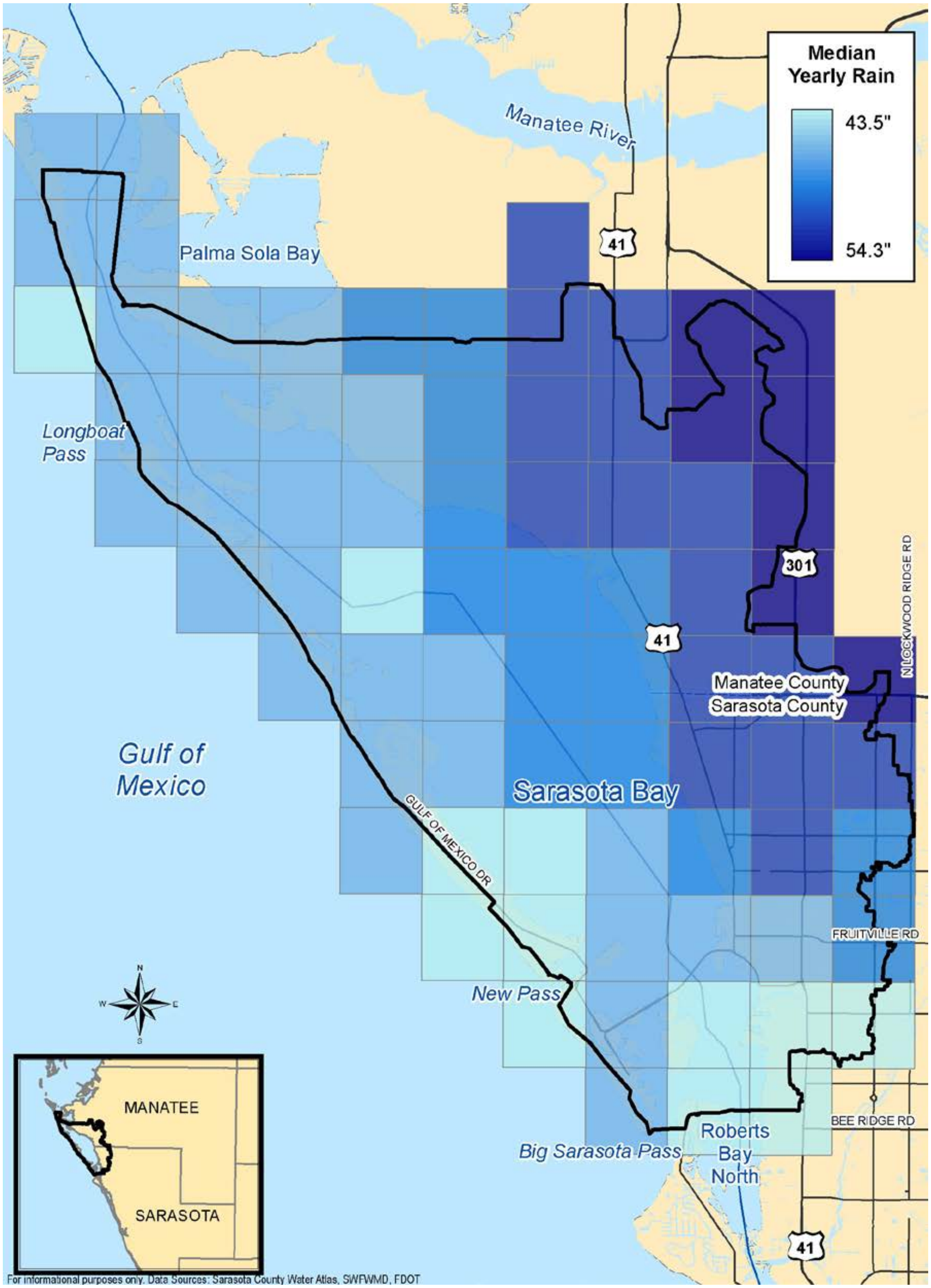


Figure 3-1 Median Annual Rainfall in Each of the Pixels Used in the Sarasota Bay SIMPLE Model

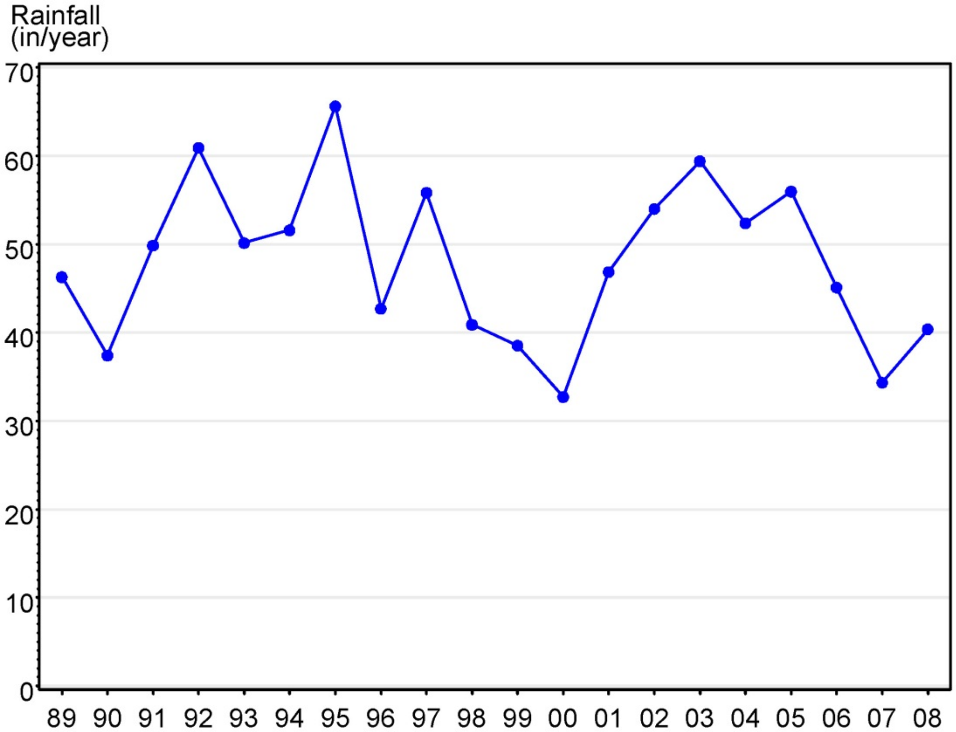


Figure 3-2 Total Annual Rainfall to Sarasota Bay and Its Watershed

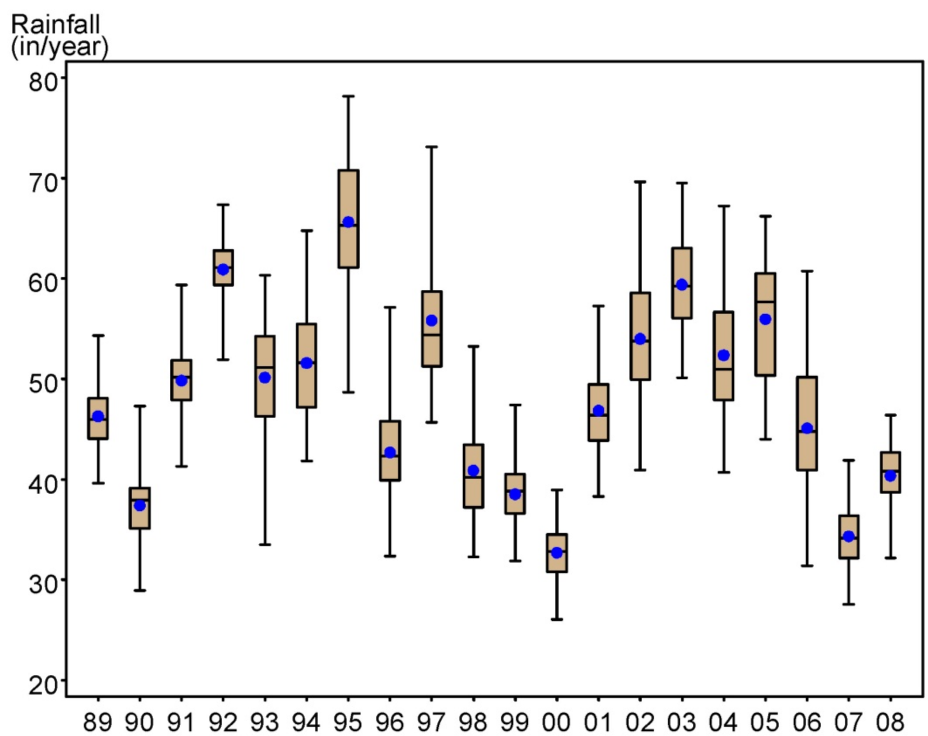


Figure 3-3 Variation in Total Annual Rainfall Among Pixels within Sarasota Bay and Its Watershed

3.2.3 Seasonal Variation

Figure 3-4 presents box-and-whisker plots of the monthly rainfall data used in the Sarasota Bay SIMPLE model. There is a distinct seasonal signal in precipitation in the watershed. As is typical of this region, June through September are significantly wetter than the other eight months. The four wet season months have average precipitation of between 6 and 8 inches, while the eight dry season months average between 2 to 3 inches, with at least one pixel showing zero rainfall for each dry month. The highest monthly rainfall of 28 inches occurred in June.

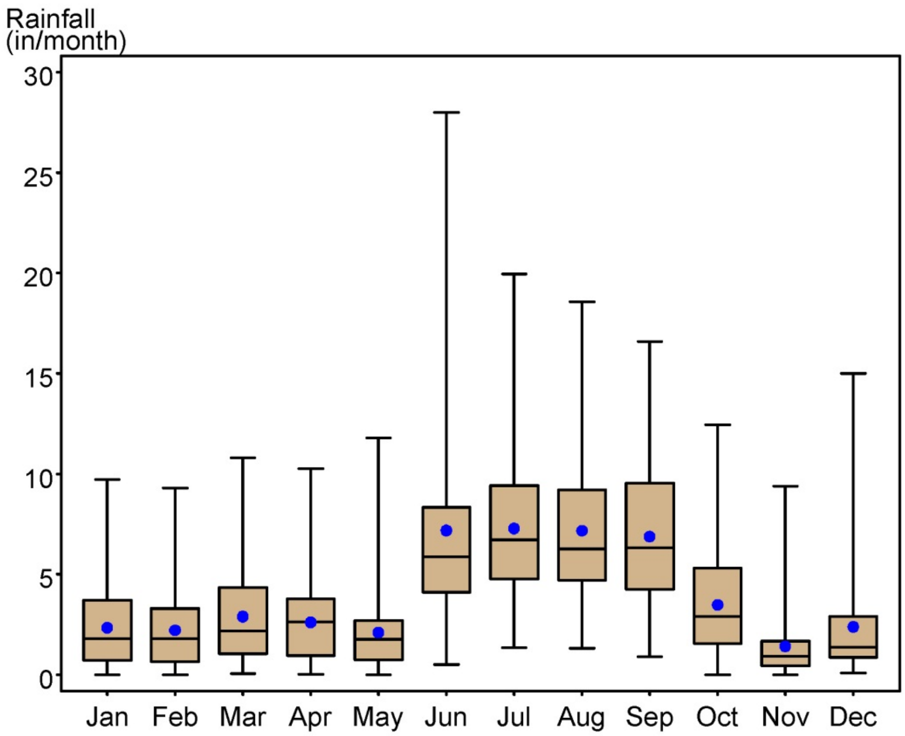


Figure 3-4 Variation in Total Monthly Rainfall to Sarasota Bay and its Watershed

3.3 HISTORICAL AND CURRENT FRESHWATER INPUTS

3.3.1 Total Freshwater Inputs

3.3.1.1 Annual

Figure 3-5 shows total annual freshwater inputs for historical and current conditions. Two patterns are evident. The first is that the freshwater inputs closely follow the precipitation pattern. Total current freshwater inputs range from around 100,000 acre-feet/year to over 200,000 acre-feet per year. The other pattern is that the current freshwater inputs are fairly uniformly larger (about 20%) than historical.

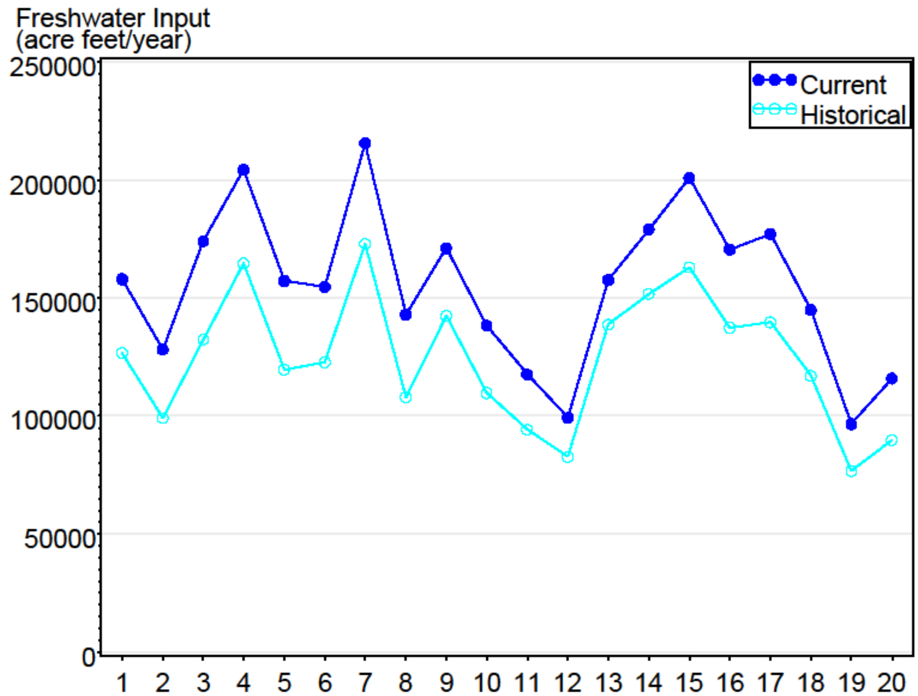


Figure 3-5 Annual Freshwater Inputs to Sarasota Bay Under Current and Historical Conditions

3.3.1.2 Seasonal

Figure 3-6 shows the seasonal variability in total freshwater inputs under historical and current conditions. This figure illustrates a similar wet-dry pattern for both time frames. June has the most extreme events, but months later in the wet season have the higher median inputs. There are no zero-flow months because precipitation-independent sources contribute to freshwater inputs each month.

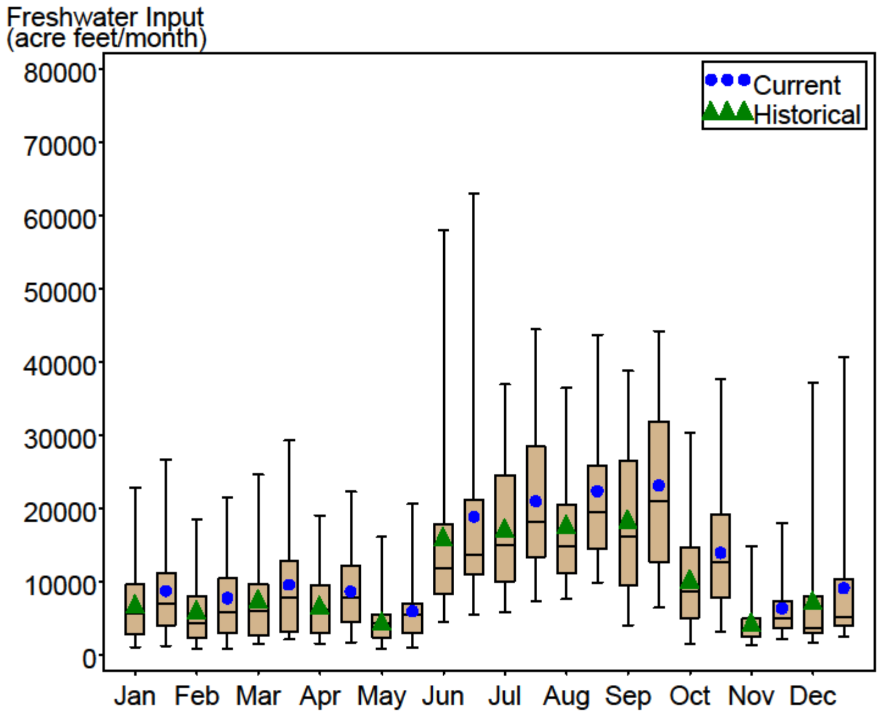


Figure 3-6 Seasonal Variation in Freshwater Inputs to Sarasota Bay under Current and Historical Conditions

3.3.1.3 Spatial

Figure 3-7 presents the changes in total freshwater inputs from each individual basin between the current and historical periods. The basin inputs reflect basin characteristics (e.g., land use, soils) and the size of the basin. The modest increase in inputs for most basins is not surprising, although the south portion of the watershed was already relatively developed in the 1950s.

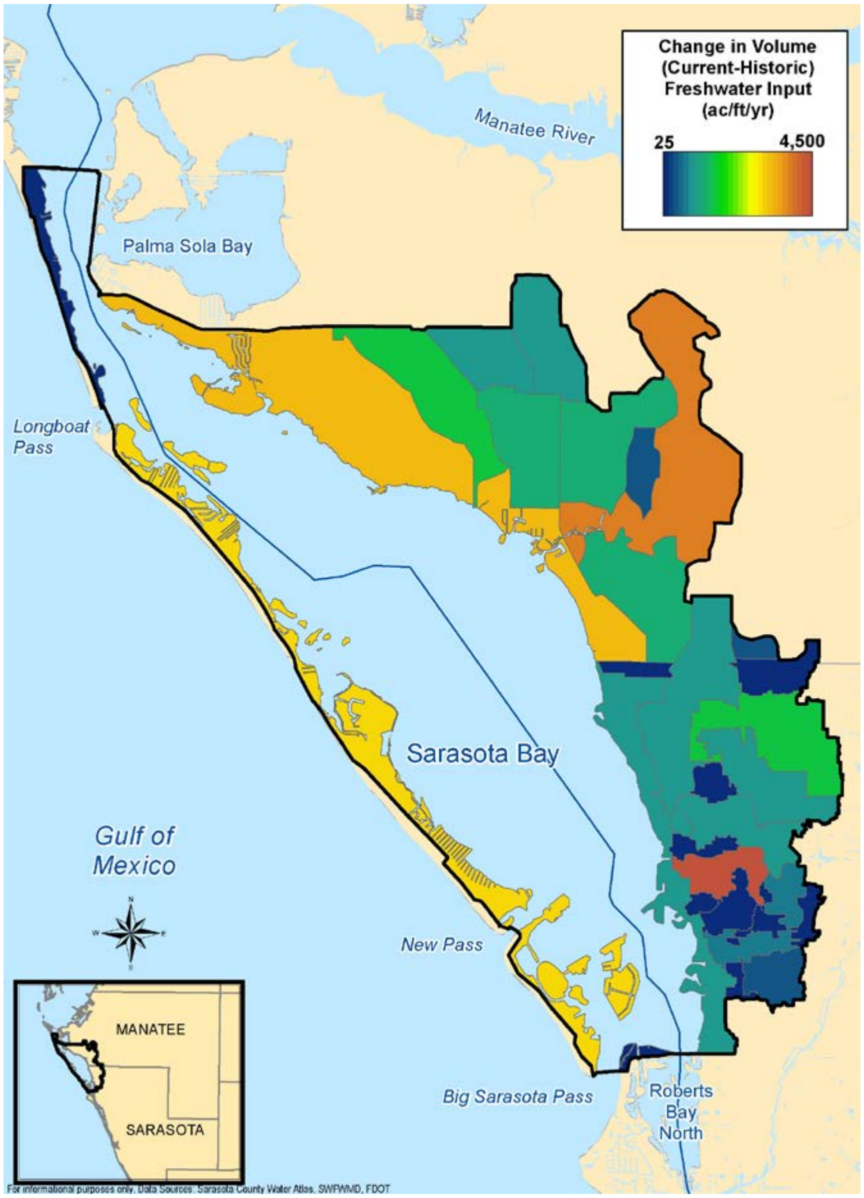


Figure 3-7 Change to Median Annual Freshwater inputs to Sarasota Bay from Basins within the Watershed from Current to Historical Conditions

3.3.1.4 Sources

Table 3-1 compares the sources of freshwater inputs to Sarasota Bay under historical and current conditions. Atmospheric deposition was the major source of freshwater to Sarasota Bay under both conditions. This is a reflection of the ratio of the area of the Sarasota Bay estuary to the area of the Sarasota Bay watershed. Baseflow and direct runoff were also significant contributors of freshwater under both conditions. Point-source inputs were greater under current conditions, reflecting the increased population served under current conditions.

Table 3-1 Current and Historical Freshwater Inputs (ac-ft/yr) to Sarasota Bay by Basin
Total does not include atmospheric deposition.

Period	Basin	Atmospheric Deposition	Base flow	Direct Runoff	Irrigation	Point Sources	Septic Tanks	Total
Current	Canal Road Drain	87,831	272	408	12	0	33	692
	Sarasota Bay Coastal North		3,977	4,380	253	0	0	8,750
	Palma Sola Drain - Bayshore		1,403	1,512	68	0	45	3,029
	Cedar Hammock Creek		3,260	3,244	113	0	238	6,855
	Bowlees Creek		7,036	7,835	205	0	374	15,450
	Longboat/Lido Key		2,156	2,753	161	0	45	5,115
	Sarasota Bay Coastal South		1,679	1820	54	0	0	3,563
	Whitaker Bayou		5,210	5,531	151	5,9740	329	16,939
	Hudson Bayou		2,538	2,810	67	0	9	5,424
	Siesta Key		74	63	4	0	1	141
	TOTAL		27,603	30,356	1,089	5,974	937	65,958
Historical	Canal Road Drain	87,831	188	267	0	0	12	467
	Sarasota Bay Coastal North		2,113	3,447	0	0	25	5,585
	Palma Sola Drain - Bayshore		732	755	0	0	0	1,487
	Cedar Hammock Creek		1,127	2,282	0	0	10	3,419
	Bowlees Creek		3,202	4,872	0	0	32	8,106
	Longboat/Lido Key		1,260	1,774	0	0	6	3,040
	Sarasota Bay Coastal South		130	140	0	0	0	270
	Whitaker Bayou		1,161	987	0	0	2	3,723
	Hudson Bayou		2,811	3,843	228	0	2	6,884
	Siesta Key		1,693	1,489	0	0	4	3,186
	TOTAL		14,417	19,856	228	0	93	36,167

Figure 3-8 presents the sources of freshwater inputs under current and historical conditions by year. The relative contributions were consistent across most years.

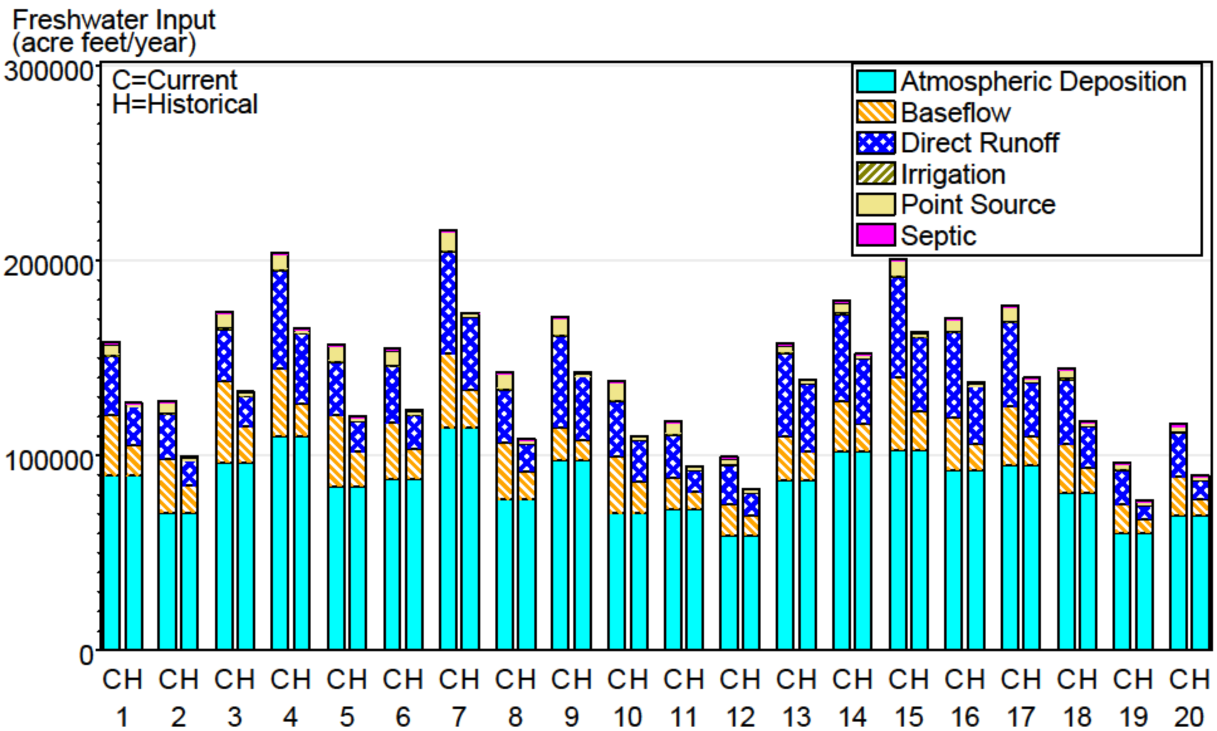


Figure 3-8 Sources of Freshwater Inputs to Sarasota Bay under Current and Historical Conditions

3.3.2 Comparison of Historical and Current Baseflow

3.3.2.1 Annual

Baseflow is shallow groundwater flow that continues even during periods of no precipitation. Figure 3-9 shows annual baseflow freshwater inputs for historical and current conditions. Two patterns are evident. The first is that the freshwater inputs closely follow the precipitation pattern. Total current freshwater inputs range from around 15,000 acre-feet/year to over 40,000 acre-feet per year. The other pattern is that, unlike total inflows, the current freshwater inputs are larger than historical but the difference is not uniform and varies from almost 50% higher during low flows to over 100% during high flows.

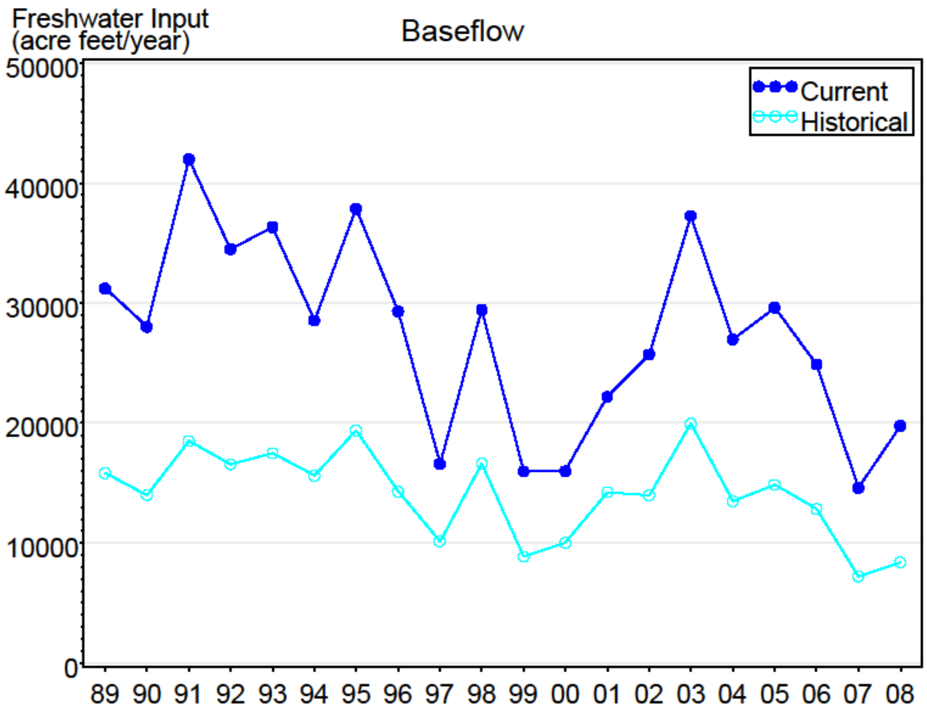


Figure 3-9 Annual Baseflow Freshwater Inputs to Sarasota Bay Under Current and Historical Conditions

3.3.2.2 Seasonal

Figure 3-10 shows the seasonal variability in baseflow freshwater inputs under historical and current conditions. In the figure, the symbol in the box (circle and triangle) represents the mean value for that month and the horizontal line is the median. The closer the symbol and line are, the more normally distributed the data are. The top and bottom of the vertical lines (whiskers) represent the highest and lowest values for that month, respectively.

Like surface runoff, baseflow is driven by rainfall and shows a distinct seasonal pattern. However, the hydrological processes involving baseflow include precipitation infiltrating the shallow water table and subsequent subsurface flow of the groundwater until it discharges into a stream or canal channel. This produces a lag effect in the expression of the baseflow, illustrated in Figure 3-10 by the low June values, increasing baseflows during July, August, and September, and a slow decline for several months after as the water table levels drop when the wet season ends. Current monthly baseflows vary from a low of about 1,200 acre-feet/month in May to a high of over 4,000 acre-feet/month in September. Historical baseflows are lower, ranging from under 1,000 acre-feet/month to just over 2,000 acre-feet/month in September.

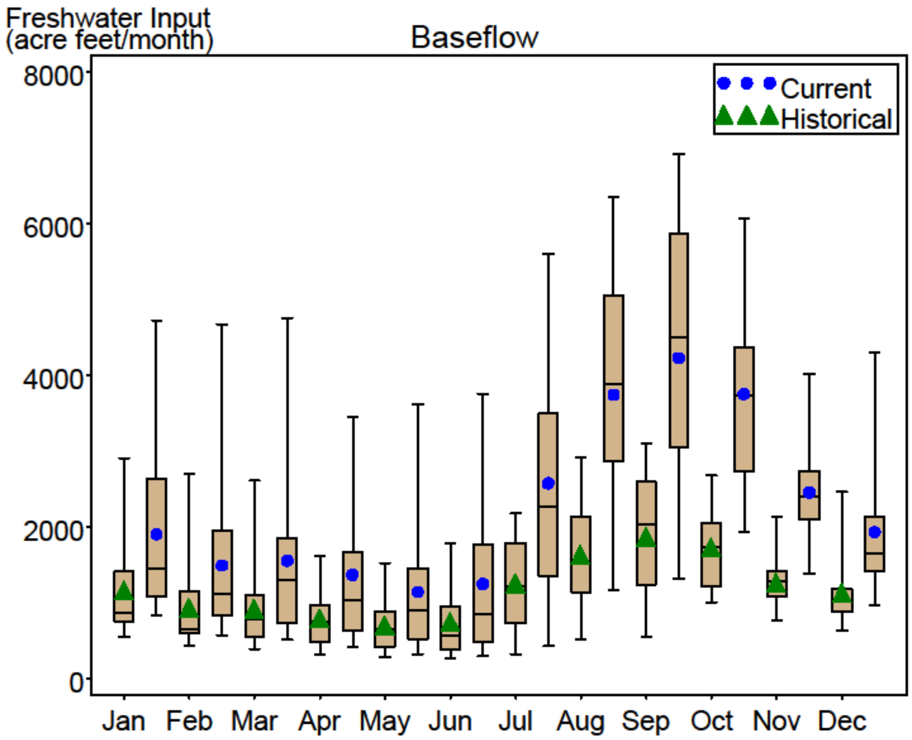


Figure 3-10 Seasonal Variation in Baseflow Freshwater Inputs to Sarasota Bay Under Current and Historical Conditions

3.3.2.3 Spatial

Figure 3-11 presents the changes to baseflow freshwater inputs from each individual basin between historical and current conditions. The volume of baseflow is mainly a reflection of basin size, although land use also accounts for spatial variation. However, in general the larger basins in the north portion of the watershed produce greater volumes of baseflow.

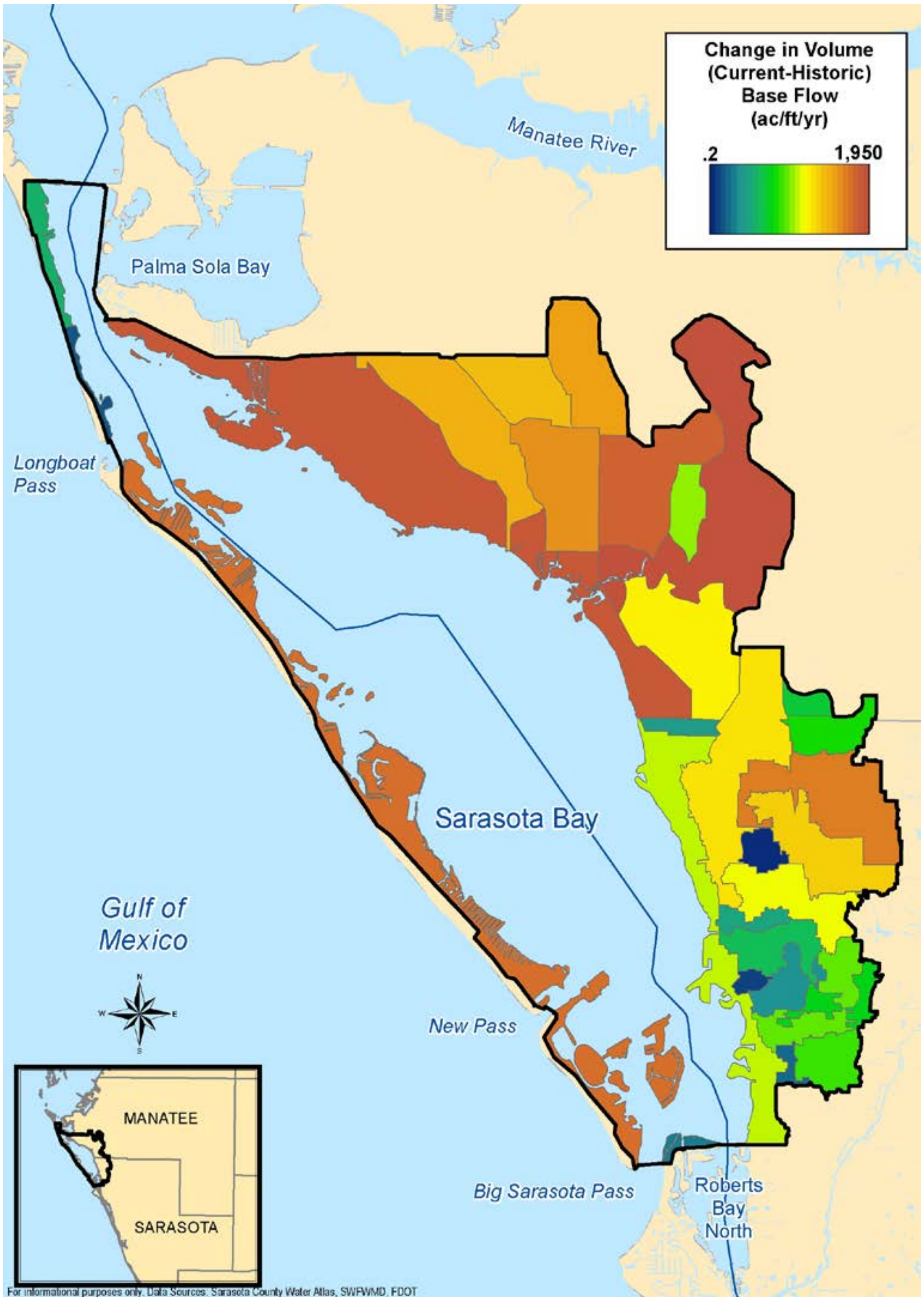


Figure 3-11 Baseflow Freshwater Inputs (acre-feet/year) to Sarasota Bay from Basins within the Watershed

Figure 3-12 presents the change in baseflow freshwater inputs from each of the individual basins corrected for basin area between the periods. Using the unit-area inputs (acre-feet/acre/year) allow large and small basins to be compared on an equivalent basis. Unit loads reflect normalized spatially-specific characteristics to be contrasted. In this case, land use is the dominant feature that affects base flow.

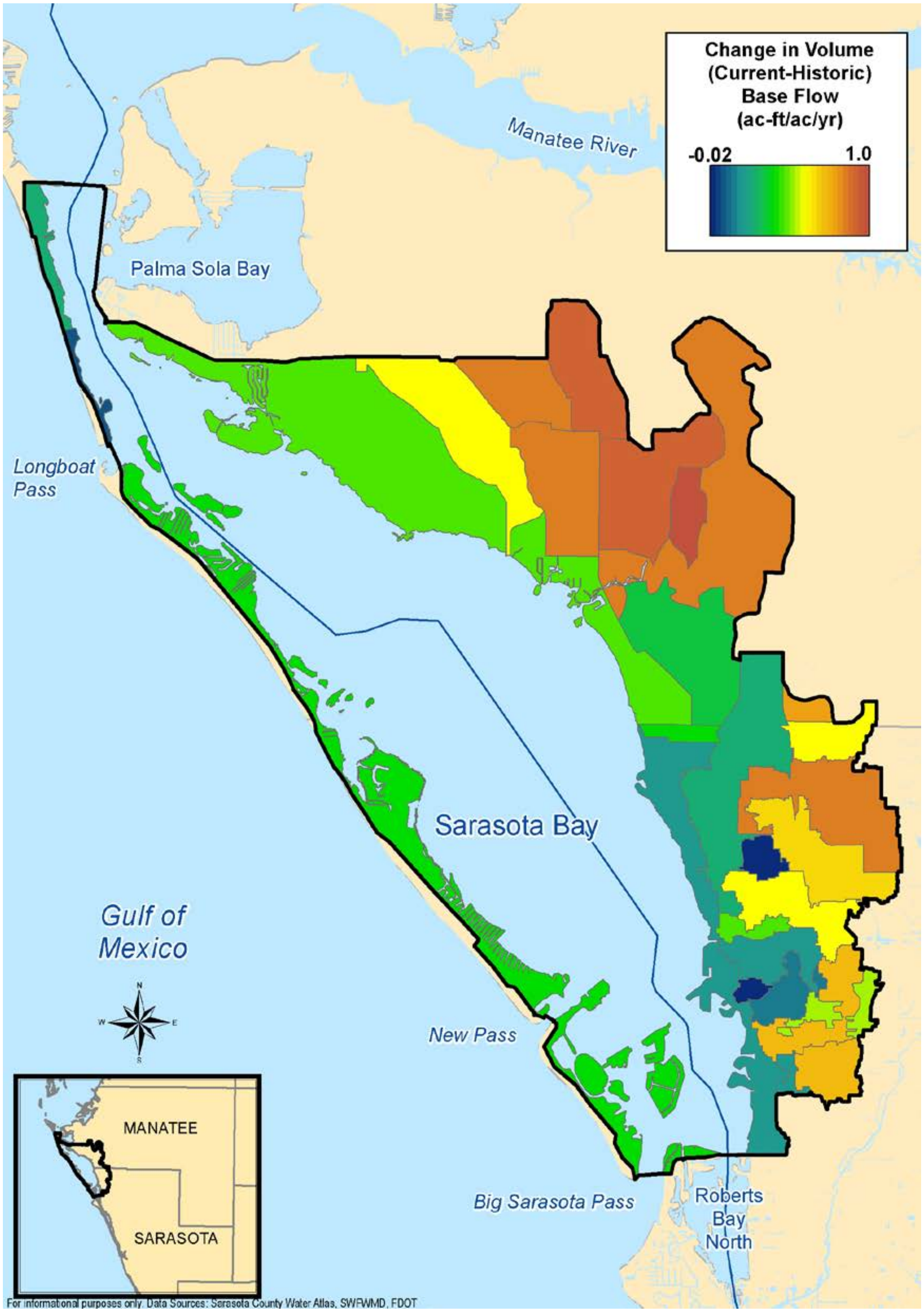


Figure 3-12 Change in Unit-Area Baseflow Freshwater Inputs (acre-feet/acre/year) to Sarasota Bay from Basins within the Watershed between Historical and current Conditions

3.3.3 Comparison of Historical and Current Direct Runoff

3.3.3.1 Annual

Figure 3-13 shows annual direct runoff freshwater inputs for historical and current conditions. Runoff occurs as a result of precipitation, so the annual runoff is a function of annual rainfall. Years of higher rainfall in general produce higher annual runoff values. Current annual runoff ranges from under 20,000 acre-feet/year (2007) to over 50,000 acre-feet/year (2003). Historical annual runoff is lower than under current conditions but follows the same patterns, as the same precipitation was used for both scenarios. Historical annual runoff varied from a low of under 10,000 acre-feet/year to a high of 38,000 acre-feet/year.

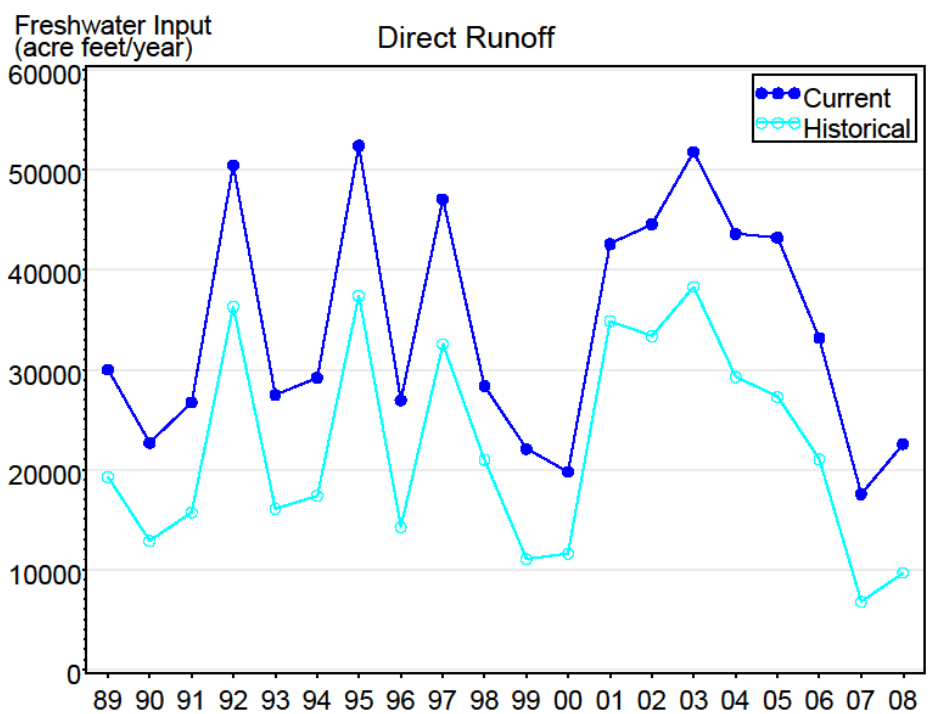


Figure 3-13 Annual Direct Runoff Freshwater Inputs to Sarasota Bay Under Current and Historical Conditions

3.3.3.2 Seasonal

Figure 3-14 shows the seasonal variability in direct runoff freshwater inputs under historical and current conditions. Runoff shows a typical seasonal pattern for both scenarios with higher monthly values during the wet season and drier values during the dry season. Current monthly values range from 6,000 acre-feet/month in September to a low of less than 1,000 acre-feet/month in May. Historical values range from almost 5,000 acre-feet/month in September to a few hundred acre-feet/month in May. The June mean and median values are well-separated. This indicates that a few extreme events (high value of 25,000 acre-feet/month) skew the distribution of the monthly values.

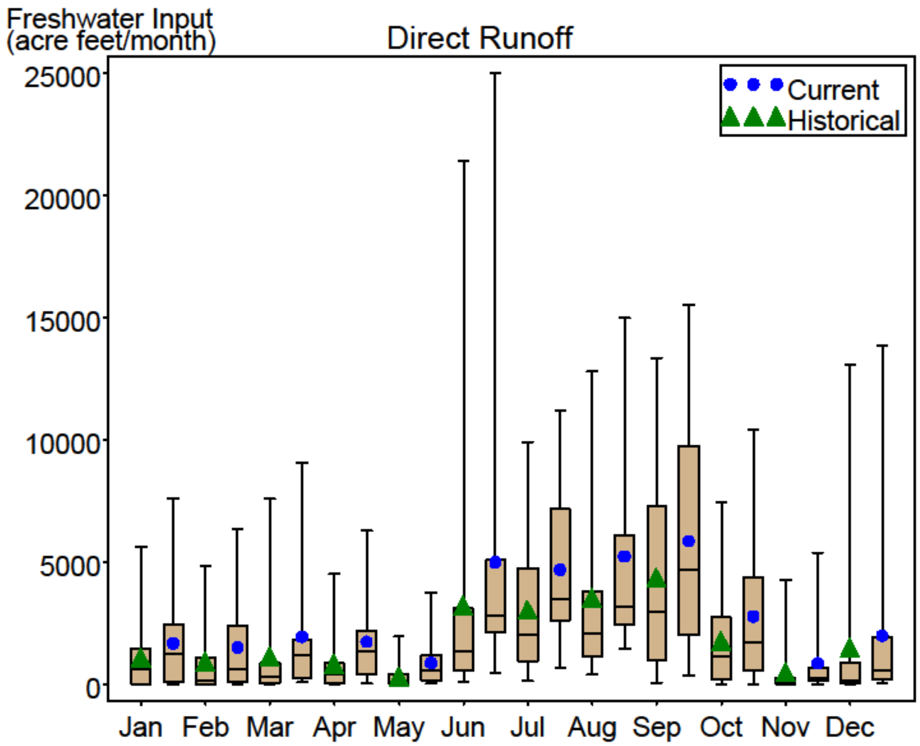


Figure 3-14 Seasonal Variation in Direct Runoff Freshwater Inputs to Sarasota Bay Under Current and Historical Conditions

3.3.3.3 Spatial

Figure 3-15 presents the change to direct runoff freshwater inputs from each individual basin between the historical and current periods. Like baseflow, the total runoff volume for a basin is determined largely by the basin size but also by land use and other factors. Figure 3-15 shows the most runoff originating in the largest basins for current and historical conditions.

Figure 3-16 presents the change to direct runoff freshwater inputs from each individual basin corrected for basin area between current and historical periods. As with baseflow, using the unit-area runoff allows runoff from different size basins to be compared on an equal basis. In this case, land use is the main basin characteristic that affects unit-area runoff, with urbanized basins generating more runoff per acre than undeveloped basins. Some of the largest unit-area volumes are generated by the smaller basins.

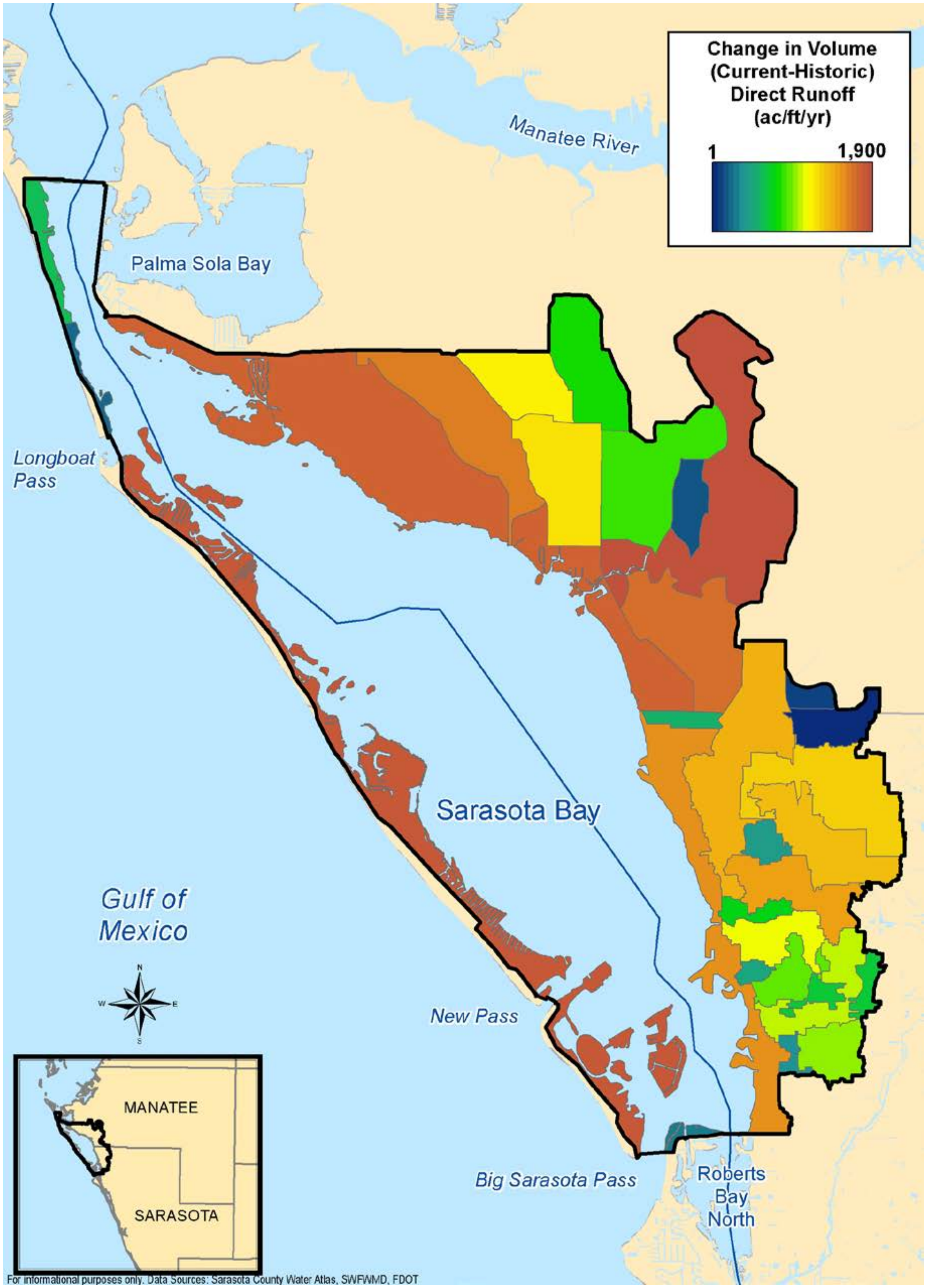


Figure 3-15 Change to Direct Runoff Freshwater Inputs (acre-feet/year) to Sarasota Bay from Basins within the Watershed between Historical and Current Conditions

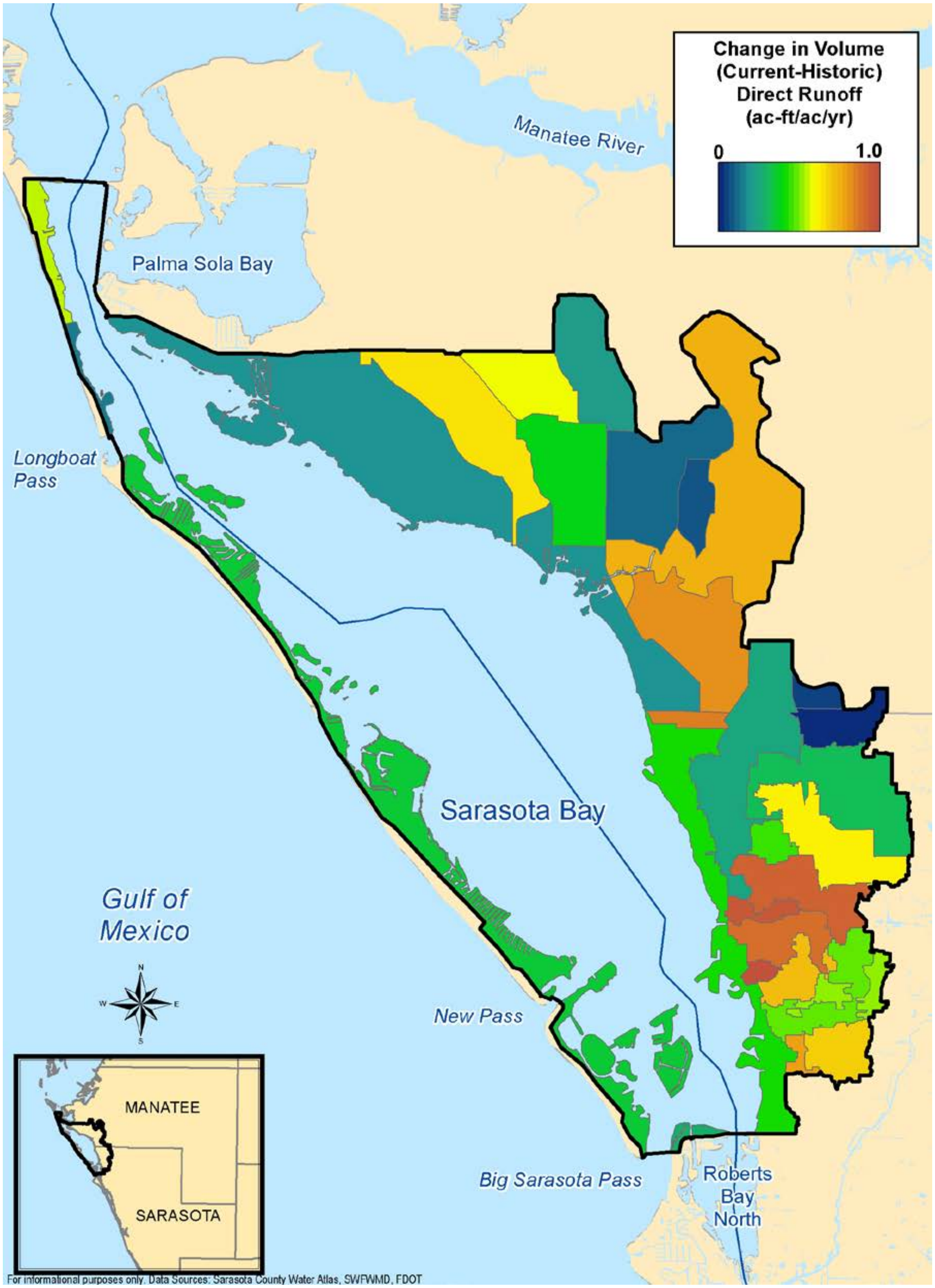


Figure 3-16 Change to Unit-Area Direct Runoff Freshwater Inputs (acre-feet/acre/year) to Sarasota Bay from Basins within the Watershed between Historical and Current Conditions

3.3.4 Rainfall-Freshwater Input Relationships

3.3.4.1 Total Freshwater Inputs

Figure 3-17 presents the ratio of total annual freshwater inputs to annual rainfall derived from the historical and current SIMPLE model runs. The relationship is relatively linear, with more precipitation generating more runoff in both scenarios.

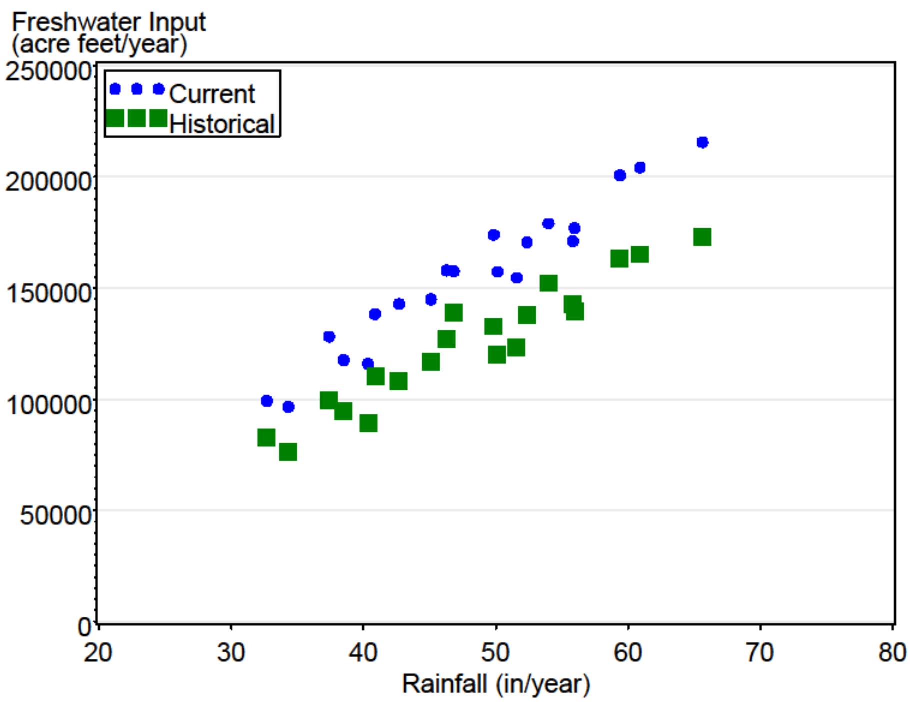


Figure 3-17 Ratio of Total Freshwater Inputs to Total Rainfall in the Sarasota Bay Estuary and Watershed for Current and Historical Conditions

3.3.4.2 Direct Runoff Freshwater Inputs

Figure 3-18 presents the ratio of annual direct runoff freshwater inputs to annual rainfall derived from the historical and current SIMPLE model runs. In the Sarasota Bay watershed, the relationship of precipitation to runoff is generally the same as for precipitation and total runoff. Higher runoff per rainfall unit reflects higher levels of urbanization in the watershed. Also, the relationship shows that runoff is the dominant source of freshwater inputs to the bay.

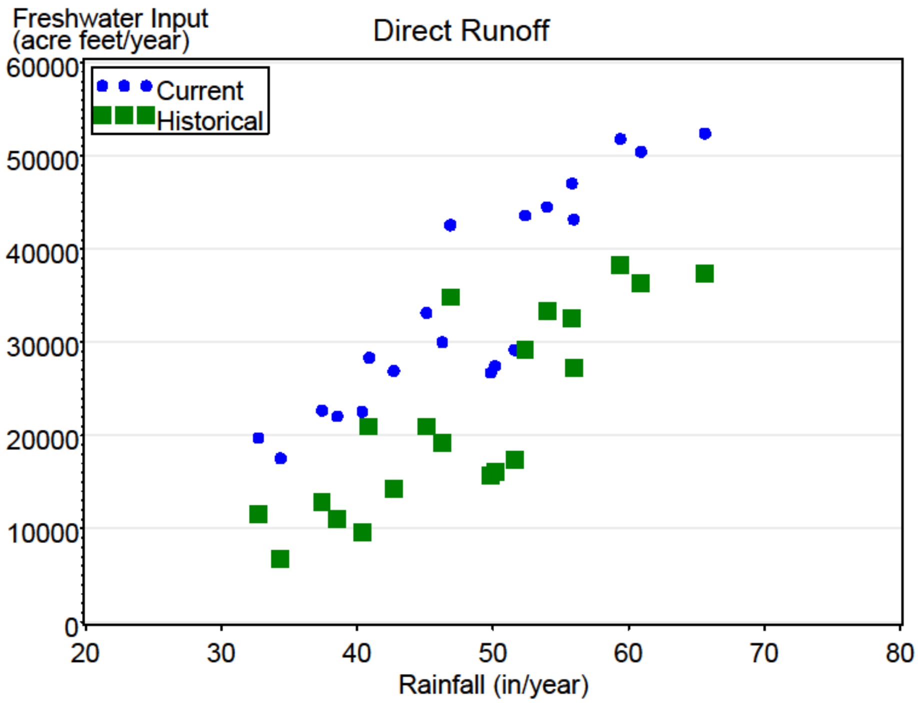


Figure 3-18 Ratio of Direct Runoff Freshwater Inputs to Total Rainfall in the Sarasota Bay Estuary and Watershed for Current and Historical Conditions

3.4 CURRENT AND FUTURE FRESHWATER INPUTS

3.4.1 Total Freshwater Inputs

3.4.1.1 Annual

Figure 3-19 shows total annual freshwater inputs for current and future conditions. Freshwater inputs closely follow the trend for precipitation depicted in Figure 3-2. Total freshwater inputs range from approximately 100,000 acre-feet/year to 225,000 acre-feet per year. There is very little difference between future and current freshwater loads.

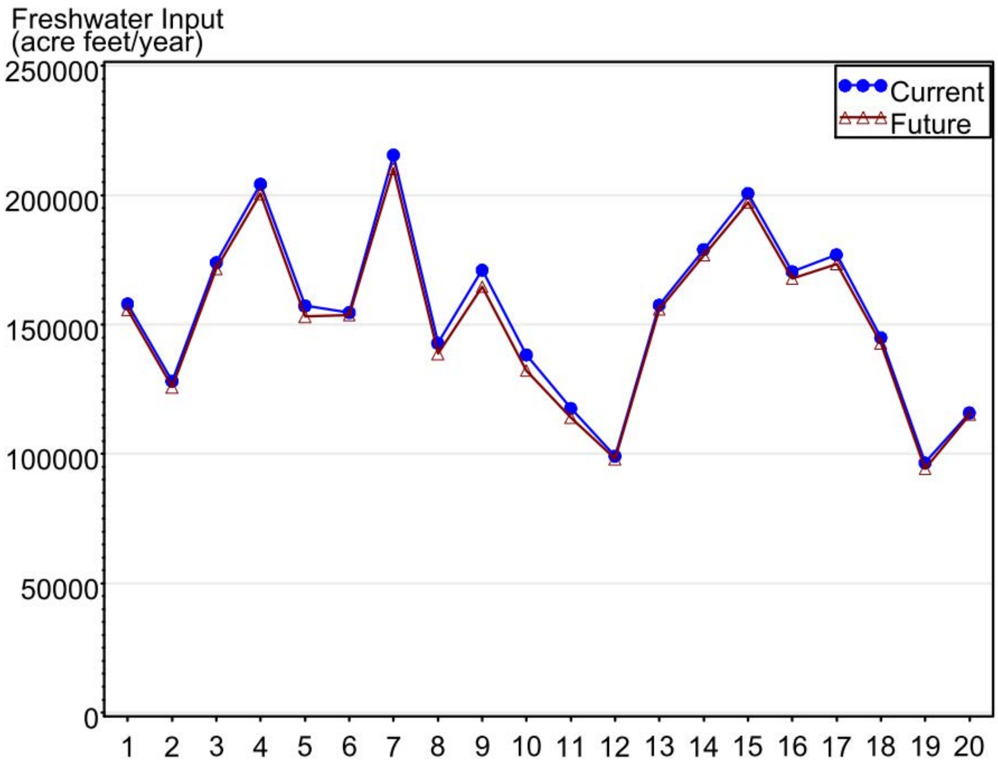


Figure 3-19 Annual Freshwater Inputs to Sarasota Bay under Current and Future Conditions

3.4.1.2 Seasonal

Figure 3-20 shows the seasonal variability in total freshwater inputs under current and future conditions. This figure illustrates a similar wet-dry pattern for both time frames. June has the most extreme events, but months later in the wet season have the higher median inputs. There are no zero-flow months because precipitation-independent sources contribute to freshwater inputs each month.

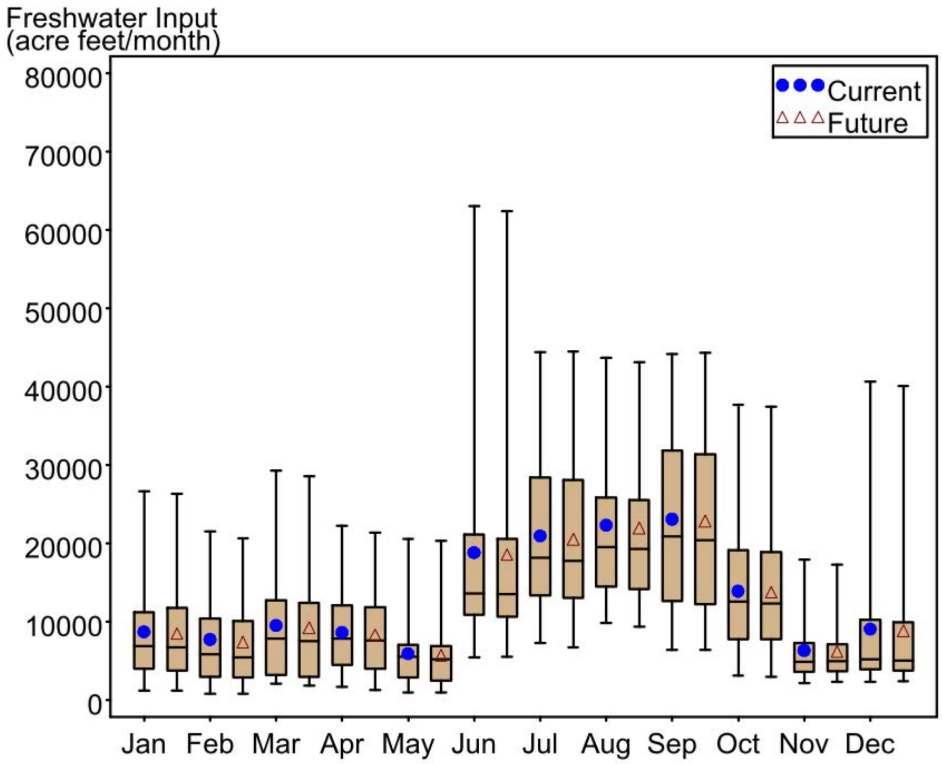


Figure 3-20 Seasonal Variation in Freshwater Inputs to Sarasota Bay under Current and Future Conditions

3.4.1.3 Spatial

Figure 3-21 presents the change in total freshwater inputs by basin between the current and future conditions. Basin inputs are a result of the composition of land use and soils within the basin as well as basin size. For the most part, there is little change in total freshwater inputs from current to future conditions with the exception of the cessation of point source discharges to Whitaker Bayou. This reflects the present high level of urbanization within the watershed and the low potential for any significant increase in urban development.

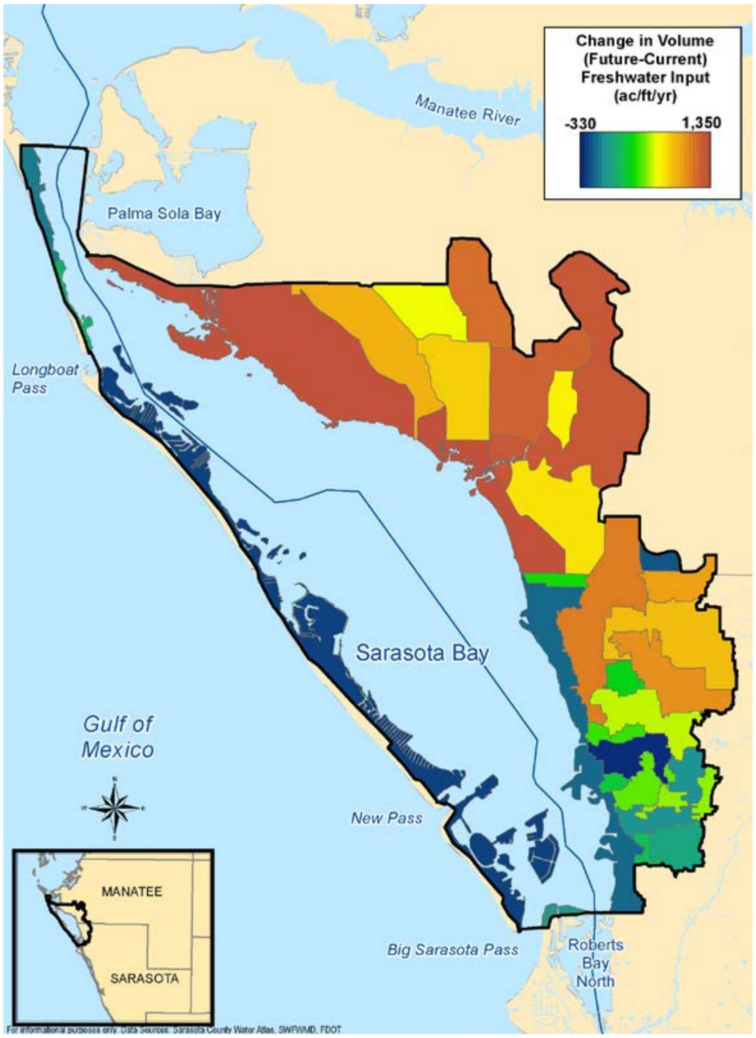


Figure 3-21 Change in Median Annual Freshwater Inputs to Sarasota Bay from the Various Basins within the Sarasota Bay Watershed Between Current and Future Conditions

3.4.1.4 Sources

Table 3-2 compares the sources of freshwater inputs to Sarasota Bay under current and future conditions. Atmospheric deposition was the major source of freshwater to Sarasota Bay under current and future conditions. This is a reflection of the ratio of the area of the Sarasota Bay estuary to the area of the Sarasota Bay watershed. Baseflow and direct runoff were also significant contributors of freshwater under both conditions. Point-source inputs were greater under the current conditions, reflecting the transition of the City of Sarasota plant from surface water discharges to deep-well injection and reuse irrigation under future conditions.

Figure 3-22 presents the sources of freshwater inputs under current and future conditions by year. The relative contributions of each source, except point source, were slightly higher under future conditions compared to current estimates of freshwater inputs.

Table 3-2 Current and Future Freshwater Inputs (ac-ft/yr) to Sarasota Bay by Basin
Total does not include atmospheric deposition.

Period	Basin	Atmospheric Deposition	Base flow	Direct Runoff	Irrigati on	Point Sources	Septic Tanks	Total
Current	Canal Road Drain	87,831	272	408	12	0	33	692
	Sarasota Bay Coastal North		3,977	4,380	253	0	0	8,750
	Pala Sola Drain - Bayshore		1,403	1,512	68	0	45	3,029
	Cedar Hammock Creek		3,260	3,244	113	0	238	6,855
	Bowlees Creek		7,036	7,835	205	0	374	15,450
	Longboat/Lido Key		2,156	2,753	161	0	45	5,115
	Sarasota Bay Coastal South		1,679	1820	54	0	0	3,563
	Whitaker Bayou		5,210	5,531	151	5,974	329	16,939
	Hudson Bayou		2,538	2,810	67	0	9	5,424
	Siesta Key		74	63	4	0	1	141
	TOTAL		27,603	30,356	1,089	5,974	937	65,958
Future	Canal Road Drain	87,831	275	400	12	0	0.3	687
	Sarasota Bay Coastal North		4,909	4,641	337	0	141	10,027
	Pala Sola Drain - Bayshore		1,446	1,535	72	0	45	3,098
	Cedar Hammock Creek		3,322	3,257	118	0	238	6,935
	Bowlees Creek		7,377	8,002	229	0	374	15,983
	Longboat/Lido Key		2,345	2,743	166	0	45	5,299
	Sarasota Bay Coastal South		1,772	1,770	55	0	10.4	3,607
	Whitaker Bayou		5,747	5,914	169	0	72	11,902
	Hudson Bayou		2,615	2,902	71	0	8.6	5597
	Siesta Key		81	62	4.0	0	0.5	148
	TOTAL		29,891	31,226	1,233	0	935	63,284

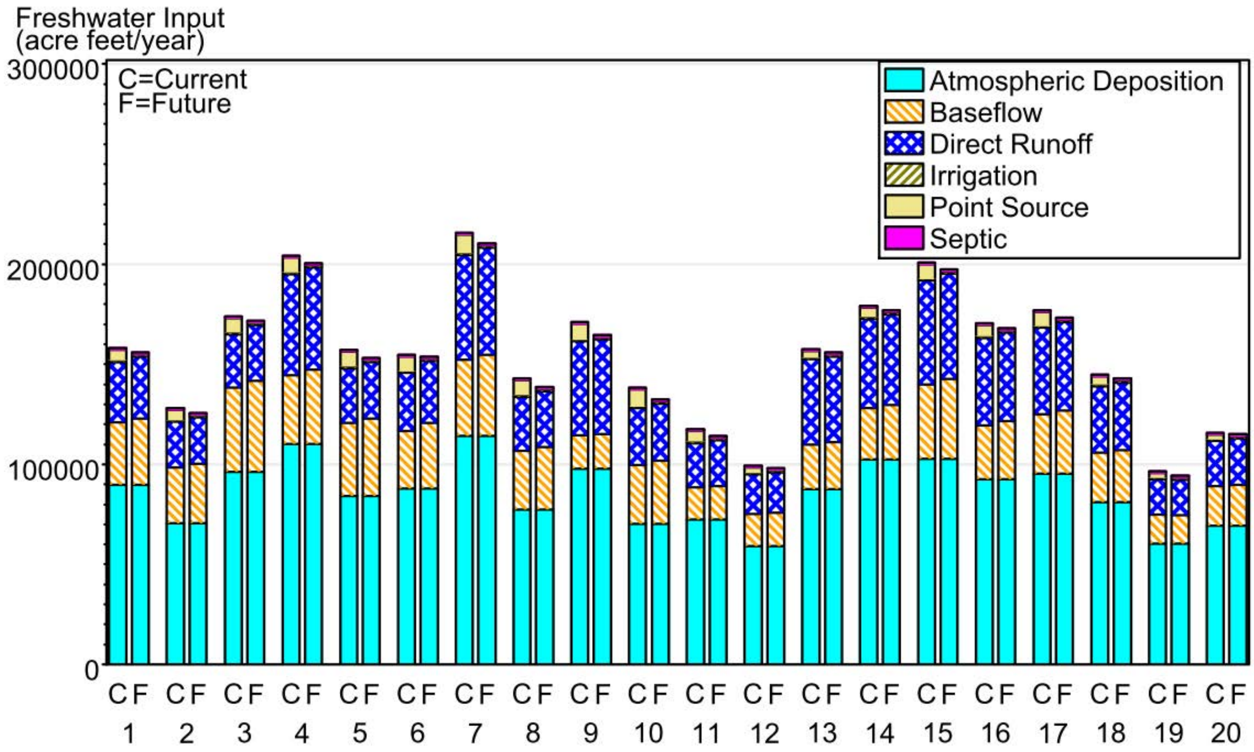


Figure 3-22 Sources of Freshwater Inputs to Sarasota Bay Under Current and Future Conditions

3.4.2 Comparison of Current and Future Freshwater Inputs from Baseflow

3.4.2.1 Annual

Baseflow is shallow groundwater flow that continues even during periods of no precipitation. Figure 3-23 shows annual baseflow freshwater inputs for current and future conditions are. Baseflow is greater under future watershed conditions, although the increase is <10% of current loads. As with total freshwater inputs, baseflow volumes reflect the annual variation in precipitation shown in Figure 3-2.

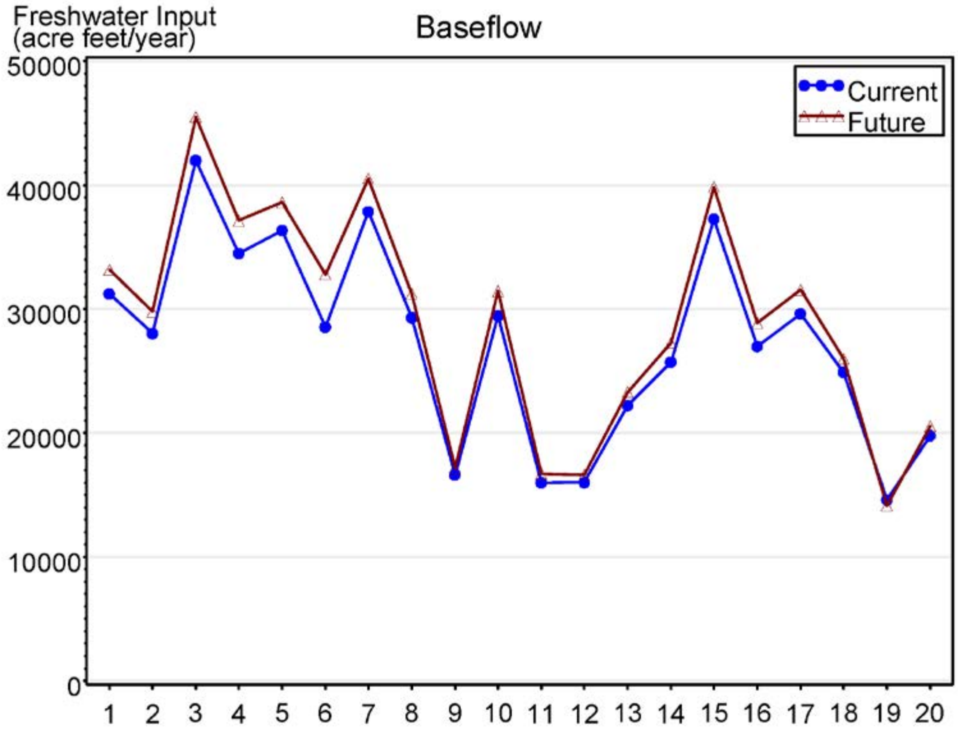


Figure 3-23 Annual Baseflow Freshwater Inputs to Sarasota Bay Under Current and Future Conditions

3.4.2.2 Seasonal

Figure 3-24 shows seasonal variability in freshwater inputs from baseflow under current and future conditions. In the figure, the symbol in the box (the circle and triangle) represents the mean value for that month and the horizontal line is the median. The closer the symbol is to the median line, the more normally distributed the data are. Vertical lines (whiskers) represent the highest and lowest values for the month.

Baseflow is driven by rainfall and exhibits distinct seasonality with greater baseflow during the wet months of June through September compared to the drier months of October through May. A lag effect is observed as a result of the time required for precipitation to infiltrate the shallow water table and discharge to surface waters. This lag effect is apparent in Figure 3-24 as low June values; increasing baseflow during July, August, and September; and a slow decline for several months following the peak wet season as the water table drops and returns to dry-season levels. Current and future monthly baseflows are similar during most months but are slightly higher during the wet season for future conditions compared to current freshwater loads. Baseflow varies from a minimum of about 500 acre-feet/month in June to a maximum of over 7,000 acre-feet/month in September. Mean monthly baseflow varied between the wet and dry seasons and ranged from approximately 1,000 to 4,500 acre feet/month during current and future conditions.

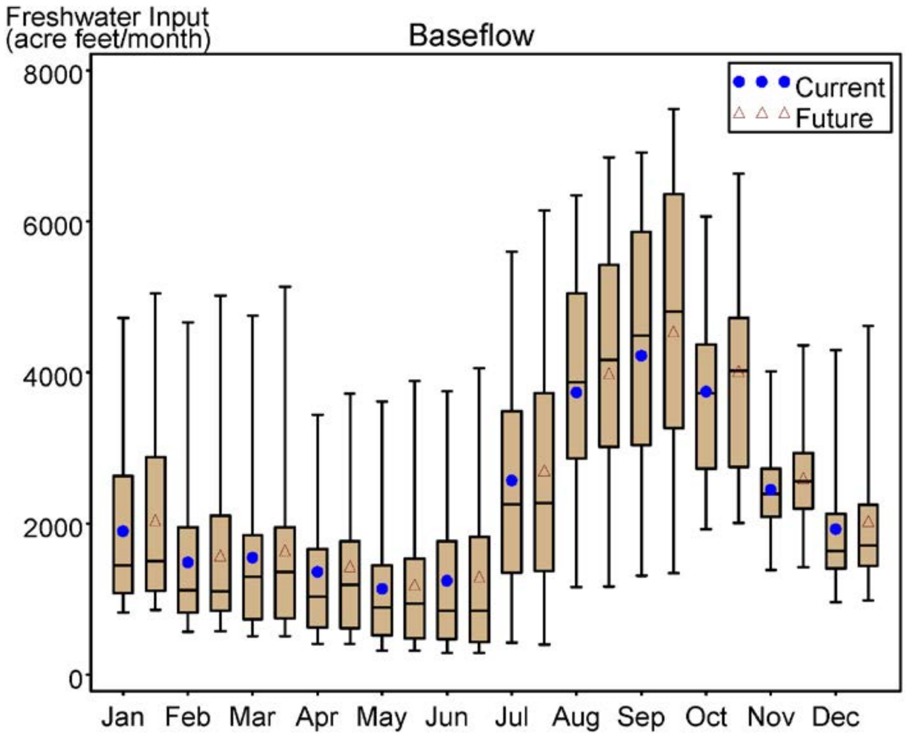


Figure 3-24 Seasonal Variation in Baseflow Freshwater Inputs to Sarasota Bay Under Current and Future Conditions

3.4.2.3 Spatial

Figure 3-25 presents changes to the freshwater inputs contributed by baseflow between the current and future periods. In both periods, baseflow is mainly a function of basin size, although land use and soil type also account for some of the observed spatial variation. In general, larger basins in the northern portion of the watershed exhibit greater volumes of baseflow. As with total freshwater inputs, there is little change from current to future conditions, again reflecting the present high level of urbanization within the watershed and the low potential for any significant increase in urban development. The most prominent increases in total freshwater inputs appear to be in the coastal basins.

Figure 3-26 illustrates changes to the unit-area-corrected freshwater inputs contributed by baseflow between the current and future periods. When baseflow is standardized for basin size, more apparent increases in freshwater inputs are observable. Again, coastal basins appear to have the largest increase in baseflow from the current to future conditions.

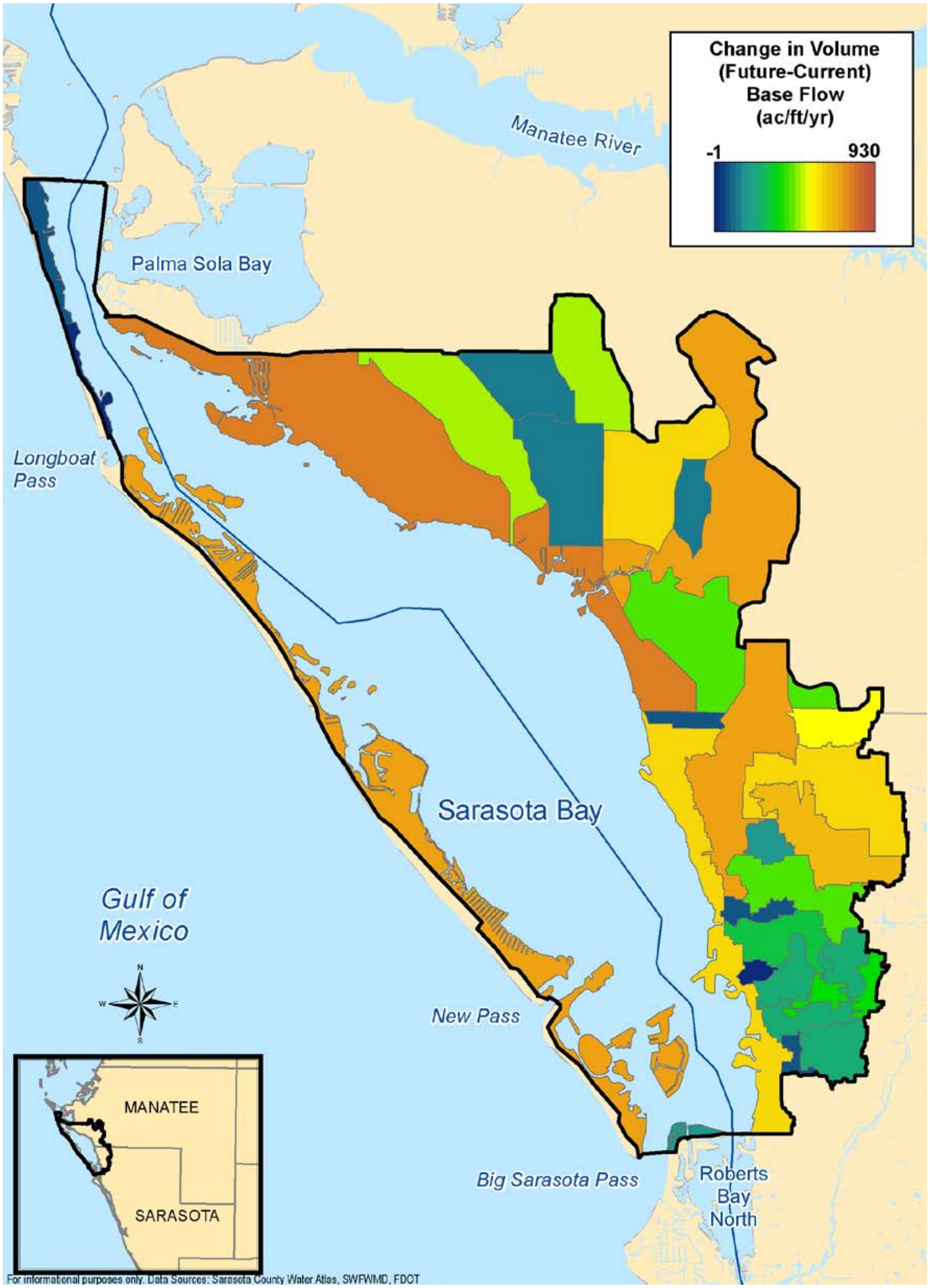


Figure 3-25 Changes to Freshwater Inputs from Baseflow (acre-feet/year) to Sarasota Bay between Current and Future Conditions

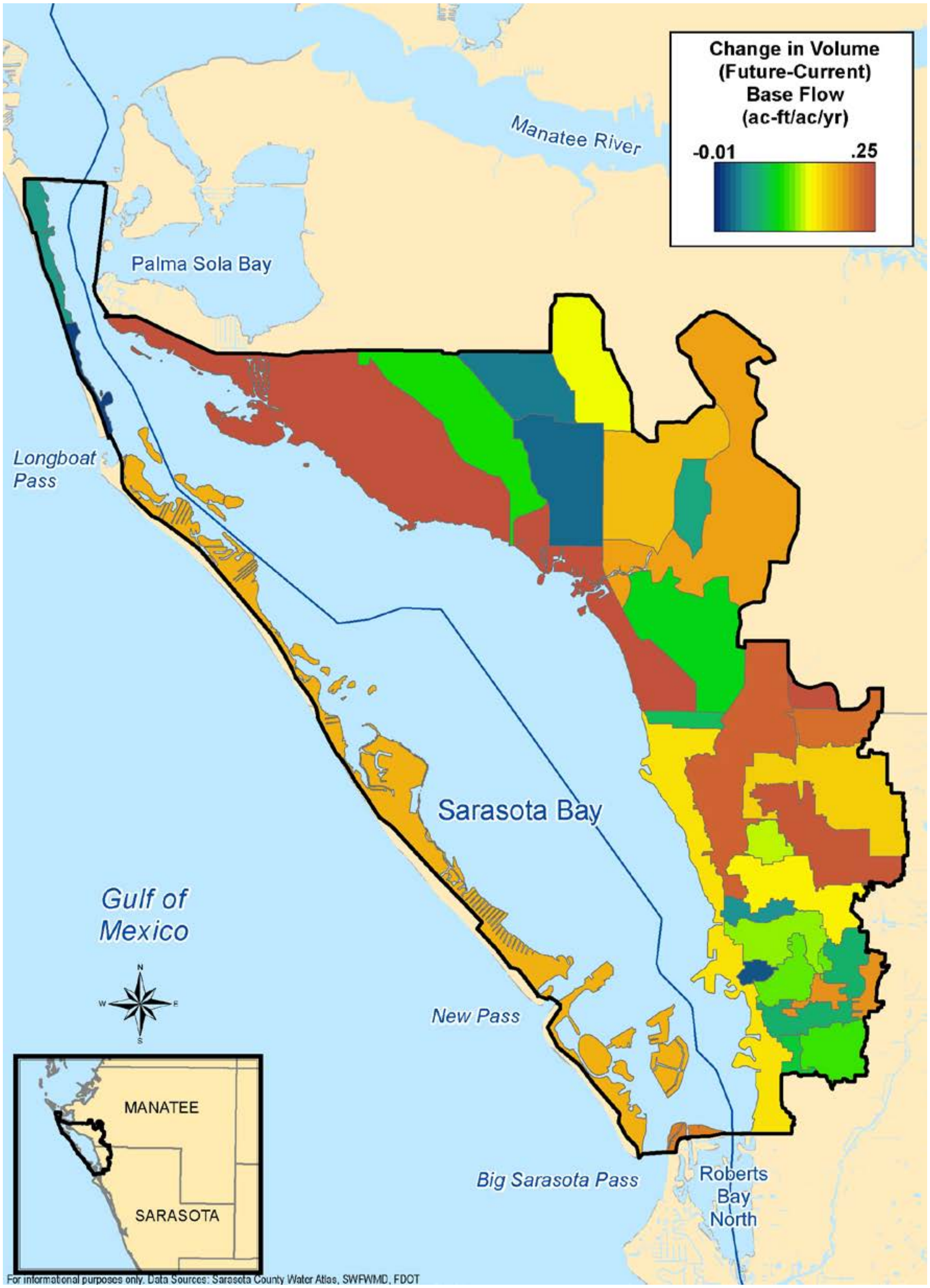


Figure 3-26 Changes to Unit-Area Freshwater Inputs from Baseflow (acre-feet/acre/year) to Sarasota Bay Between Current and Future Conditions

3.4.3 Comparison of Current and Future Freshwater Inputs from Direct Runoff

3.4.3.1 Annual

Figure 3-27 shows annual variation in freshwater inputs from direct runoff the current and future periods. Runoff occurs as a result of precipitation, so the annual runoff is a function of annual rainfall. Years of higher rainfall generally produce higher annual runoff values. Current annual runoff ranges from approximately 20,000 acre-feet/year to just over 50,000 acre-feet/year. Current annual runoff is lower than that estimated for future conditions, although runoff estimates for both periods exhibit a similar trend because the same precipitation record was used for both scenarios. Estimates of annual runoff for the future condition were very similar to those observed for current conditions.

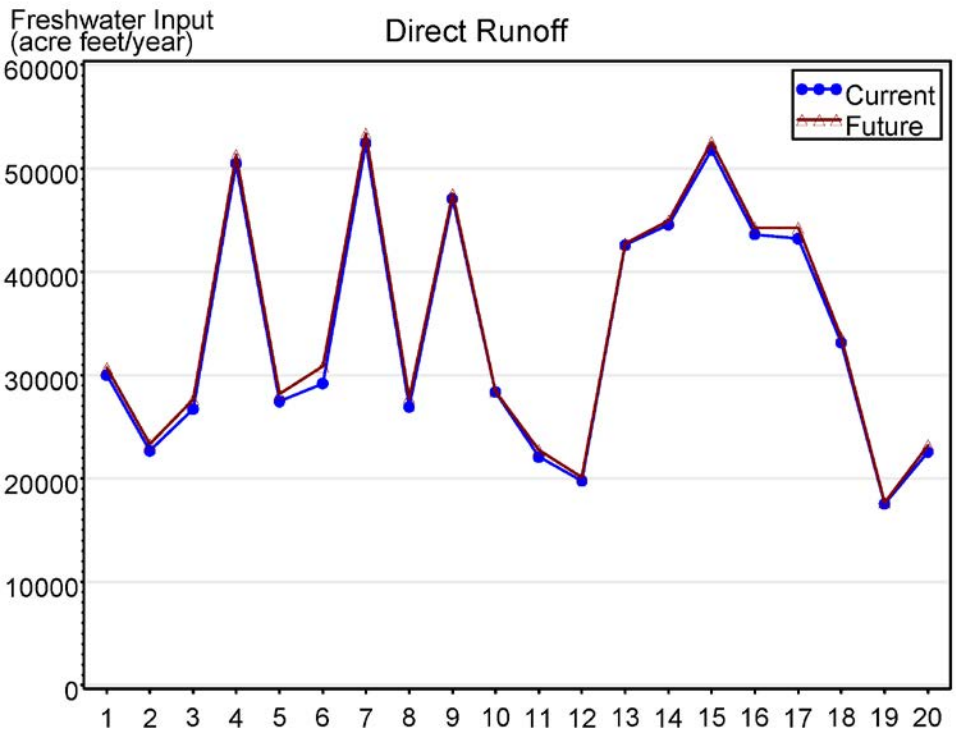


Figure 3-27 Annual Direct Runoff Freshwater Inputs to Sarasota Bay Under Current and Future Conditions

3.4.3.2 Seasonal

As with baseflow, direct runoff is driven by rainfall and shows a distinct seasonal pattern. This seasonal variation under current and future conditions is represented by higher monthly values during the wet season and lower values during the dry season as shown in Figure 3-28. Current monthly values range from a maximum of 25,000 acre-feet/month in September to nearly 0 acre-feet/month in May. Future runoff values were very similar to those for current conditions. The mean and median values for June are well-separated, indicating that a few extreme rain events skewed the distribution of monthly values (i.e., high value of 25,000 acre-feet/month). Mean monthly runoff varied by an order of magnitude between the wet and dry seasons and ranged from 500 to 5,000 acre feet/month during current and future conditions.

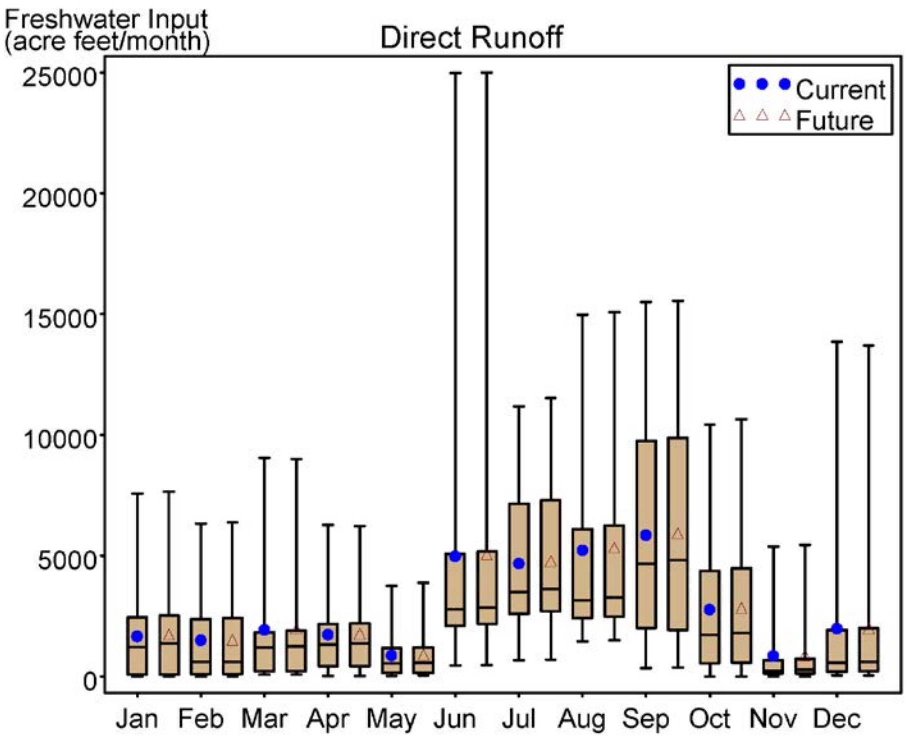


Figure 3-28 Seasonal Variation in Direct Runoff Freshwater Inputs to Sarasota Bay Under Current and Future Conditions

3.4.3.3 Spatial

Figure 3-29 presents changes to the spatial distribution of freshwater inputs from direct runoff between the current and future periods. Like baseflow, the total direct runoff from a basin is determined largely by the basin size but also by land use, soil type, and other factors. Figure 3-29 shows the most runoff originating in the largest basins in future and current conditions, although there is little difference in runoff volumes between current and future conditions.

Figure 3-30 depicts changes to the unit-area corrected freshwater inputs from direct runoff between the current and future periods. Standardizing by basin area makes it possible to identify basins contributing a disproportionate volume of freshwater to the estuary. In the case of Sarasota Bay, land use appears to be closely related to unit-area runoff, with more urbanized basins generating more runoff per acre than less developed basins. Some of the largest unit-area volumes originate in the smaller basins. The largest change in runoff from current to future conditions appears to be in the more southern basins of Sarasota County.

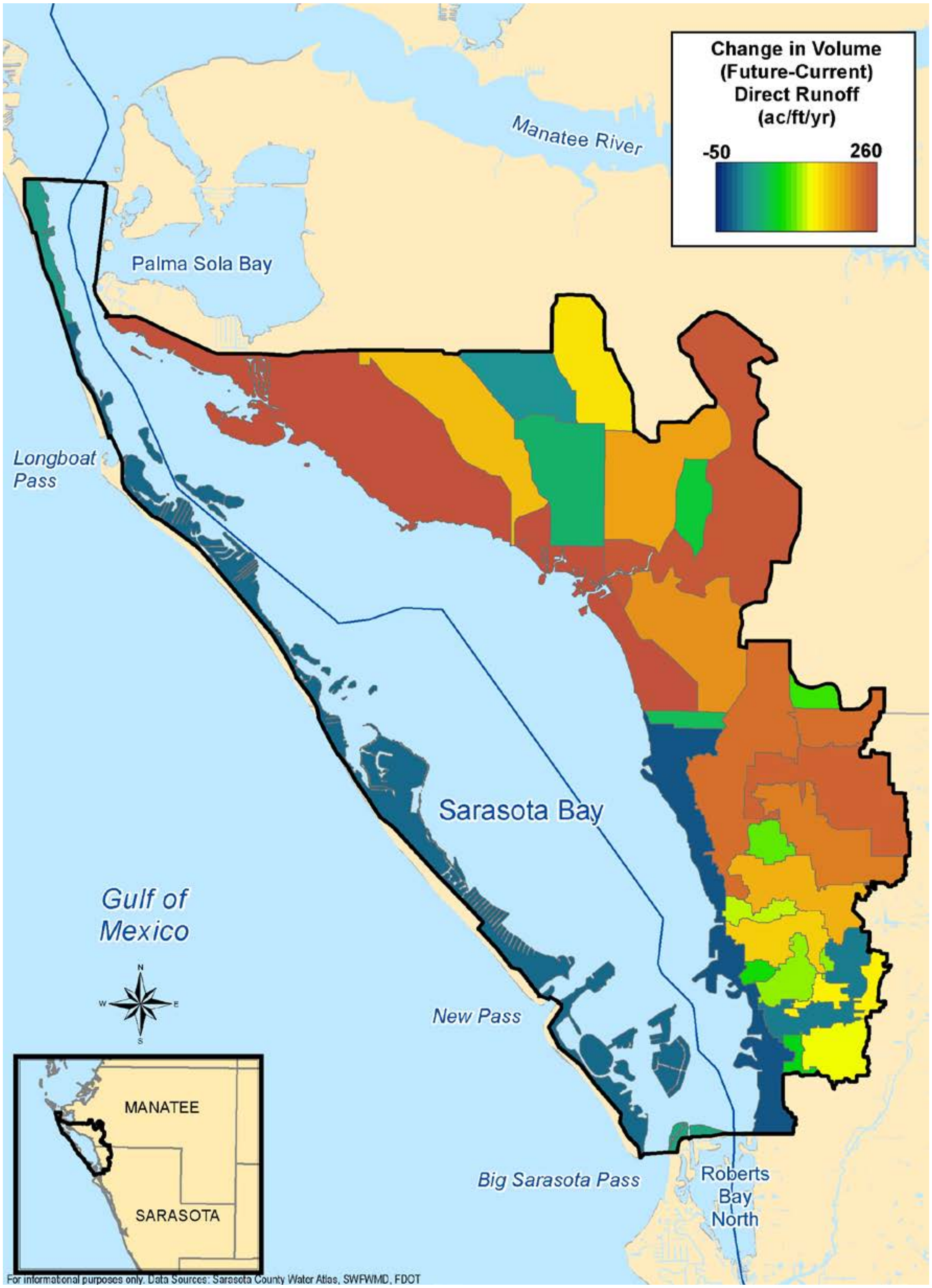


Figure 3-29 Changes to Freshwater Inputs from Direct Runoff (acre-feet/year) to Sarasota Bay between Current and Future Conditions

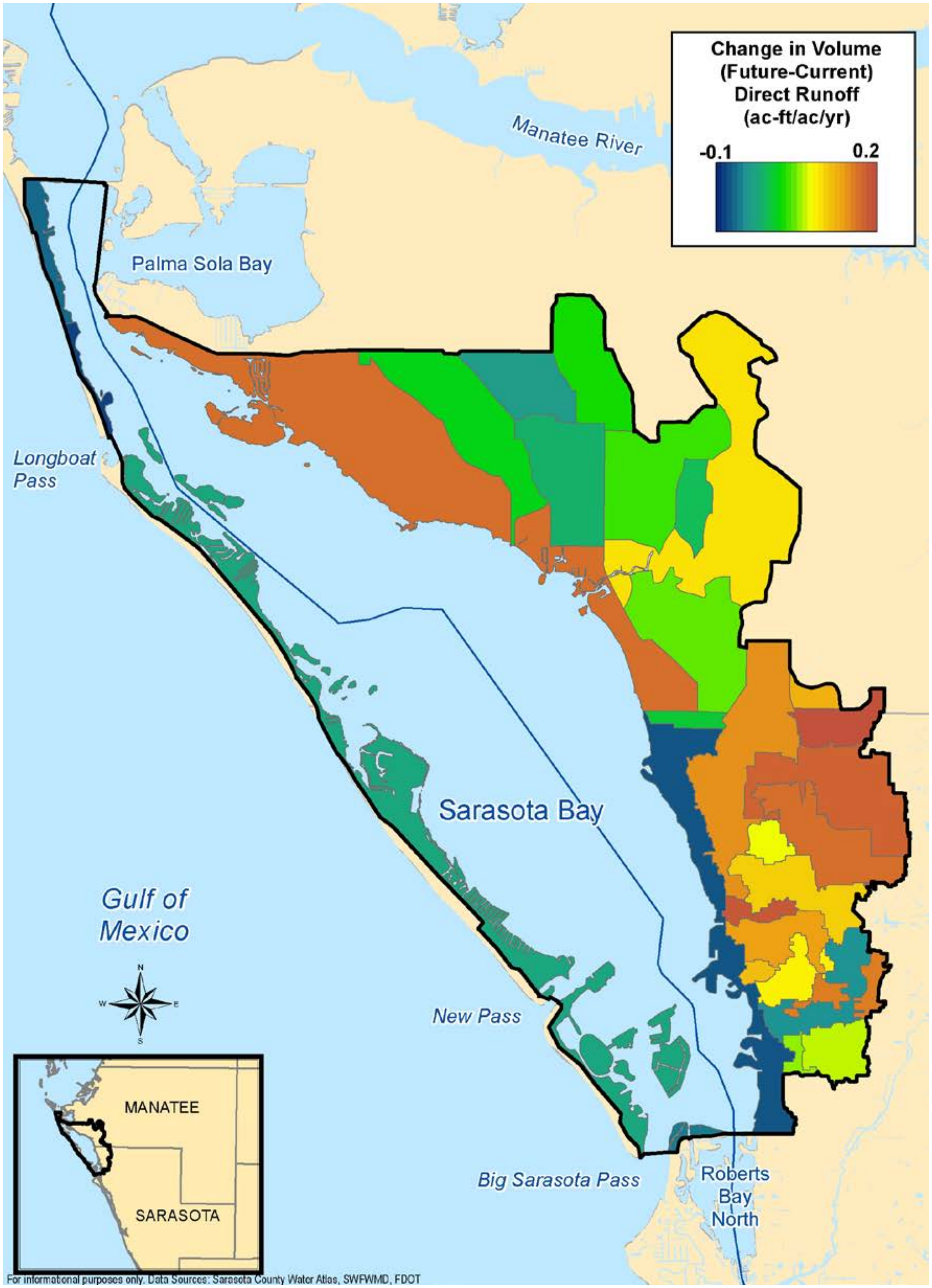


Figure 3-30 Changes to Unit-Area Freshwater Inputs from Direct Runoff (acre-feet/acre/year) to Sarasota Bay Between Current and Future Conditions

3.4.4 Relationships between Rainfall and Freshwater Input

3.4.4.1 Total Freshwater Inputs

Figure 3-31 compares total annual rainfall to freshwater loadings for the current and future periods. There is a positive relationship between rainfall and freshwater inputs, with more precipitation generating greater volumes of freshwater. Freshwater inputs are only slightly greater for a given amount of rainfall in the future scenario relative to current estimates.

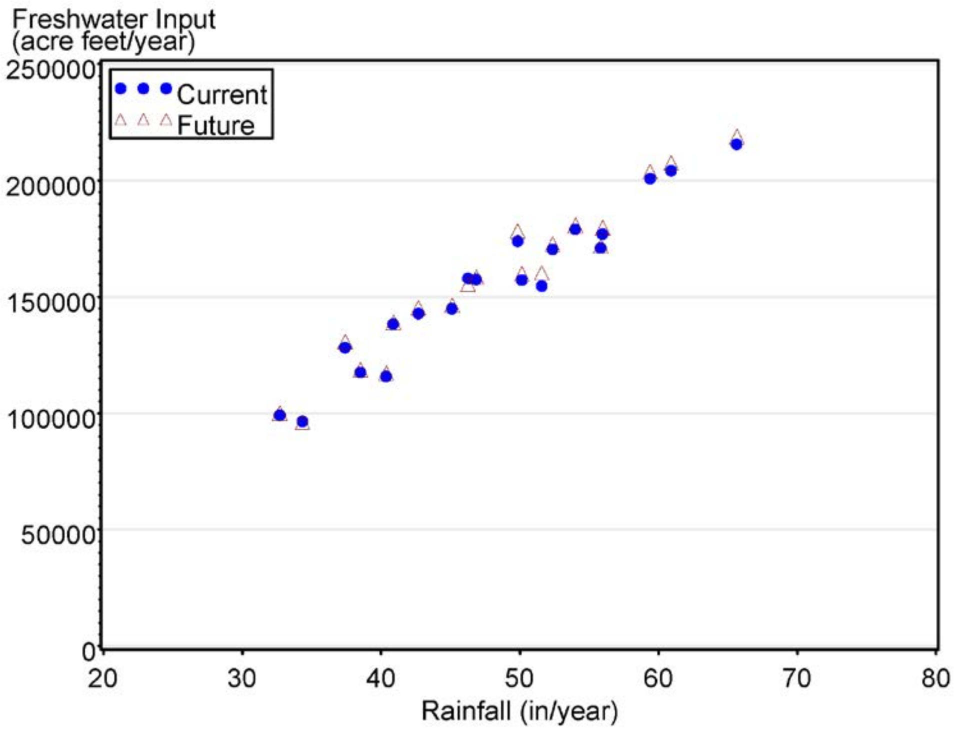


Figure 3-31 Relationship Between Total Freshwater Inputs and Total Rainfall for Current and Future Conditions in the Sarasota Bay Watershed

3.4.4.2 Direct Runoff Freshwater Inputs

Figure 3-32 compares total annual direct runoff as a function of annual rainfall amounts for current and future periods. In the Sarasota Bay watershed, the relationship between precipitation and direct runoff is generally the same as that for total freshwater inputs. Higher runoff during the future period reflects the increased extent of urban land cover in the watershed compared to the current level of development.

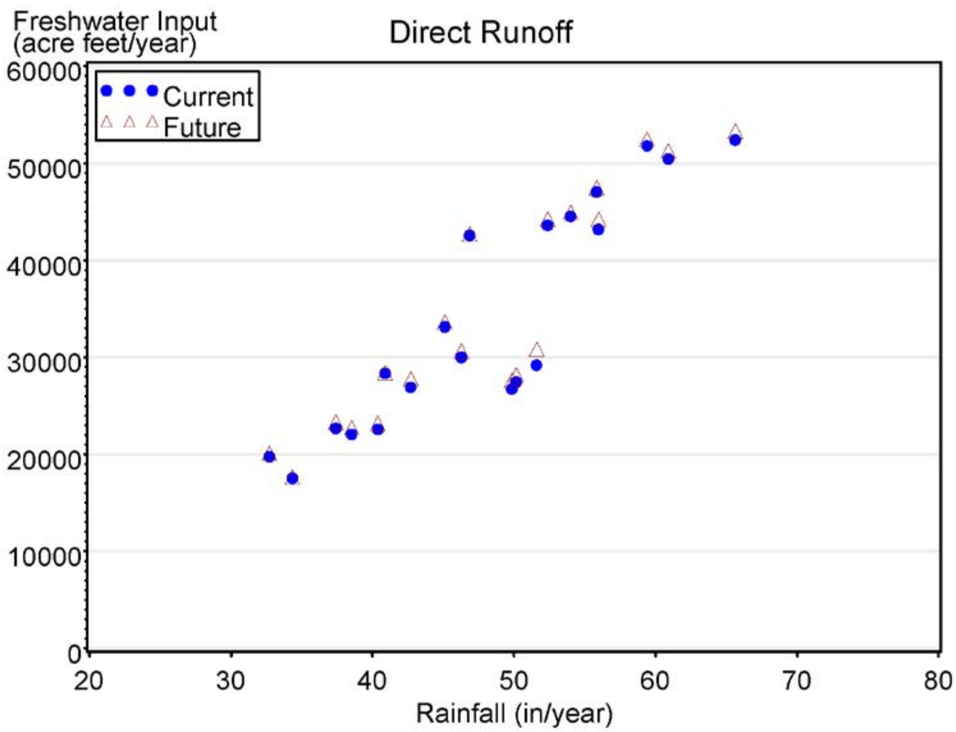


Figure 3-32 Relationship Between Direct Runoff Freshwater Inputs and Total Rainfall for Current and Future Conditions in the Sarasota Bay Watershed

4.0 PROJECT AND PROGRAM RECOMMENDATIONS

Sarasota County is innovative in its intent to evaluate alternative means of water supply and on-site storage to meet irrigation needs and reduce stormwater runoff to the bay. For this plan, we will look at alternative methods of stormwater harvesting. Jones Edmunds identified potential conservation and stormwater harvesting opportunities in the Sarasota Bay Watershed. Project and site-selection methodology is provided in Section 4.1, and the site investigation process is described in Section 4.2. Analysis of project and programmatic recommendations to reduce potable water demands are described in Section 4.3.

For this TSD, all the projects are identified as stormwater-harvesting projects. While augmenting reclaimed water with harvested stormwater is permittable (62-610.472(3), FAC), design and operational issues associated with this type of system will require special attention. Specifically, a one-way flow device must be installed so reclaimed water is not introduced to the stormwater system, a condition that is not permittable. From an operational standpoint, disinfection must be provided and the fecal coliform and total suspended solids limits established for high-level disinfection must be met (62-600.440(5), FAC) for the treated surface water or stormwater supply before mixing with the reclaimed water.

Augmenting stormwater-harvesting ponds with reclaimed water is also permittable and does not require the special considerations listed above. Rule 62-610.464(4)(c), FAC, states "Existing or proposed lakes or ponds (such as golf course ponds) are appropriate for storage of reclaimed water and stormwater management if all Department rules are met and the use of lakes or ponds for reclaimed water storage will not impair the ability of the lakes or ponds to function as a stormwater management system. Rule 62-610.830, FAC, contains permitting requirements for these types of storage lakes or ponds. Lakes or ponds (such as golf course ponds) used to store reclaimed water are not required to meet the storage pond design, construction, and operation requirements in Rules 62-610.414(7) and (8), FAC." If the ponds discharge intermittently or continuously to waters of the state, the discharge must be permitted under 62-620, FAC (62-610.830, FAC).

Stormwater-harvesting opportunities in the County can be divided by scale: regional, subregional, and local. Regional-scale projects impact water supply for the entire watershed, subregional-scale projects impact communities such as irrigation systems within a subdivision, and local-scale projects are implemented by homeowners for individual property conservation and use such as rain barrels and cisterns.

Harvesting stormwater runoff provides a source for an alternative water supply while maintaining flows to Sarasota Bay and its tributaries.

At the largest (i.e., regional) scale, stormwater may be available to supplement the County water supply. At the next largest (i.e., subregional) scale, stormwater may be available largely as a non-potable irrigation source or supplement. Opportunities at the subregional scale will typically serve a limited number of larger entities, such as a residential development or a golf course. At the smallest (i.e., local) scale, stormwater-harvesting opportunities are typically confined to the individual property owner. Regardless of scale, the following four components are necessary to implement a stormwater-harvesting project:

- Sustainable supply—A sufficient volume of stormwater is needed to satisfy all or a significant percentage of the intended end use. The available volume must exceed the volume needed to sustain a healthy downstream ecosystem.

- Storage—The timing between the availability of stormwater and the needed end use rarely coincides. Thus, storage is required to bridge the timing gap between supply and demand. Larger storage volumes translate to higher rates of use for harvested stormwater but at larger costs. New storage opportunities at the regional and subregional scale in a relatively developed watershed like Sarasota Bay are typically space-constrained due to the lack of available land.

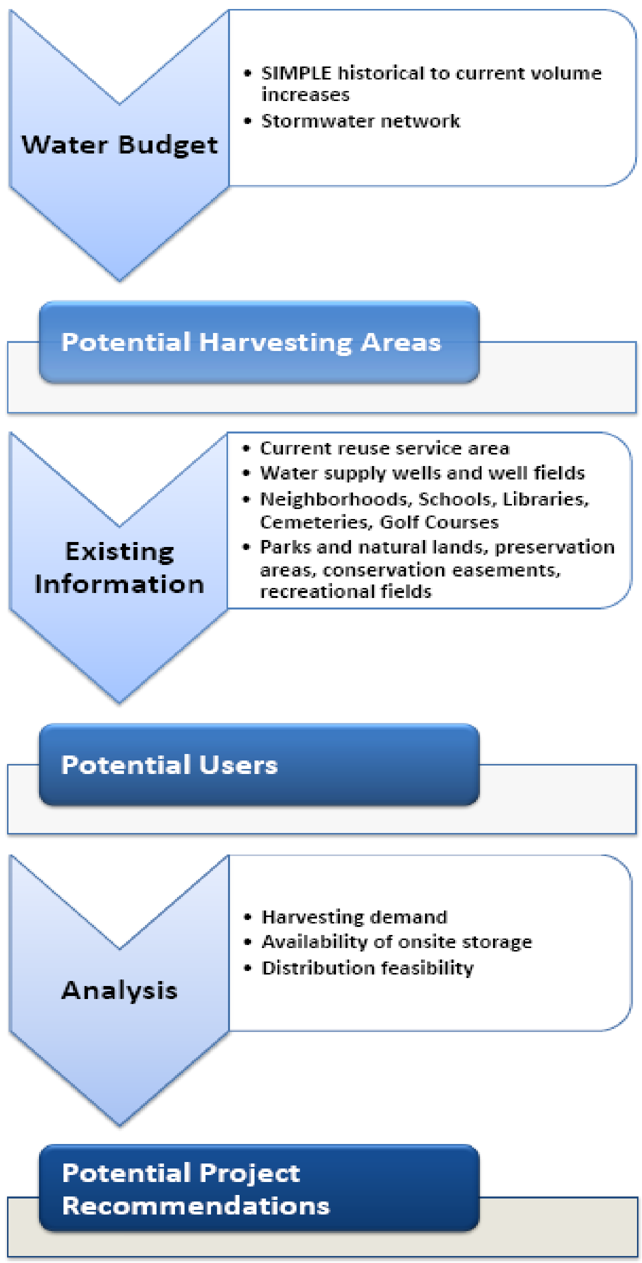
- Transmission/distribution system—Distance and elevation differences between the supply/storage location and the end use must be overcome with a transmission/distribution system. At the regional scale, the relative cost of this component is typically not as large since the distribution system to the end user usually exists. At the local scale, the distribution system is often simple to construct and maintain. The transmission/distribution system at the subregional scale is often the limiting factor for stormwater-harvesting opportunities because of the relatively high cost of the component—particularly for retrofits, which is more of a necessity in a relatively developed watershed such as Sarasota Bay.

- End use—A beneficial end use is necessary to implement a stormwater-harvesting project. At the regional scale, the end use is typically as a potable water source. At the subregional and local scale, it is typically a supplemental irrigation source. Although end uses for stormwater are ubiquitous throughout the Sarasota Bay Watershed, the challenge is in cost-effectively matching end use with the other three components—sustainability, storage, and transmission/distribution. Regardless of whether the end use of the stormwater is potable or non-potable, effective conservation measures should remain in place.

Although not listed as a necessary component above, treatment in some form is usually needed in stormwater-harvesting projects at the two larger scales. The type of treatment varies by end use.

4.1 METHODOLOGY

Jones Edmunds collected and assembled information, including existing reports, plans, and GIS data, to identify potential stormwater-harvesting opportunities in the Sarasota Bay Watershed. Jones Edmunds began the investigation with a GIS desktop analysis to identify potential stormwater-harvesting areas and potential user areas throughout the watershed. These areas were then refined to potential stormwater-harvesting project sites. Finally, Jones Edmunds evaluated project feasibility at the sites. The following summarizes this methodology, and Section 4.3 provides the results from the analysis and potential project and program recommendations.



4.2 INVESTIGATION

Details concerning the elements of Jones Edmunds' investigations are provided in the following subsections.

4.3 IDENTIFICATION OF POTENTIAL HARVESTING AREAS

Jones Edmunds used GIS to compile and review data developed from the Pollutant Loading Model input and results together with aerials and other base data and information obtained from Sarasota County and SWFWMD. These datasets and information included the following:

- Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE) model input and results (i.e., irrigation areas and changes in direct runoff volumes).
- Sarasota County Interconnected Channel and Pond Routing (ICPR) watershed models.
- Sarasota County Stormwater Inventory.
- Sarasota County Utilities Inventory (reclaimed water lines).
- 2010 SWFWMD aerial imagery.

A GIS desktop analysis of the parameters above yielded potential sources of stormwater in the watershed (Figure 4-1). SIMPLE volume results are detailed in the Water Budget Technical Support Document: *Historical and Current Water Budget Loadings*.

4.4 IDENTIFICATION OF POTENTIAL USERS

Jones Edmunds used GIS to screen the Sarasota Bay Watershed for potential stormwater users. The screening focused on larger neighborhoods with neighborhood associations, schools, parks, recreational fields, libraries, cemeteries, and other locations. The datasets and information used in the screening were obtained from Sarasota County and SWFWMD and included the following:

- Current reuse service area.
- Neighborhoods, public schools, libraries, and public golf courses.
- Parks and natural lands, preservation areas, conservation easements, and recreational fields.

A GIS desktop analysis of the parameters above yielded potential users of stormwater in the watershed (Figure 4-2).

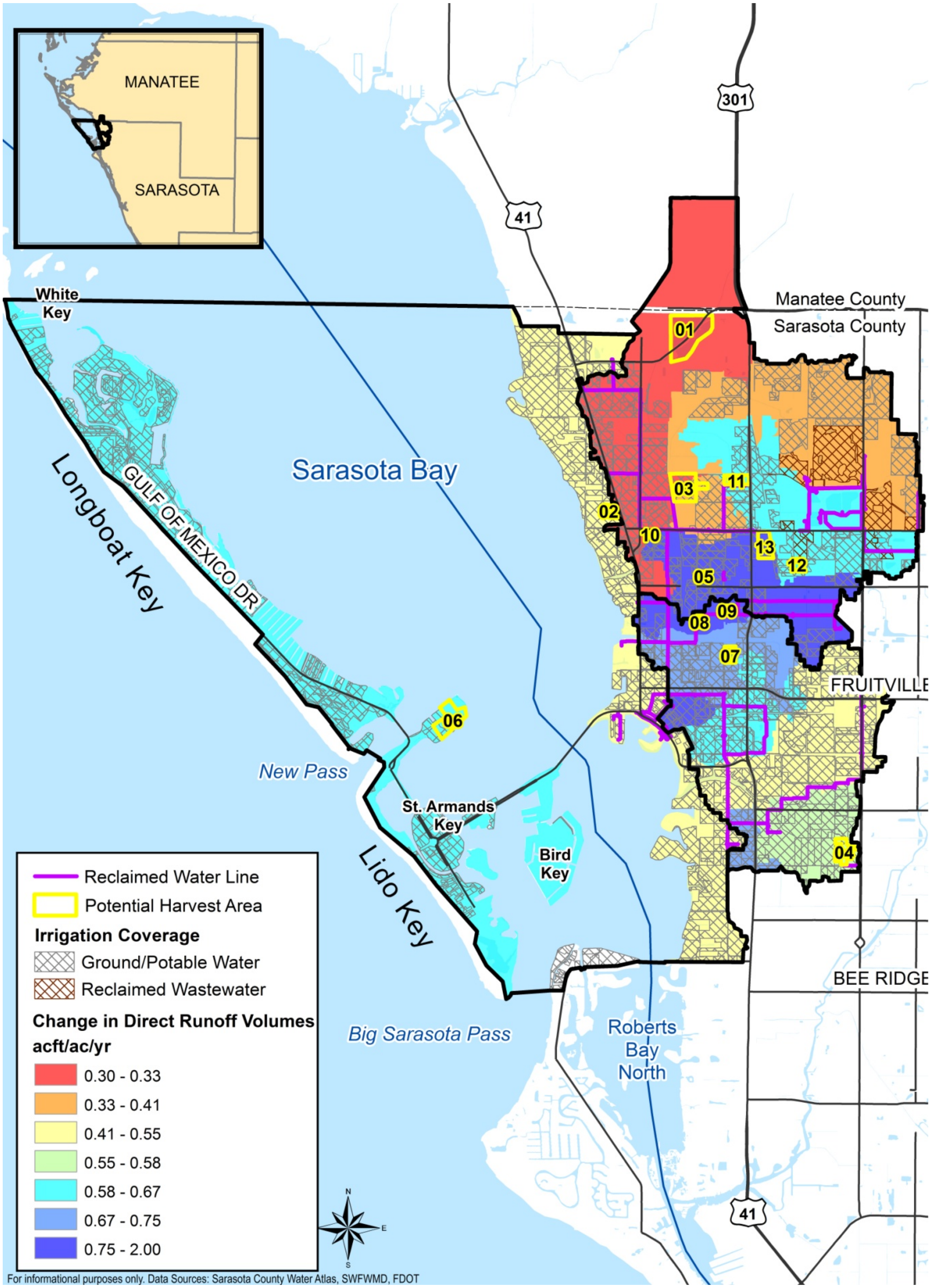


Figure 4-1 Potential Stormwater Harvesting Identification Parameters

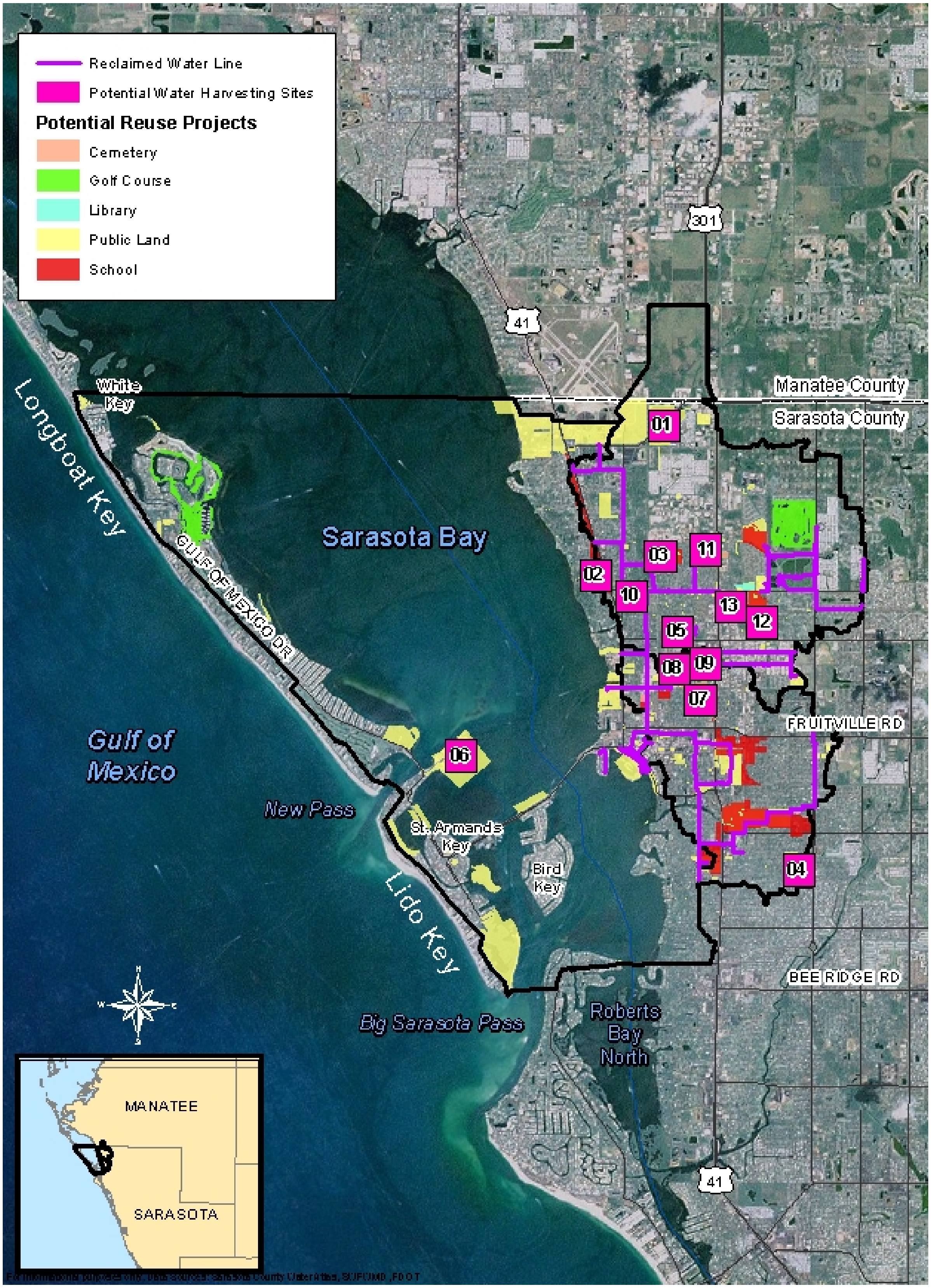


Figure 4-2 Potential Stormwater Harvesting Projects

4.4.1 Identification of Potential Projects

Using the criteria discussed below, a scoring system was established for ranking the potential locations as stormwater-harvesting projects. The criteria have cost and feasibility implications. In each case, a higher score indicates a more favorable value with respect to the harvesting opportunity at the site.

- Distribution—This criterion reflects the relative difficulty of constructing a stormwater-harvesting distribution system, with values ranging from 0 to 2. A value of 0 represents a new distribution system that would need to be constructed in an area with many site constraints. A value of 2 represents a distribution system that is largely built and only needs a relatively small number of additions or improvements.

- Availability of on-site storage—Values in this category range from 0 to 2, with 0 representing that all storage would need to be constructed, 1 representing that usable storage is present but significant expansion would be required, and 2 representing that it may be possible to use existing storage with little to no modification.

- Harvesting demand—Values in this category range from 0 to 3, with 3 representing the highest irrigation needs in terms of volume over the site area. These values are largely based on the rates from the irrigation feature class developed for the SIMPLE-monthly model.

- Level of runoff—Values in this category range from 0 to 2, with 0 representing the areas where the direct runoff is currently lowest, and 2 representing areas where the direct runoff is the highest and therefore in the greatest need of water capture. These values are based on the volumes (acres per foot per year) of each watershed basin in the direct runoff feature class developed for the SIMPLE-monthly model.

Points were assigned to each category. Because of their relative respective impacts to cost using the value ranges discussed above, a weighting factor of 2 was applied to distribution and availability of on-site storage. After applying the weighting factor, the values were summed in the three categories for an overall score. Figure 4-3 shows the 13 sites evaluated, and Table 4-1 shows the unweighted scores for each criterion and total weighted scores.

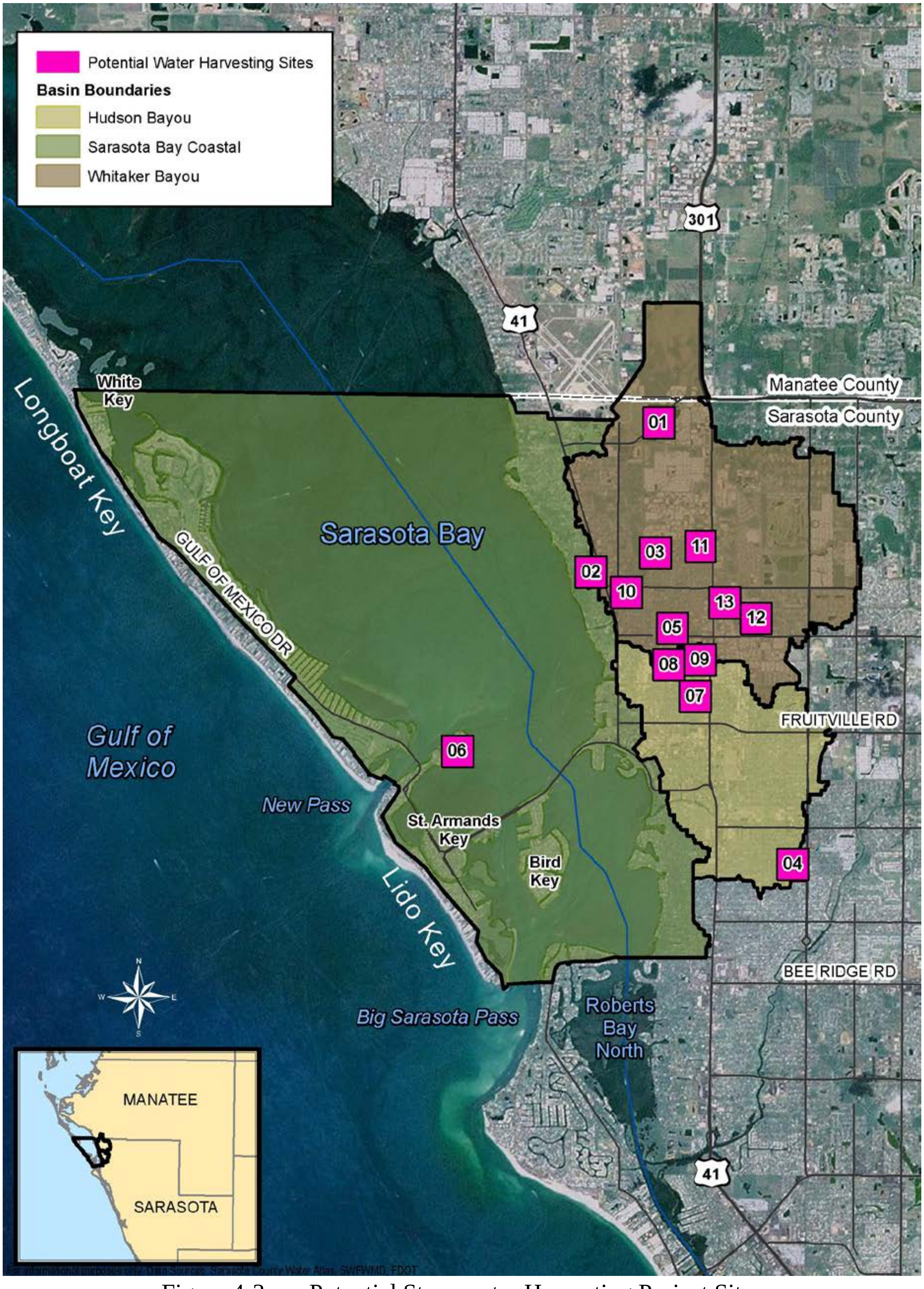


Figure 4-3 Potential Stormwater Harvesting Project Sites

Table 4-1 Summary of Potential Stormwater Reuse Projects										
Project Site ID	Site Name	Owner	Scale	Area (acres)	Distribution	Demand	Storage	Level of Runoff	Weighted Total	Recommended
1	Airport Ponds	Sarasota County	Regional	73.2	2	3	2	0	11	No
2	Bay Haven Elementary School	Sarasota County School Board	Subregional	5.4	2	1	0	1	6	Yes
3	Booker High School	Sarasota County School Board	Subregional	38.6	2	2	1	0	8	Yes
4	Arlington Park and Aquatic Complex	City of Sarasota	Subregional	14.6	2	2	1	1	9	Yes
5	Orange Avenue Park	City of Sarasota	Subregional	4.9	2	3	0	2	9	Yes
6	Ken Thompson Park	City of Sarasota	Subregional	3.7	1	2	0	1	5	Yes
7	Gillespie Park	City of Sarasota	Subregional	9.6	2	2	1	2	10	Yes
8	City of Sarasota Wastewater Treatment Plan	City of Sarasota	Regional	2.5	2	3	2	2	13	No
9	12th Street Pond	City of Sarasota	Subregional	2.7	2	3	2	2	13	No
10	Martin Luther King Park	City of Sarasota	Subregional	32.1	2	3	0	1	8	Yes
11	Robert Taylor Community Complex	City of Sarasota	Subregional	12.1	2	2	0	1	7	Yes
12	Lime Lake Park	Sarasota County	Subregional	4.6	1	2	3	1	11	Yes
13	Marion Anderson Place	City of Sarasota	Subregional	18.7	0	2	0	2	4	No

4.5 ANALYSIS\RECOMMENDATIONS

The following sections provide investigation summaries and recommendations for the selected project sites as well as program recommendations to help manage water supply in the watershed.

This section contains water supply project descriptions. Including proposed projects does not confer any special status, approval, permitting, standing, or funding from SWFWMD. All proposed projects are subject to regulatory review and permitting. Requests for funding assistance will have to meet the requirements of funding programs and be subject to SWFWMD's Governing Board appropriating funds.

4.6 REGIONAL-SCALE PROJECTS

Conditions for regional-scale stormwater-harvesting projects are generally unfavorable in this watershed for two primary reasons. First, the most favorable storage locations in terms of having the largest contributing area are in essentially built-out portions of the watershed that thus have little room for storage. Second, a considerable amount of new infrastructure through urbanized areas would be required to convey flows to a treatment facility.

4.6.1 Site 1 – Airport Ponds

This County-owned site just southeast of the Sarasota Bradenton International Airport (Figure 4-4) in the Whitaker Bayou basin has sizable surface water impoundments that cause this site to stand out as a potential water supply project.

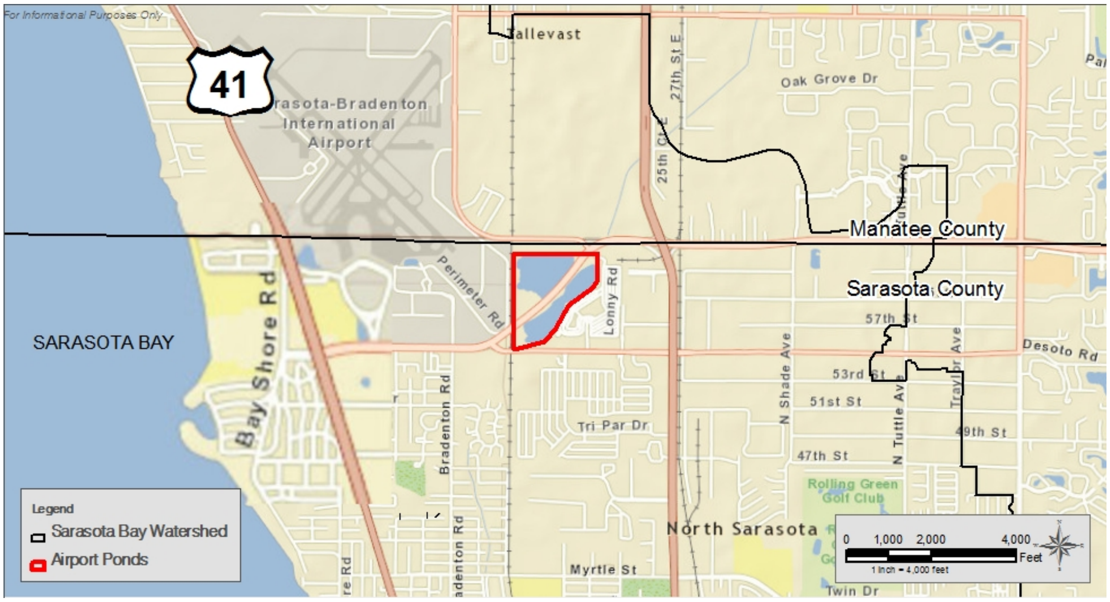


Figure 4-4 Airport Ponds Location Map

4.6.1.1 GIS Desktop Analysis

According to the SIMPLE model, this region is showing a slight increase in direct runoff from historical conditions. Direct runoff has increased significantly more in other areas across the watershed, which makes this location a candidate to receive excess runoff transferred from other areas, especially since a large on-site surface water impoundment already exists. Reclaimed and irrigation water lines are lacking in this area, but the extensive inventory of stormwater structures on this site should be evaluated to determine if a regional-scale distribution system would be feasible for this area to offset potable and groundwater use (Figure 4-5).

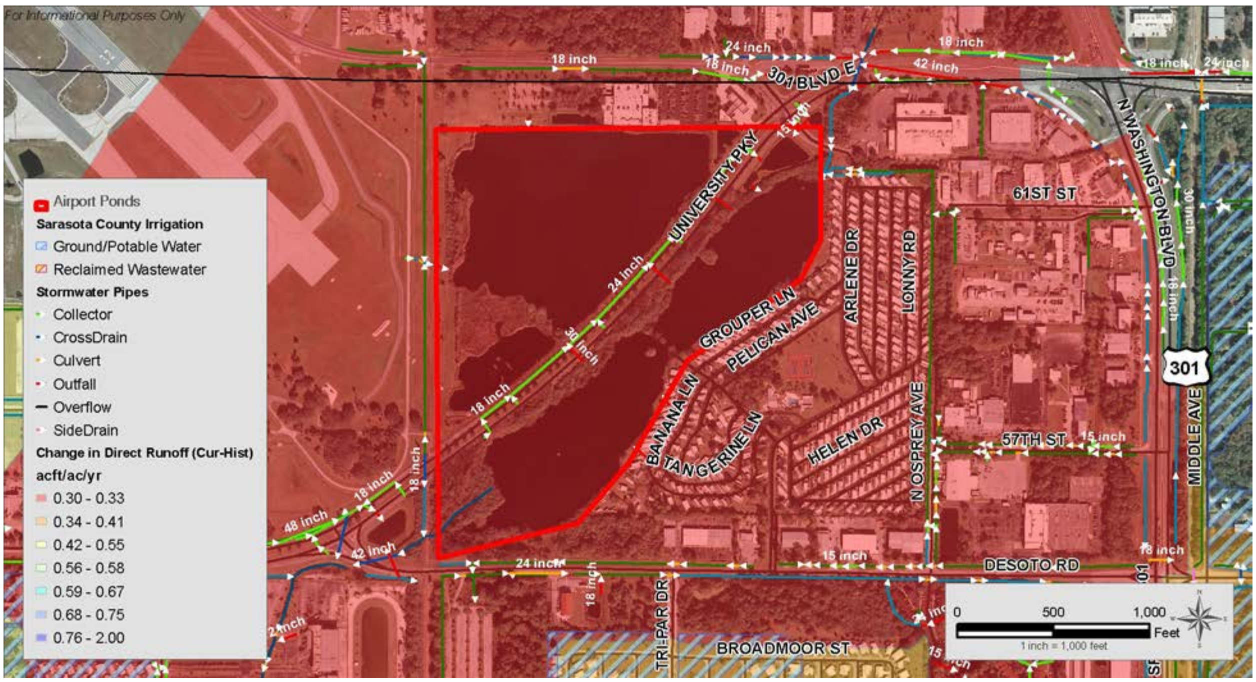


Figure 4-5 Airport Ponds GIS Analysis Map

4.6.1.2 Recommendation

Jones Edmunds does not recommend a project at this site at this time because further investigation showed that the parcels are owned by Manatee County. The County only wishes to consider publicly owned lands for this plan. We recommend that the County work with Manatee County to identify potential partnering opportunities.

4.6.2 Site 8 – City of Sarasota Wastewater Treatment Plant and Site 9 – 12th Street Pond

Site 8 is in the Hudson Bayou basin at the southeast corner of 12th Street and Orange Avenue (Figure 4-6), and Site 9 is across the street on the north side of 12th Avenue. Both sites are owned by the City of Sarasota.

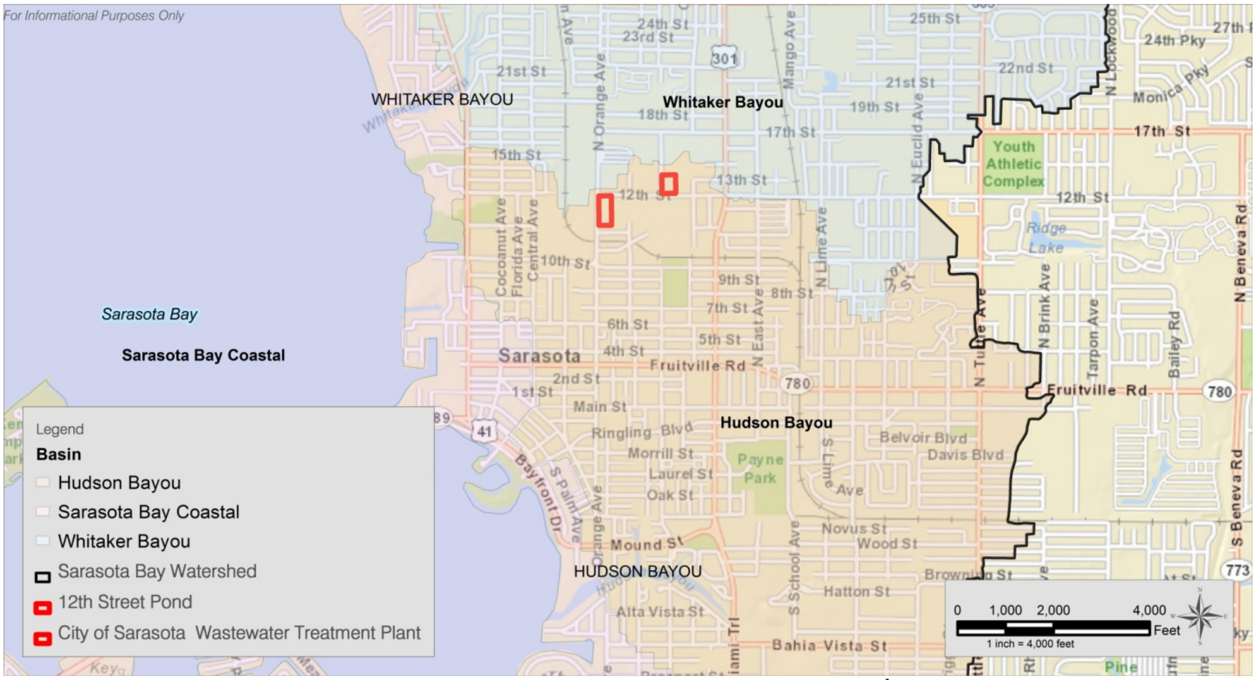


Figure 4-6 City of Sarasota Wastewater Treatment Plant and 12th Street Pond Location Map

4.6.2.1 GIS Desktop Analysis

Sites 8 and 9 are adjacent to the City of Sarasota Wastewater Treatment Plant and have large ponds available for storage. According to the SIMPLE model, this region is showing a high increase in direct runoff from historical conditions, so capturing the increased runoff before it leaves the site would be beneficial. The captured stormwater could be directed to the treatment plant, treated, and used as reclaimed water, thus reducing runoff in the area (Figure 4-7).

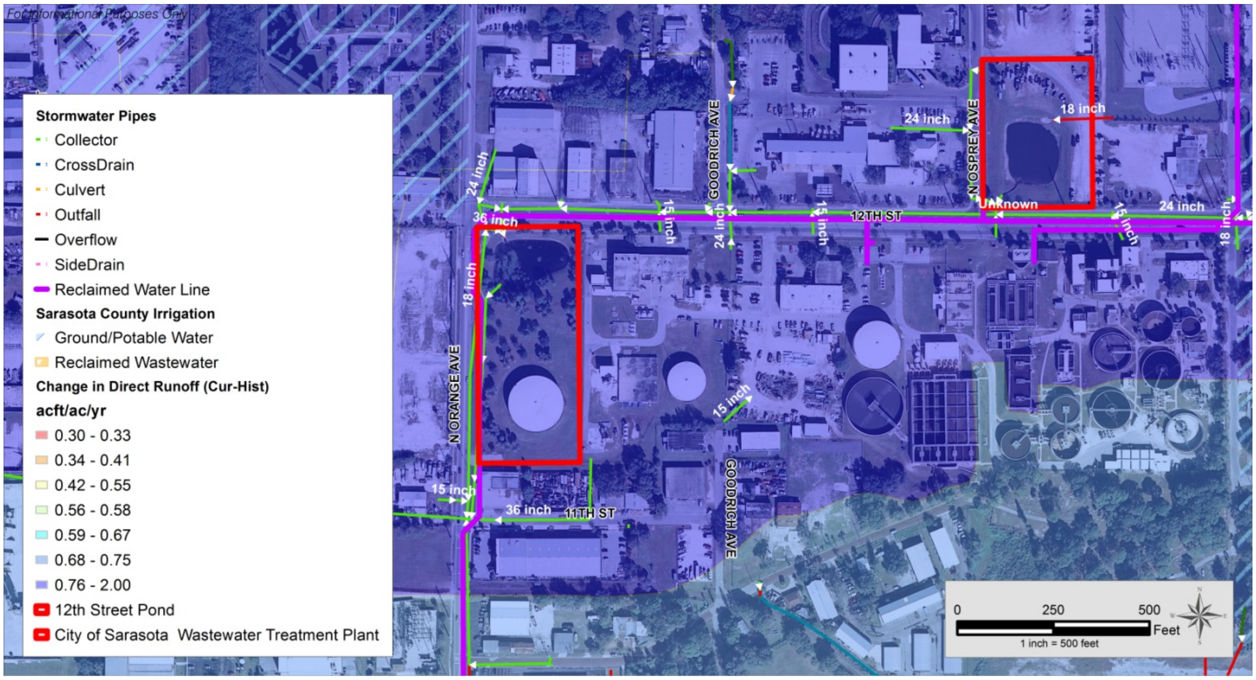


Figure 4-7 City of Sarasota Wastewater Treatment Plant GIS Analysis Map

4.6.2.2 Recommendation

Jones Edmunds does not recommend this project at this time because the County has more available reclaimed water than demand and the benefits would not justify the cost. If the County reclaimed water demand increases, the project should be re-evaluated to direct stormwater from the pond to augment the system.

4.7 SUBREGIONAL-SCALE PROJECTS

Subregional-scale stormwater-harvesting opportunities in the Sarasota Bay Watershed exist largely as projects that can provide a non-potable irrigation source or supplement. Subregional-scale projects will typically serve one or two larger users (e.g., a school). Sustainable supplies are relatively plentiful throughout the watershed. The Water Budget Analysis indicates greater average-annual direct runoff under existing conditions than under historical conditions (Figure 4-8). Because of the relatively small storage footprint required for a stormwater-harvesting system, an abundance of potential withdrawal locations exist throughout the watershed in the form of potential storage areas that can capture the excess runoff and distribute it on site, thus removing it from the overall system that ultimately drains to the Bay. Potential storage areas would rely on retrofitting existing ponds or constructing new ponds or cisterns on public properties.

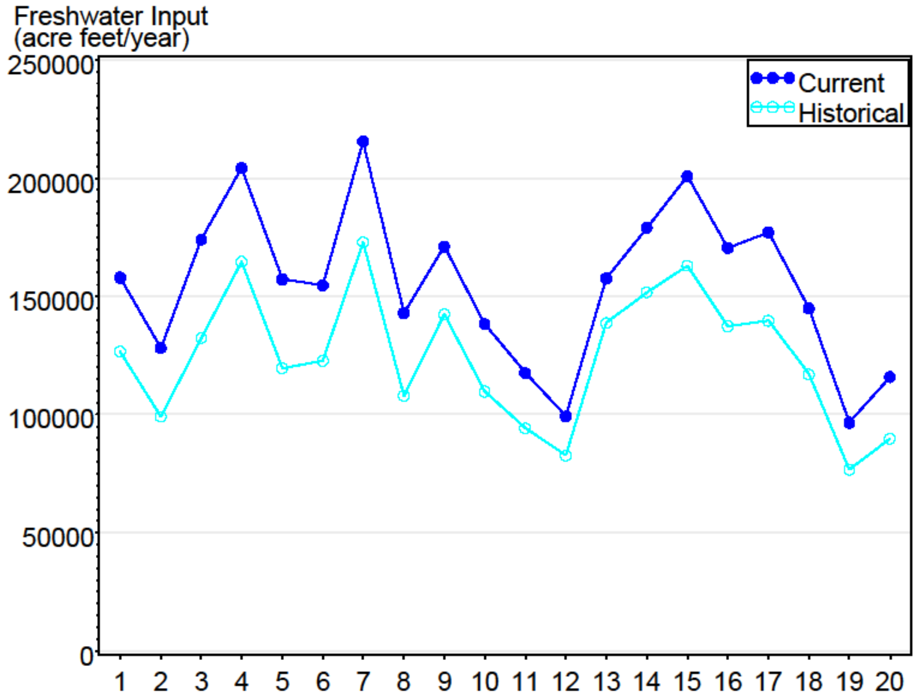


Figure 4-8 Annual Direct Runoff Freshwater Inputs to Sarasota Bay under Current and Historical Conditions

Transmission/distribution is one of the most limiting factors for stormwater-harvesting opportunities in this watershed. Irrigation systems that use stormwater cannot be connected to potable distribution systems because of potential contamination of the potable source. Retrofitting existing urban land uses (e.g., residential development) with separate or disconnected irrigation systems is typically cost-prohibitive. Therefore, subregional opportunities are limited to areas where separate distribution systems already exist or where retrofitting the distribution system may not be cost-prohibitive.

4.7.1 Site 2 – Bay Haven Elementary School

This potential project site is at Bay Haven Elementary School just west of US 41 and south of Patterson Drive (Figure 4-9). The school is in the Sarasota Coastal watershed basin.

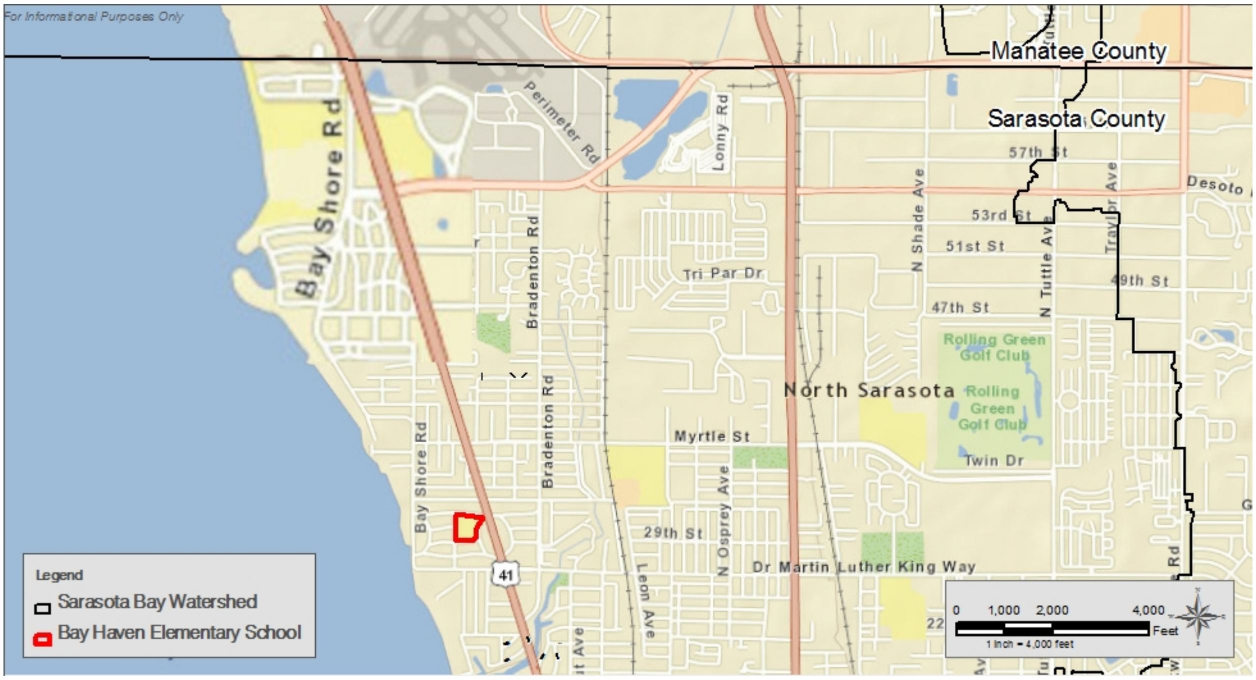


Figure 4-9 Bay Haven Elementary School Location Map

4.7.1.1 GIS Desktop Analysis

This school is an appropriate site for a cistern (Figure 4-10), and the school currently irrigates its grounds using potable water. Runoff volumes at Bay Haven Elementary are slightly higher than historical conditions, and the area is not served by reclaimed line (Figure 4-11).

Figure 4-10 Bay Haven Elementary School Aerial Map

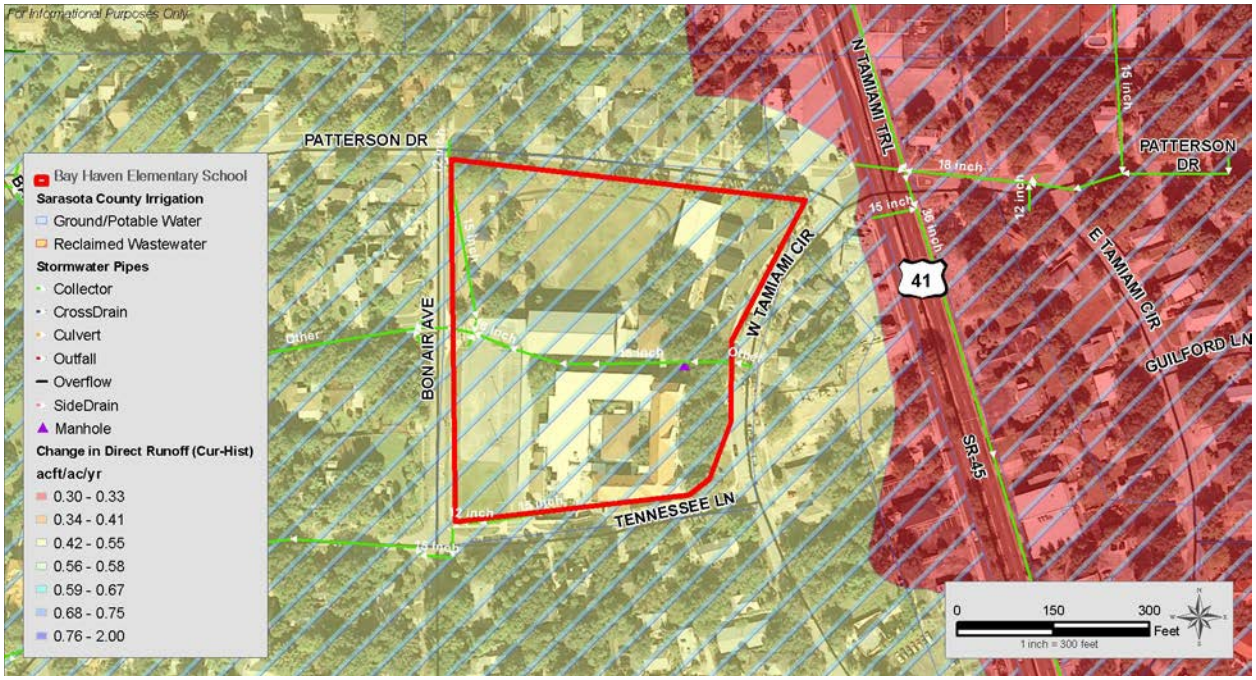


Figure 4-11 Bay Haven Elementary School GIS Analysis Map

4.7.1.2 Recommendation

Jones Edmunds recommends working with the school to install roof-top cisterns to offset the potable water uses such as irrigation. Additionally, the County could work with school staff to implement an educational outreach program. The faculty and students could install and maintain rain barrels and monitor the amount of rainwater captured and used throughout a school year. This educational component would teach students to conserve stormwater and facilitate shared learning in their communities.

Summary:

- ❖ Install cisterns.
- ❖ Irrigate with harvested rainwater before potable water.
- ❖ Install rain barrels.
- ❖ Start educational program with students and faculty.

4.7.2 Site 3 – Booker High School

Booker High School is in the Whitaker Bayou basin south of Myrtle Street and east of Orange Avenue (Figure 4-12).

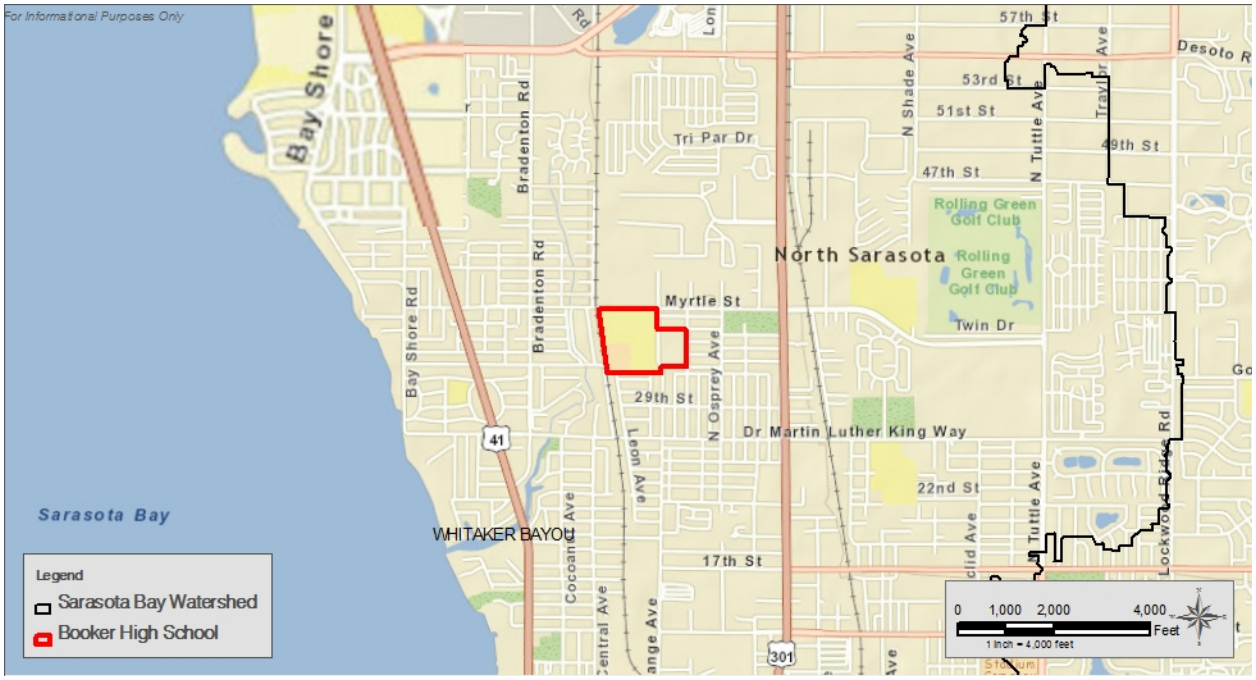


Figure 4-12 Booker High School Location Map

4.7.2.1 GIS Desktop Analysis

Sarasota County landfill files indicate that the Booker High School site may have been an old landfill; however, Sarasota staff reviewed historical aerials (Figure 4-13) and were unable to confirm the site's previous landfill status.

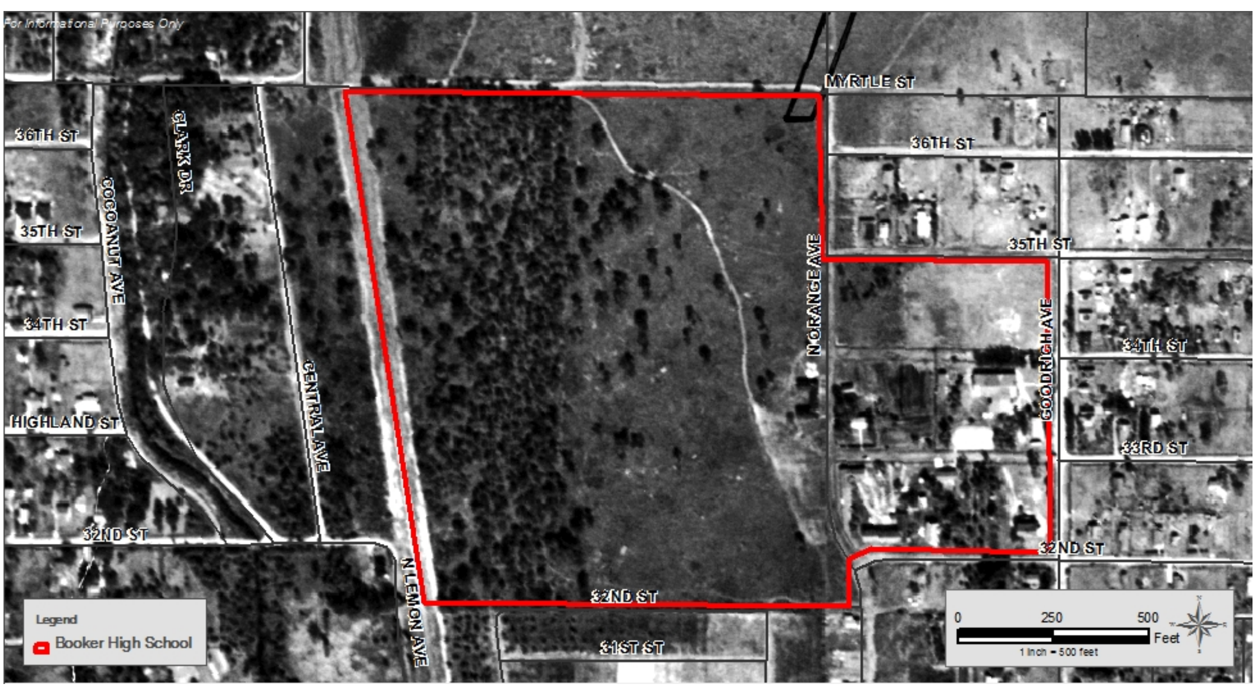


Figure 4-13 Booker High School 1948 Aerial Map

Booker High School is currently under renovation. Construction is scheduled to be completed in 2013, and the re-routed Orange Avenue is expected to open in early February. Renovations to the school include adding five new buildings and major renovations to five buildings.

The Booker High School Project site encompasses two adjacent parcels owned by the Sarasota County School Board. The off-site parcels contain an extensive stormwater system that currently discharges through a series of ponds before discharging through a pipe network south and west to Whitaker Bayou. The school parcel discharges through several storm drain collection systems via open channels and pipe networks to the south and then west to Whitaker Bayou.

The school has several recreational facilities, including a baseball field, a football field, and tennis courts. The school currently irrigates with potable water (Figure 4-14 and Figure 4-15).

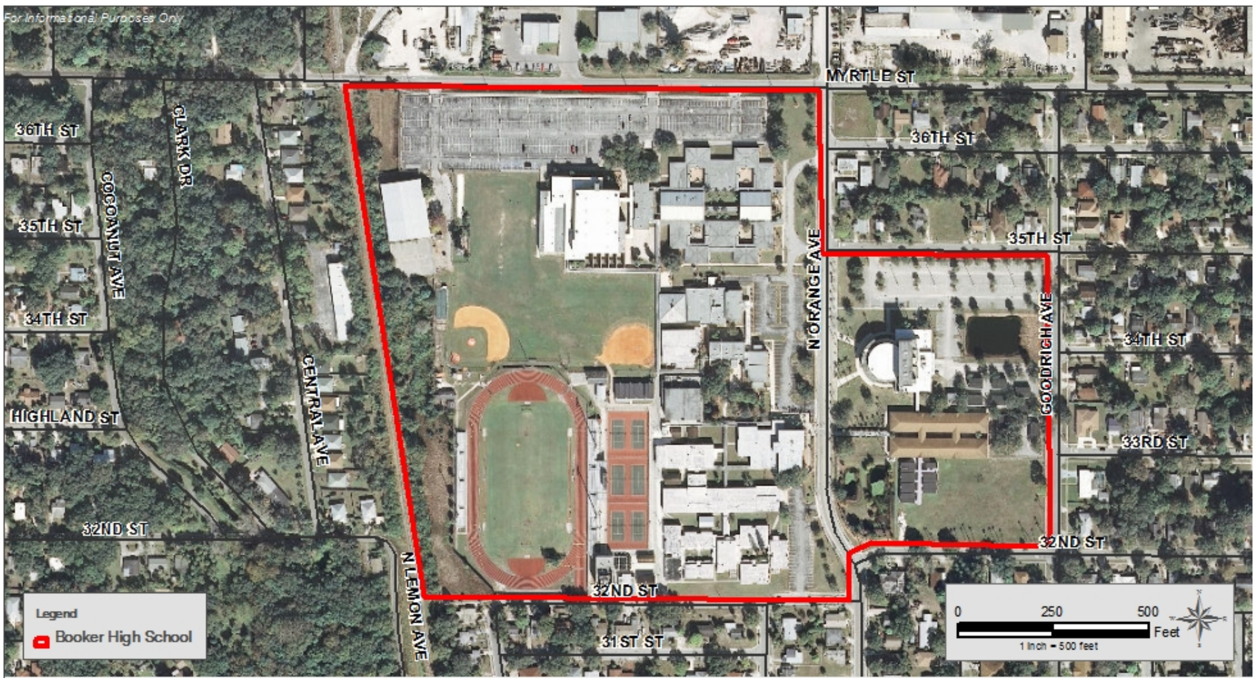


Figure 4-14 Booker High School 2010 Aerial Map

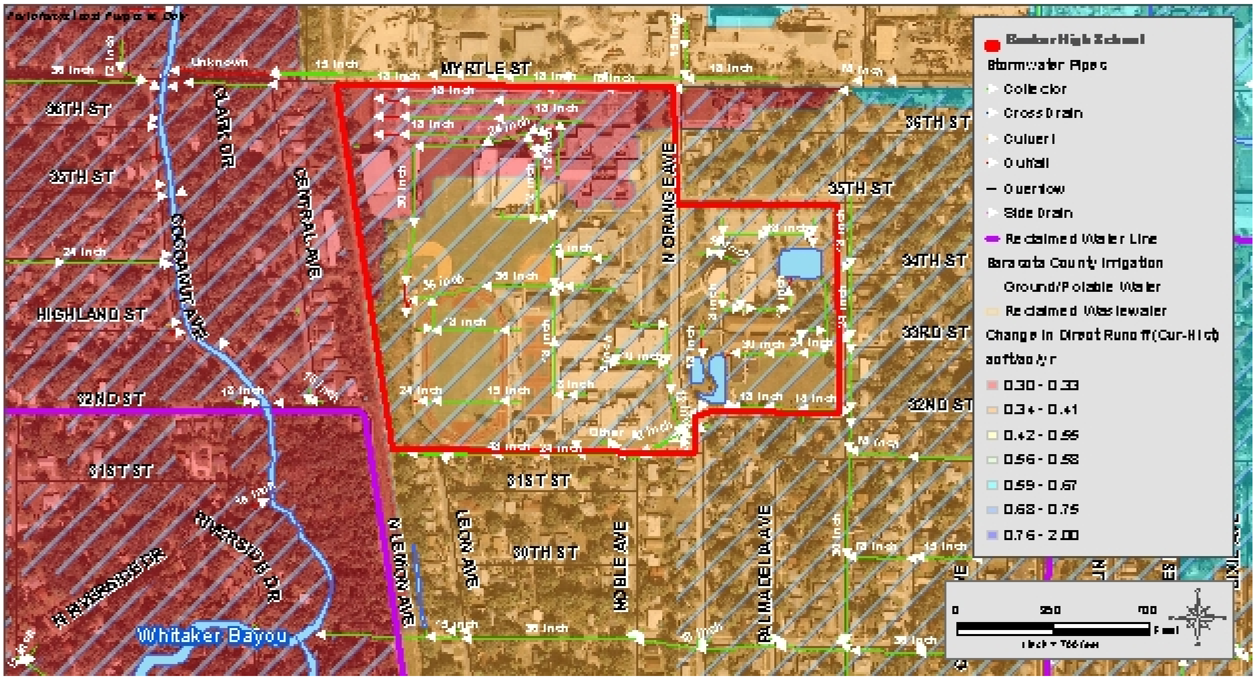


Figure 4-15 Booker High School GIS Analysis Map

4.7.2.2 Recommendation

Jones Edmunds recommends working with the high school to convert the ponds on the east parcel to stormwater-harvesting ponds with some water quality components and re-directing the majority of the site runoff to the ponds for storage and irrigation use. Jones Edmunds also recommends evaluating the construction plans for the current renovations to see if adding Low Impact Development (LID) options to reduce the amount of runoff leaving the site is feasible. Rooftop cisterns, rain barrels, and parking pavers would be low-cost, feasible options that can be incorporated into Booker High School's Science, Technology, Engineering, and Math (STEM) Program as an educational outreach element to teach students about water conservation.

Summary:

- ❖ Install cisterns.
- ❖ Convert the ponds on the east parcel to stormwater-harvesting ponds for irrigation.
- ❖ Install rain barrels.
- ❖ Install permeable pavers in parking lot.
- ❖ Work with the STEM Program for educational opportunities related to water conservation.

4.7.3 Site 4 – Arlington Park and Aquatic Complex

The Arlington Park and Aquatic Complex is in the Hudson Bayou basin. The complex is east of Tamiami Trail between Waldemere and Hyde Park Streets (Figure 4-16). The park is owned by the City of Sarasota; operated by Sarasota County Parks and Recreation; and offers recreational as well as aquatic services such as multiple pools, basketball, tennis, and racquetball courts, playground, walking trail, and gymnasium.

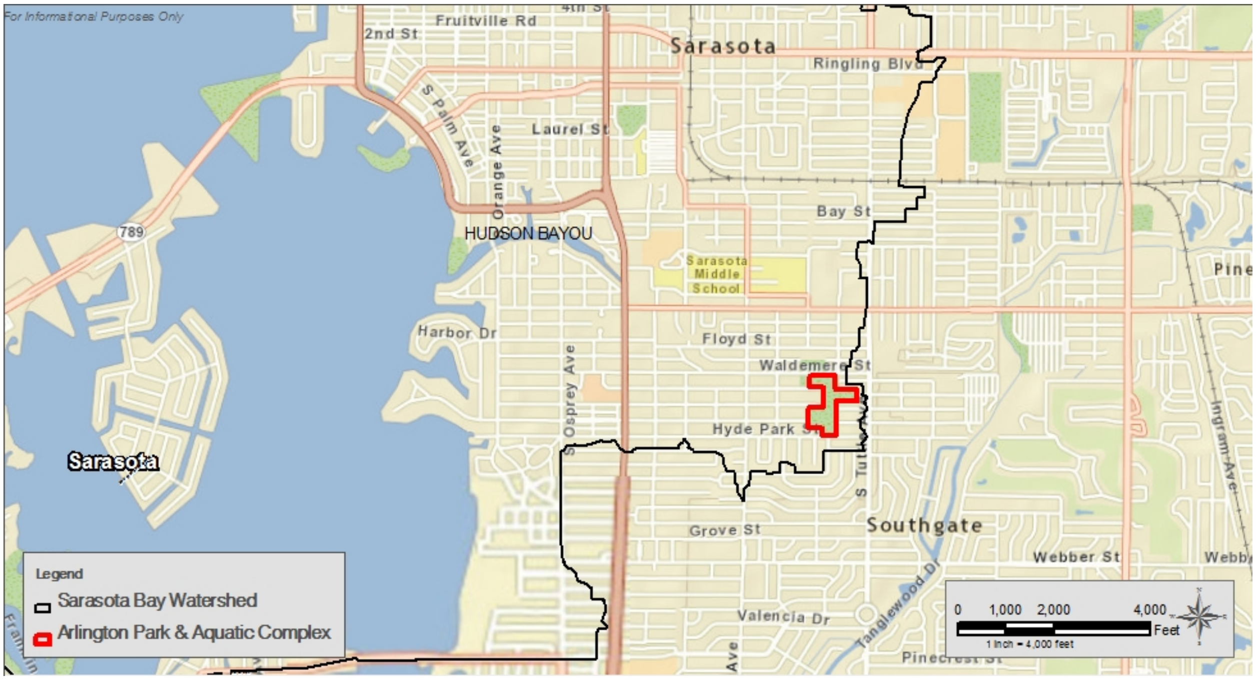


Figure 4-16 Arlington Park and Aquatic Complex Location Map

4.7.3.1 GIS Desktop Analysis

The Arlington Park and Aquatic Complex is an approximately 15-acre site that appears to be partially irrigated with potable water. Stormwater runoff from the site and adjacent areas drain to a large on-site stormwater pond via swales and open ditches (Figure 4-17). The pond discharges off site to the west via an open channel to the Hudson Canal (Figure 4-18). The direct stormwater runoff for the area has increased 0.58 acre-foot/acre/year from historical conditions according to the SIMPLE model, which makes this site ideal with respect to supply.

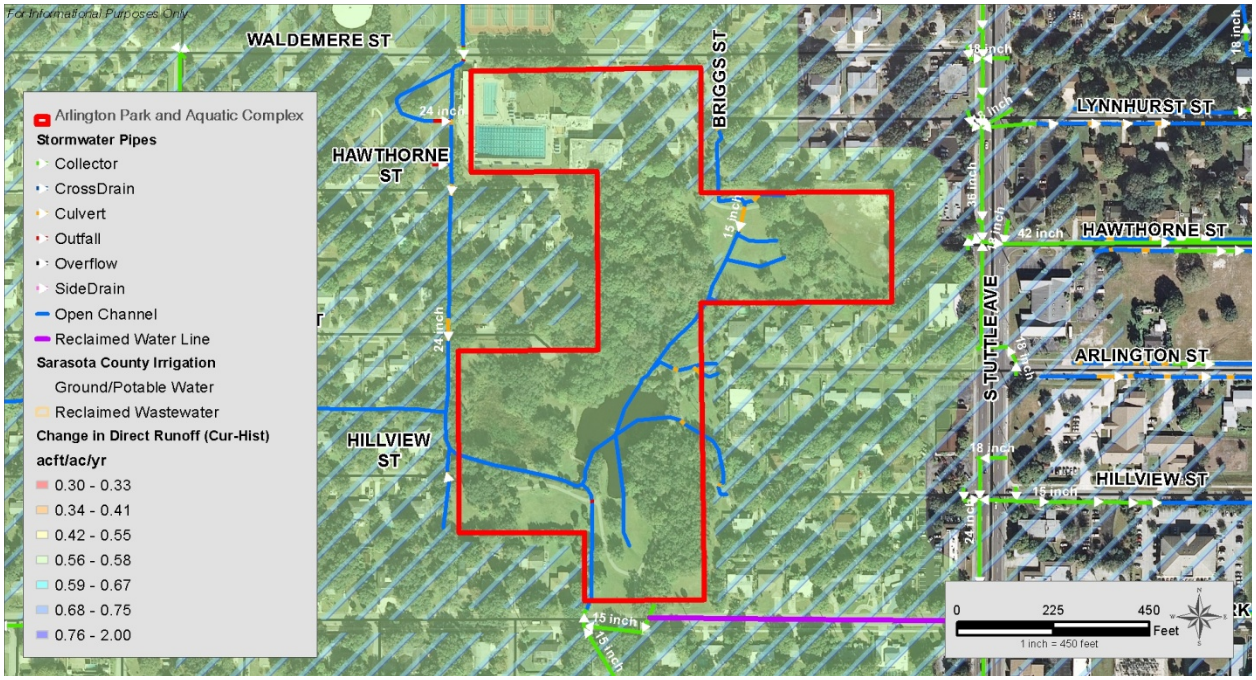


Figure 4-17 Arlington Park and Aquatic Complex GIS Analysis Map

Figure 4-18 Arlington Park and Aquatic Complex Aerial Map

4.7.3.2 Recommendation

Jones Edmunds recommends converting the existing pond to a stormwater-harvesting pond to supply irrigation to the complex. We also recommend investigating the feasibility of working with local residents to supply harvested stormwater to offset residents' potable water irrigation needs and installing public education signs.

Summary:

- ❖ Convert the on-site ponds to stormwater-harvesting ponds.
- ❖ Install a public education kiosk to display how water is harvested and re-used.
- ❖ Work with local residents to augment their irrigation with harvested stormwater.

4.7.4 Site 5 – Orange Avenue Park

Orange Avenue Park is in the Whitaker Bayou basin at the northeast corner of 18th Street and Orange Avenue (Figure 4-19). The park is owned by the City of Sarasota and operated by Sarasota County Parks and Recreation. The park is a small community park within walking distance to neighborhoods and features a basketball court, playground, and picnic benches.

Photo credits (http://sarasota.patch.com/, William Mansell)

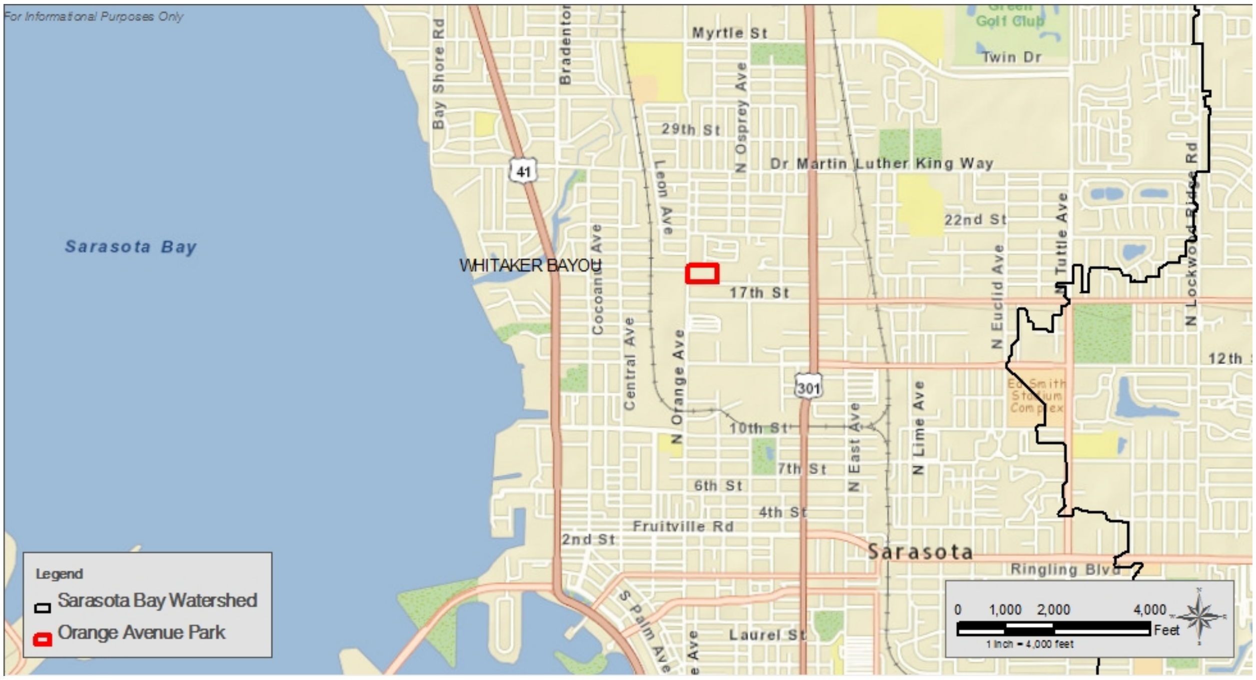


Figure 4-19 Orange Avenue Park Location Map

4.7.4.1 GIS Desktop Analysis

Orange Avenue Park is in an area with a high increase in stormwater runoff from historical conditions. The park is approximately 5 acres in size. According to the Sarasota County GIS irrigation layer, the site is irrigated by potable water (Figure 4-20). The nearest reclaimed lines are more than a mile from the park. The stormwater inventory shows a 42-inch pipe along the south property line of the parcel (Figure 4-21).

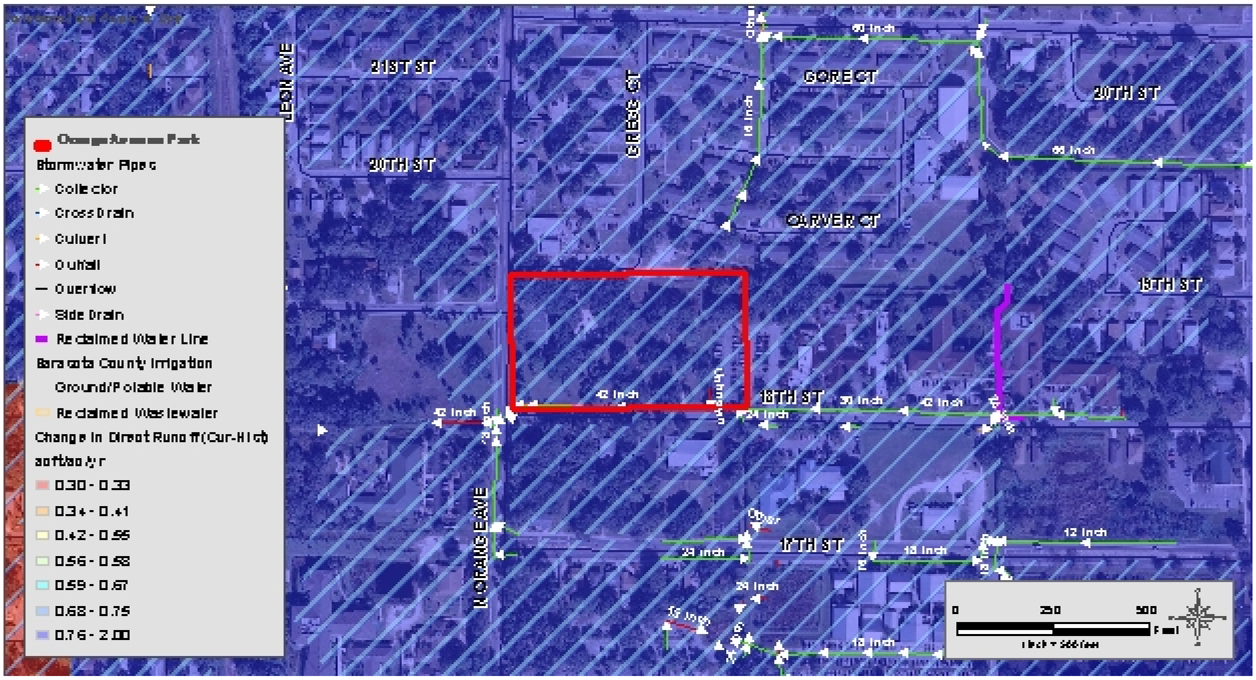


Figure 4-20 Orange Avenue Park GIS Analysis Map

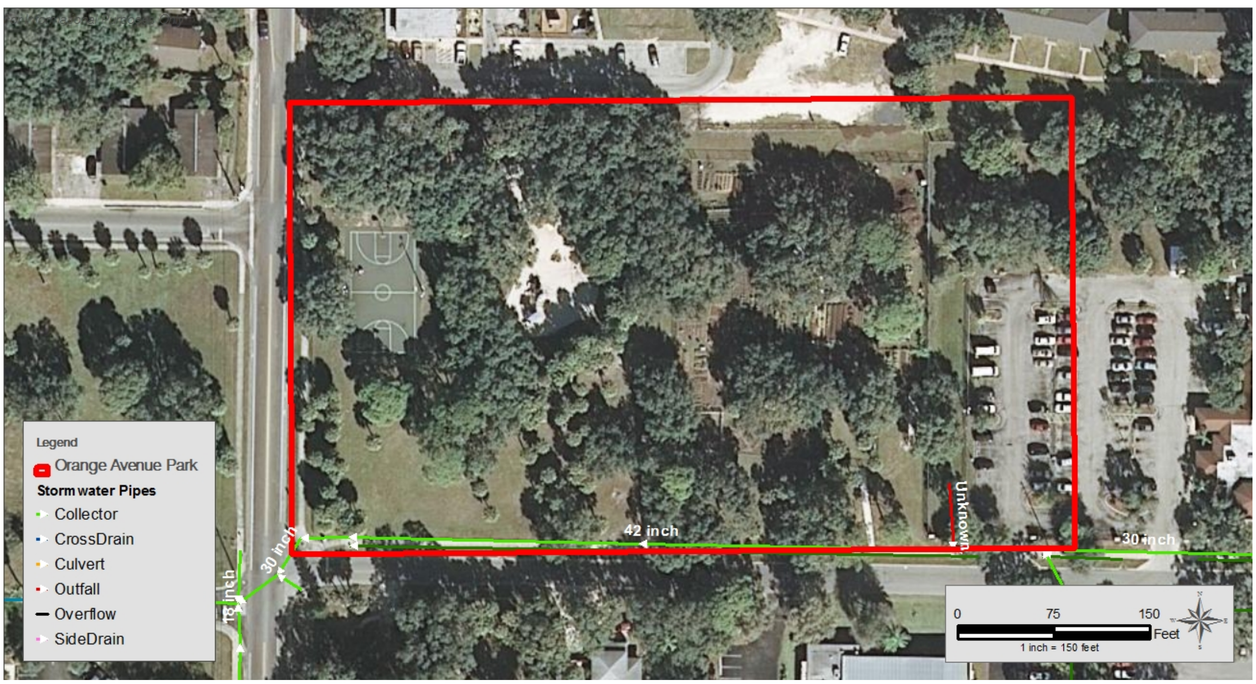


Figure 4-21 Orange Avenue Park Aerial Map

4.7.4.2 Recommendation

Jones Edmunds recommends evaluating the construction of a stormwater-harvesting pond at the southwest corner of the park. The pond should be designed to be large enough to augment the park's irrigation needs during the rainy season. Public education signs or kiosks should be displayed near the ponds.

Summary:

- Install a stormwater-harvesting pond.
- Irrigate the park with harvested water.
- Install a public education kiosk to display how water is harvested and re-used.

4.7.5 Site 6 – Ken Thompson Park Preserve

Ken Thompson Park is in the Sarasota Coastal basin on Ken Thompson Parkway on City Island (Figure 4-22). This 92-acre park is owned by the City of Sarasota and operated by Sarasota County Parks and Recreation. The park is a waterfront park with boardwalks through mangroves and tidal marsh restoration areas and features a boat ramp, canoe/kayak launch, fishing pier, playground, bait shop, and rest rooms.

Photos courtesy of http:\\discovernaturalsarasota.org

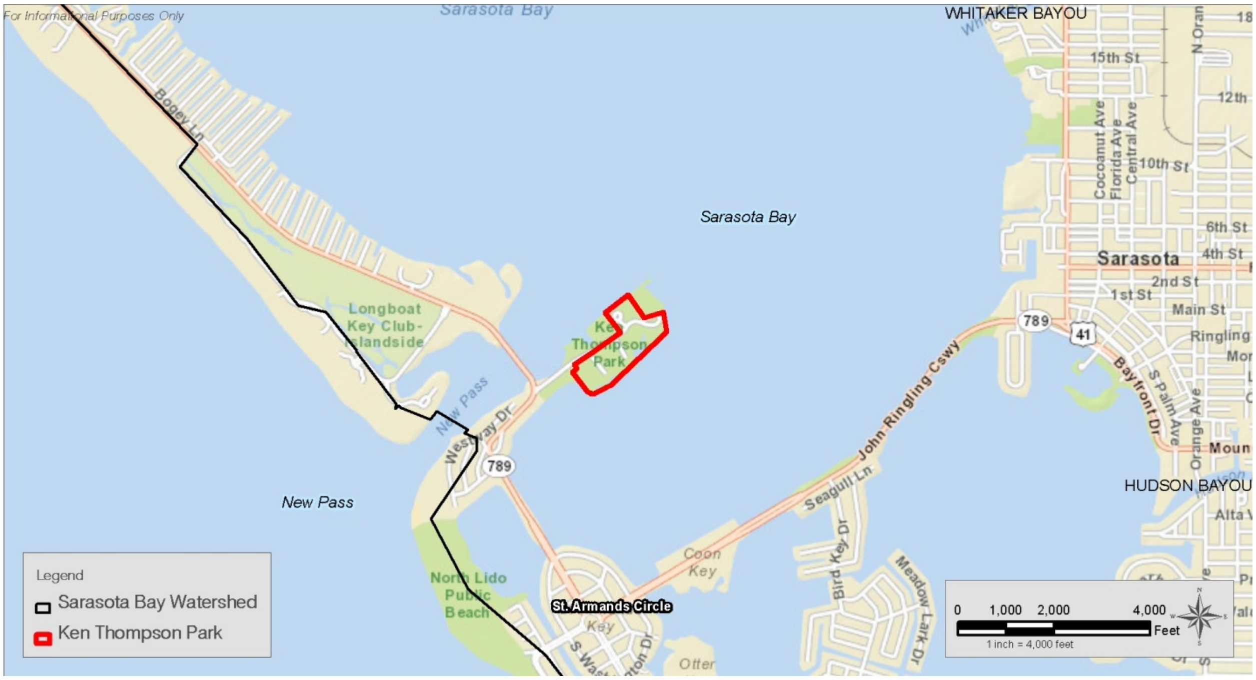


Figure 4-22 Ken Thompson Park Location Map

4.7.5.1 GIS Desktop Analysis

Ken Thompson Park is in an area with a high increase (0.59-acre-foot/acre/year) in stormwater runoff from historical conditions. According to the Sarasota County GIS irrigation layer, the southwest portion of the park is irrigated by potable water (Figure 4-23). The 2010 SWFWMD aerial photos show several buildings in the irrigated area (Figure 4-24).

Figure 4-23 Ken Thompson Park GIS Analysis Map

Figure 4-24 Ken Thompson Park Aerial Map

4.7.5.2 Recommendation

Jones Edmunds recommends installing greenroofs and rain barrels on the larger buildings in the southwest portion of the park. We also recommend installing cisterns on other City-owned buildings in the area, such as the large buildings to the west leased by Mote Marine. The cisterns will collect rainwater to irrigate the plants.

Summary:

- ❖ Install greenroofs on the park buildings.
- ❖ Install cisterns or rain barrels on the other City-owned buildings.
- ❖ Install a public education kiosk to display how water is harvested and re-used and the benefits of a greenroof.
- ❖ Replace parking lot asphalt with pervious pavers

4.7.6 Site 7 – Gillespie Park

Gillespie Park is in the Hudson Bayou basin north of 7th Street between Osprey and Gillespie Avenues (Figure 4-25). The park was originally platted in 1917 as part of the City's experimental farm (http://sarasotagov.com) and was sold to the City in 1924. This approximately 10-acre park is owned by the City of Sarasota and operated by Sarasota County Parks and Recreation. The park is named after the first mayor of Sarasota and features a Gallery of Patriots, lawn bowling, tennis courts, playgrounds, walking trails, and picnic areas.

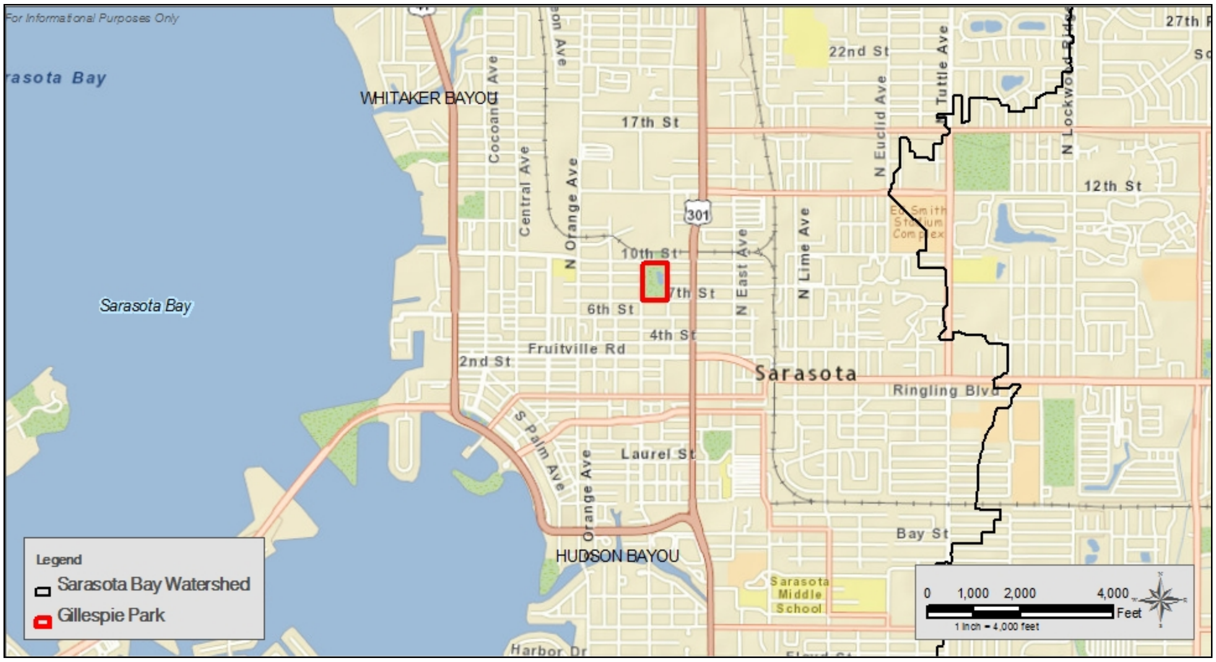


Figure 4-25 Gillespie Park Location Map

4.7.6.1 GIS Desktop Analysis

Gillespie Park is in an area with a high increase (0.73-acre-foot/acre/year) in stormwater runoff from historical conditions. According to the Sarasota County GIS irrigation layer, the park does not irrigate on site; however, several nearby residents have potable irrigation systems and may be able to beneficially use the stormwater captured onsite (Figure 4-26 and Figure 4-27).

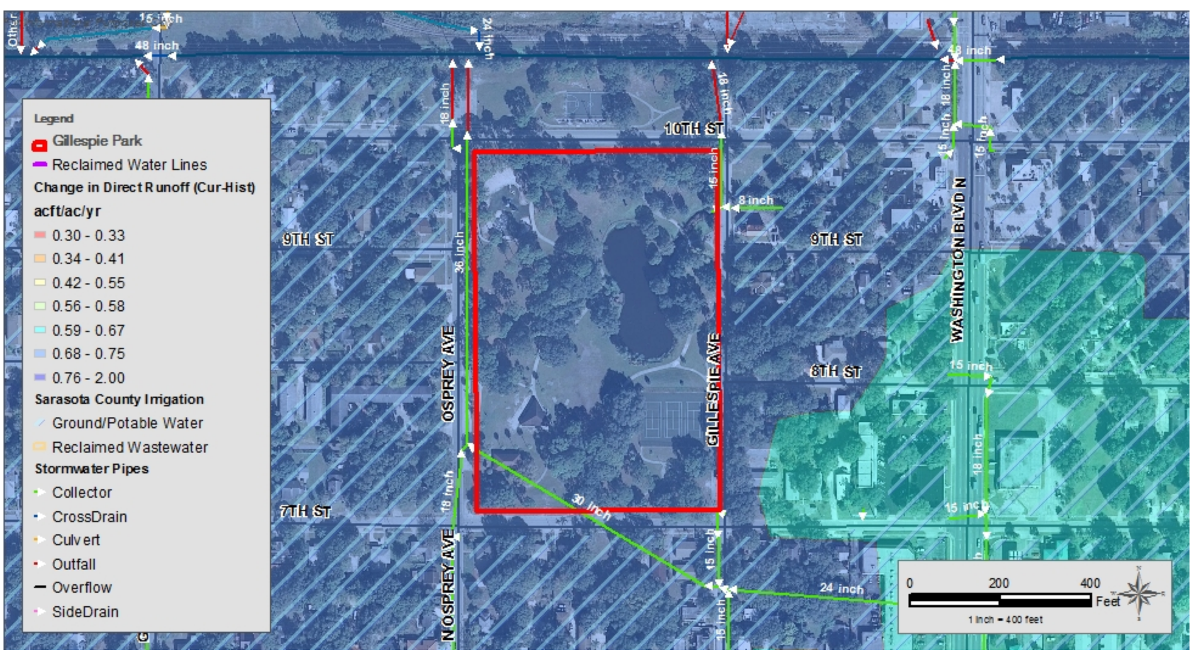


Figure 4-26 Gillespie Park GIS Analysis Map

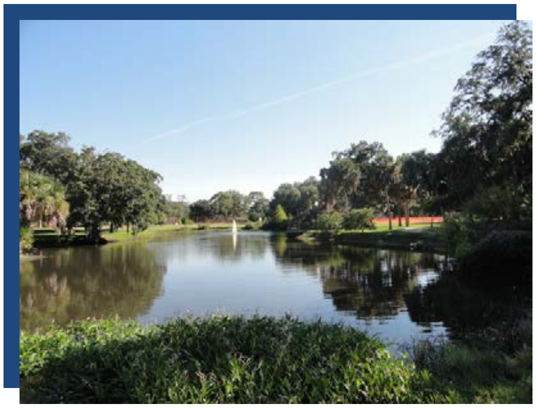


Photo credit: William Mansell

Figure 4-27 Gillespie Park GIS Aerial Map

4.7.6.2 Recommendation

Jones Edmunds recommends installing greenroofs on the buildings in the southwest portion of the park to reduce runoff from the site. We recommend installing rain barrels on the buildings, converting the on-site pond to a stormwater-harvesting pond to collect rainwater to irrigate plants, and adding public education kiosks and sign.

Summary:

- ❖ Install greenroofs on the park buildings.
- ❖ Install rain barrels on the park buildings.
- ❖ Convert the existing stormwater pond to a stormwater-harvesting pond for on-site irrigation and other uses.
- ❖ Install a public education kiosk to display how water is harvested and re-used and the benefits of a greenroof.

4.7.7 Site 10 – Martin Luther King Park

Martin Luther King Park is in the Whitaker Bayou basin at the southwest corner of Dr. Martin Luther King Jr. Way and Coconut Avenue (Figure 4-28). This small neighborhood park features picnic areas and a rest room. Whitaker Bayou runs along the west boundary of the park.

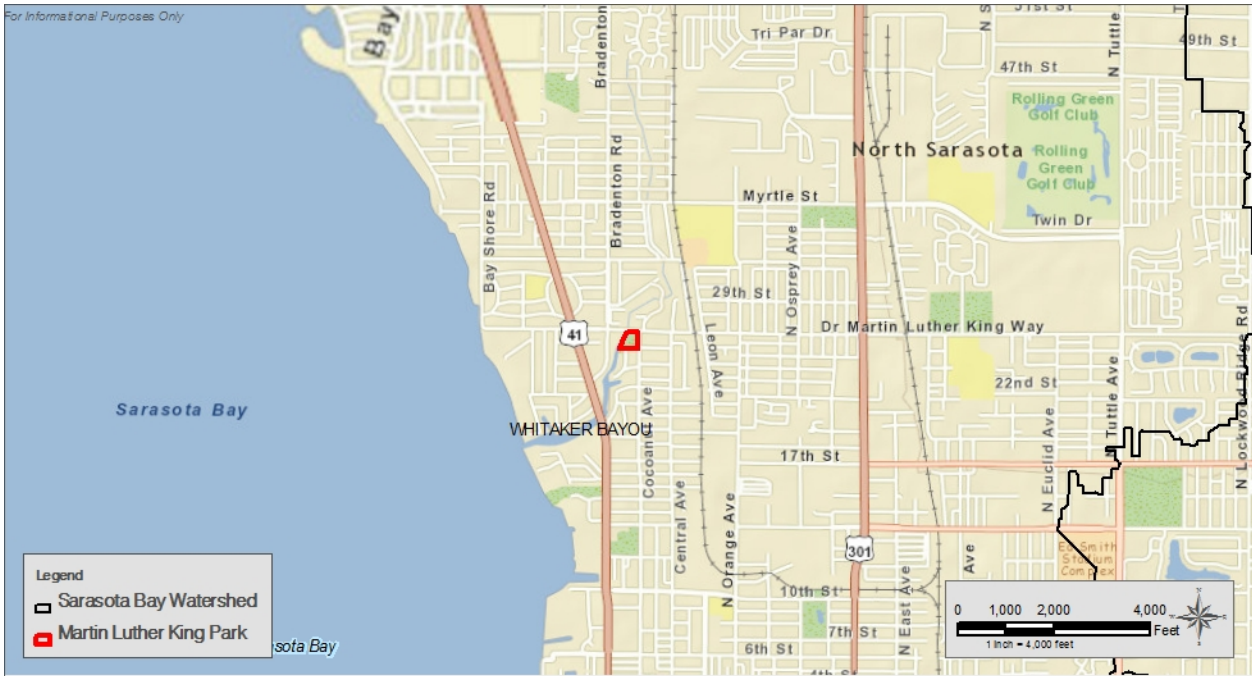


Figure 4-28 Martin Luther King Park Location Map

4.7.7.1 GIS Desktop Analysis

Martin Luther King Park is in an area with an increase of 0.32-acre-foot/acre/year of stormwater runoff from historical conditions. According to the Sarasota County GIS irrigation layer, the park does not have an on-site irrigation system (Figure 4-29). The park is immediately adjacent to Whitaker Bayou and does not have on-site storage.

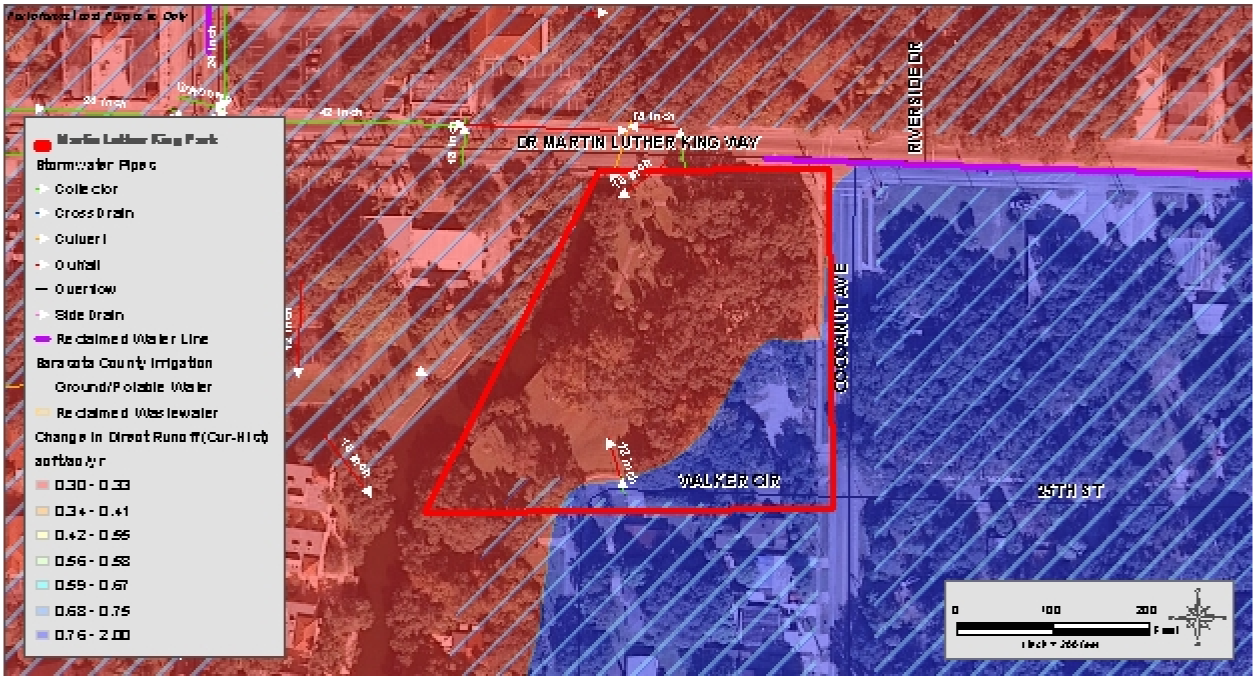


Figure 4-29 Martin Luther King Park GIS Analysis Map

4.7.7.2 Recommendation

Jones Edmunds recommends installing a greenroof and rainbarrels on the larger building to reduce runoff from the site. Because Wilson Miller-Stantec is working with the Sarasota Bay Estuary Program (SBEP) to develop conceptual plans to renovate the park, we recommend working with SBEP to incorporate the greenroof and rainbarrels into the design.

Summary:

- ❖ Work with SBEP to include the following components into their design:
  - Install a greenroof on the park building.
  - Install rainbarrels on the park building.
  - Install a public education kiosk to display how water is being harvested and re-used and the benefits of a greenroof.
  - Replace parking lot asphalt with pervious pavers

4.7.8 Site 11 – Robert Taylor Community Complex

Robert Taylor Community Complex is in the Whitaker Bayou basin at the southwest corner of US 301 and Myrtle Street (Figure 4-30). The complex is a historical community center with a 13-acre campus that houses a 44,000 square-foot facility. The complex features indoor and outdoor amenities such as a fitness center, childcare, computer lab, recording studio, aquatic center, amphitheater, and basketball courts.

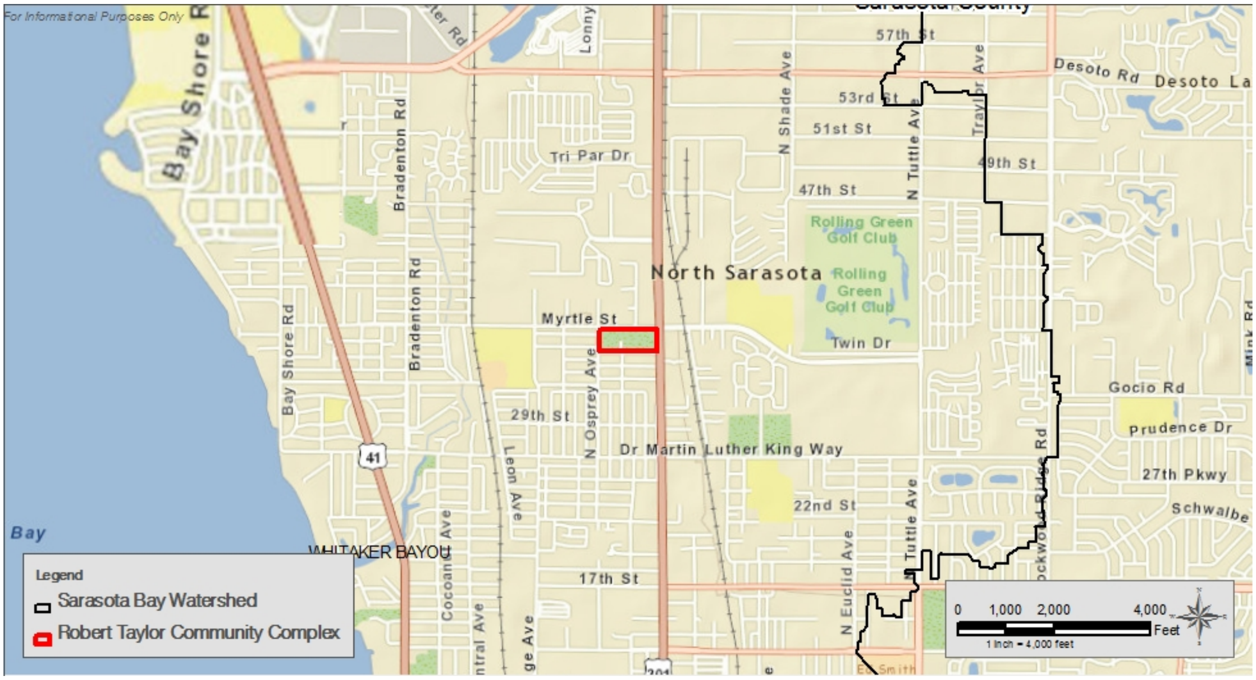


Figure 4-30 Robert Taylor Community Complex Location Map

4.7.8.1 GIS Desktop Analysis

The Robert Taylor Community Complex is in an area with an increase of 0.66-acre-foot/acre/year of stormwater runoff from historical conditions. According to the Sarasota County GIS irrigation layer, the complex does not have an on-site irrigation system (Figure 4-31). Storage is not readily available on site, but there is room on site for a storage pond.

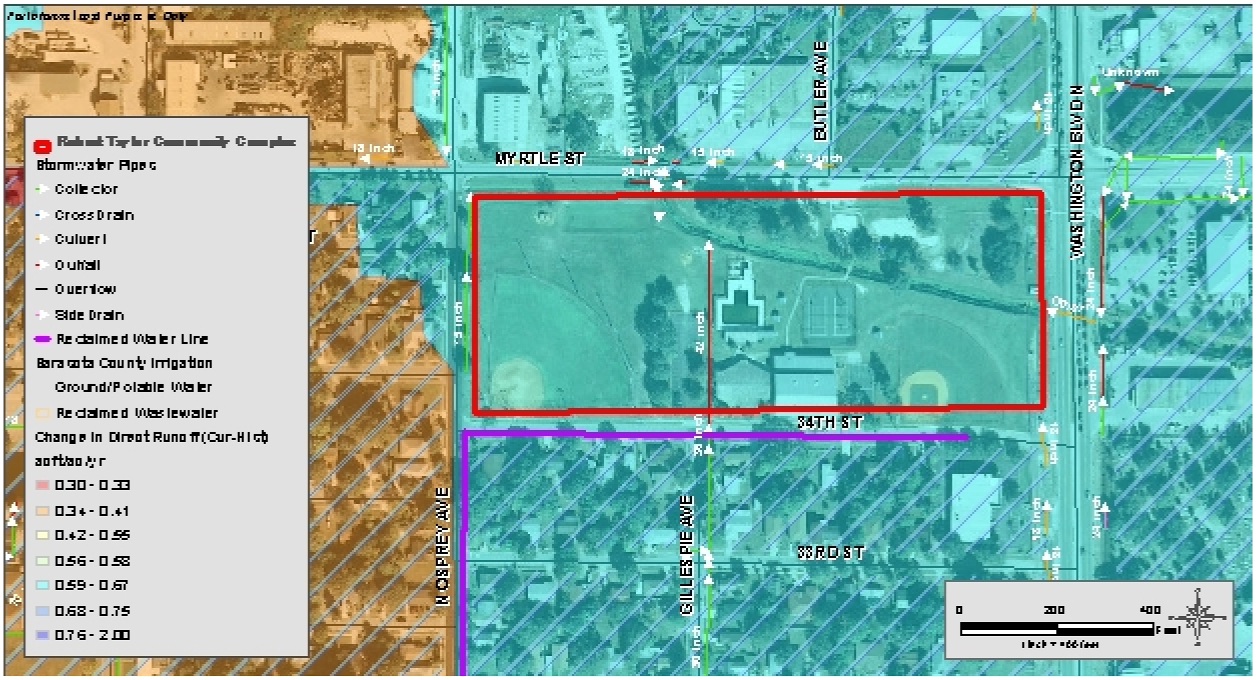


Figure 4-31 Robert Taylor Community Complex GIS Analysis Map

4.7.8.2 Recommendation

Jones Edmunds recommends working with the complex to install roof-top cisterns to offset the potable water uses such as washing recreational areas. Additionally, the County could work with staff to implement an educational outreach program. The staff and local student groups or residents could install and maintain rain barrels and monitor the amount of rainwater captured and used throughout each year. This educational component would teach residents to conserve stormwater and facilitate shared learning in their communities.

Summary:

- Install cisterns/rain barrels
- Wash recreational areas with rainwater before potable water.
- Start educational program.
- Install a public education kiosk to display how water is harvested and re-used.

4.7.9 Site 12 – Lime Lake Park

Lime Lake Park is in the Whitaker Bayou basin approximately 0.4 mile east of US 301 and between 22nd and 20th Streets (Figure 4-32) at the end of Lime Avenue. The park is a small neighborhood park that was recently renovated to include a walking trail around the perimeter of the lake, a fishing pier, gazebo, solar-powered aerator in the middle of the lake (for filtration and aesthetics), benches, picnic tables, ADA parking spaces, areas for shoreline plantings/ restoration, and educational signage (see Figure 4-33).

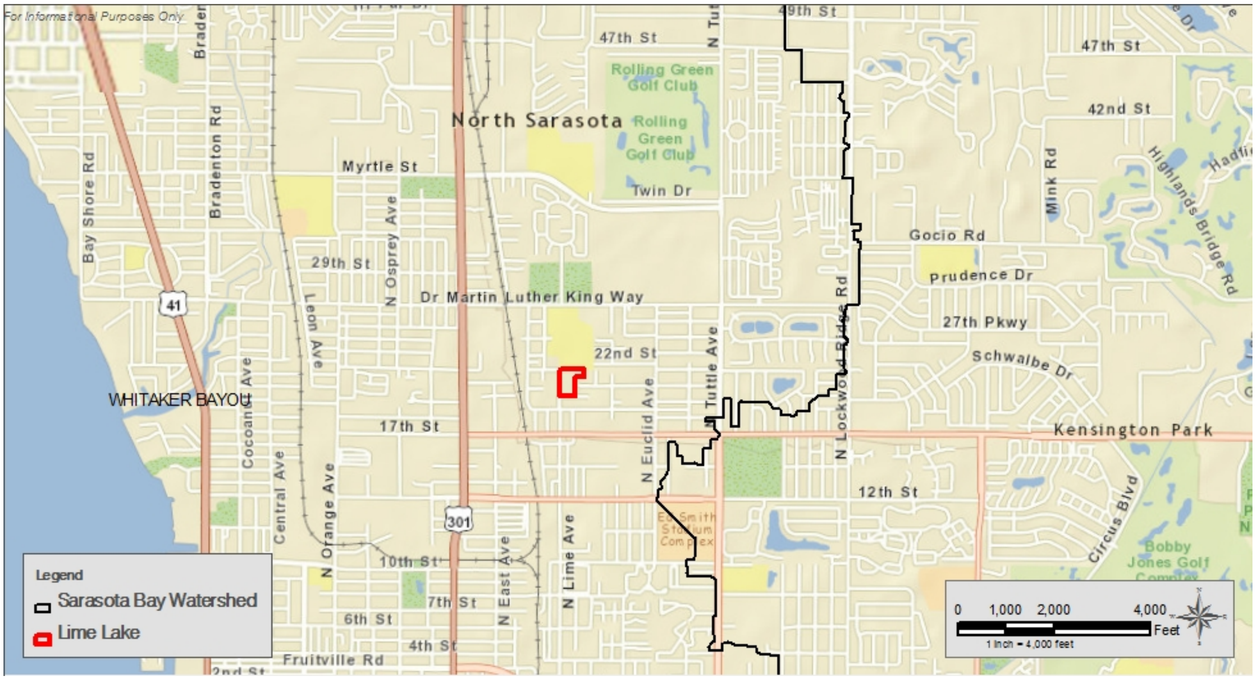


Figure 4-32 Lime Lake Park Location Map

Figure 4-33 Lime Lake Park Concept Plan (courtesy of http:\\scgov.net)

4.7.9.1 GIS Desktop Analysis

Lime Lake Park is in an area with an increase of 0.66-acre-foot/acre/year of stormwater runoff from historical conditions. According to the Sarasota County GIS irrigation layer, the park does not have an on-site irrigation system (Figure 4-34), and local residents irrigate with potable water. Storage is available in the on-site 3-acre pond.

Figure 4-34 Lime Lake Park GIS Analysis Map

4.7.9.2 Recommendation

Jones Edmunds recommends converting the existing pond to a stormwater-harvesting pond to supply irrigation to the park landscaping. We also recommend working with local residents to supply them with harvested stormwater to offset residents' potable water irrigation needs.

Summary:

- ❖ Convert the on-site ponds to stormwater-harvesting ponds.
- ❖ Irrigate with harvested rainwater before potable water.
- ❖ Install a public education kiosk to display how water is harvested and re-used.

4.7.10 Site 13 – Marion Anderson Place

The Marion Anderson Site is in the Whitaker Bayou basin south of Dr. Martin Luther King Jr. Way and east of US 301 (Figure 4-35). The site is a historical landfill with 13 acres of cleared and fenced property within the Newtown Community Redevelopment Area (CRA).

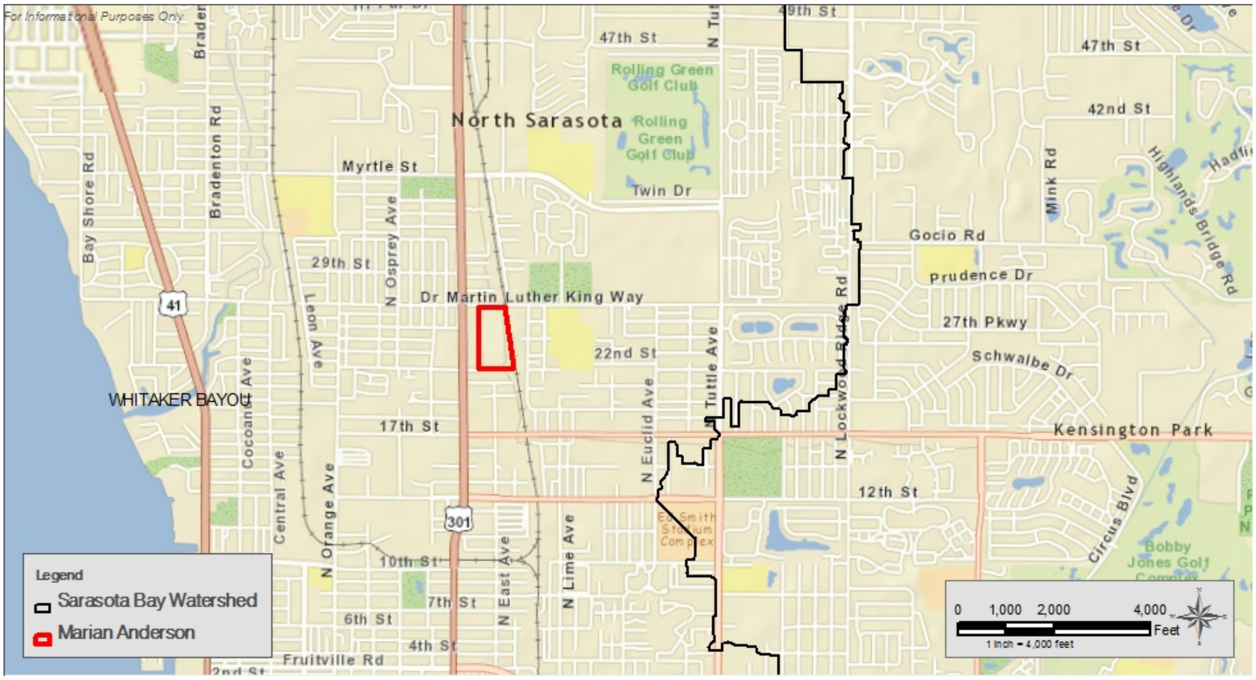


Figure 4-35 Marion Anderson Place Location Map

4.7.10.1 GIS Desktop Analysis

The Marion Anderson Site is in an area with an increase of 0.75-acre-foot/acre/year of stormwater runoff from historical conditions. According to the Sarasota County GIS irrigation layer, the site does not have an on-site irrigation system and nearby parcels are not irrigated with potable water (Figure 4-36). Additionally, the Marion Anderson Place Landfill Opportunity Report recommends that this site be designated for a quality commercial redevelopment project, which is in line with the CRA requirements.

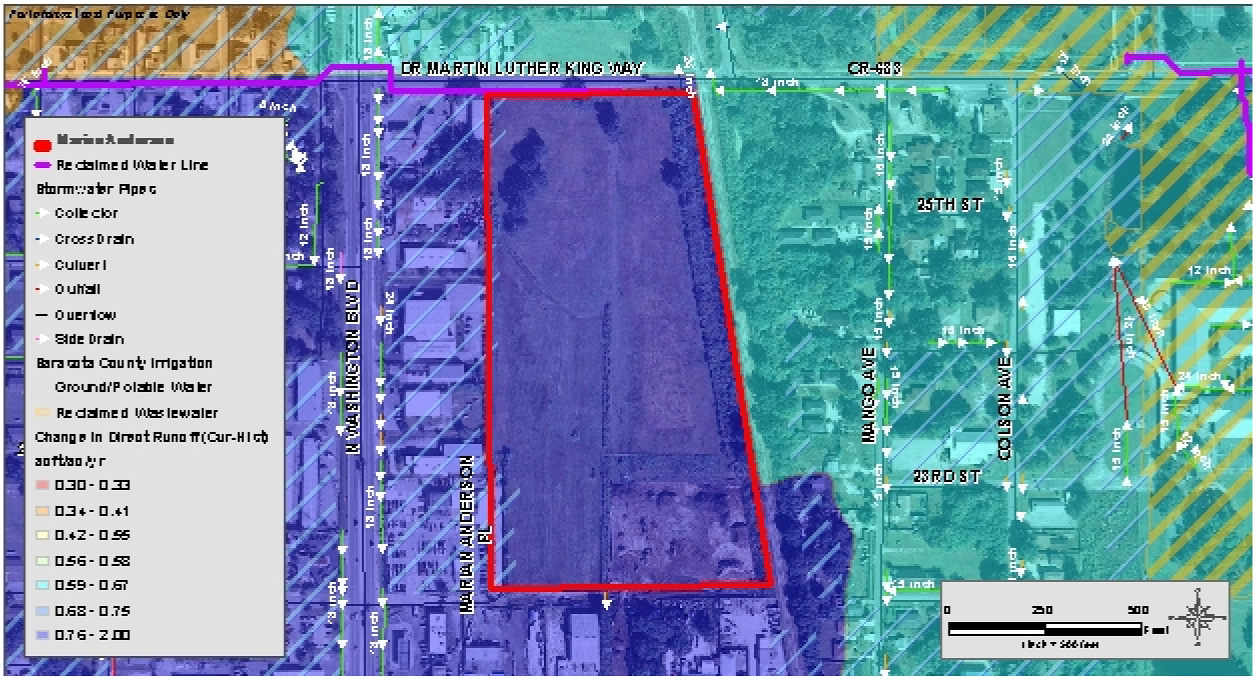


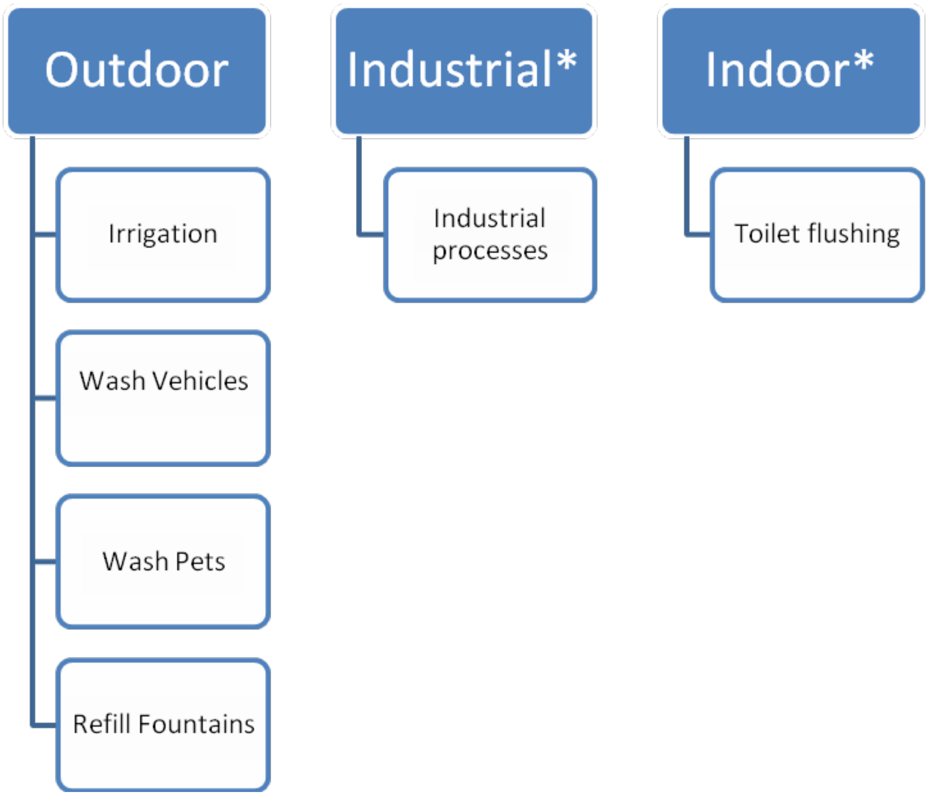
Figure 4-36 Marion Anderson Place GIS Analysis Map

4.7.10.2 Recommendation

Jones Edmunds does not recommend a project at this site. We recommend that the County work with the City of Sarasota and Newtown CRA to identify potential stormwater-harvesting opportunities as part of the site redevelopment.

4.8 LOCAL-SCALE PROGRAMS

Local-scale stormwater-harvesting projects typically consist of pond pumps, cisterns, or rain barrels that serve individual properties. Since local-scale stormwater-harvesting projects typically consist of construction on private property, the County is unlikely to participate directly in the construction of most of these projects. However, local-scale harvesting projects are highly recommended since they provide the same potable-water offset, freshwater balance, and pollutant-loading reduction benefits as any other form of reuse. Possible uses for stormwater include:



* May require additional treatment before use.

Local-scale projects will vary in efficiency based on the amount of storage provided and how the stored water is used for beneficial purposes. Based on some typical values, an individual homeowner may achieve a roughly 5% reduction in average annual flows and loads by using rain barrels at each downspout on a guttered house. Although estimates for reductions using larger cisterns are more variable because of differences in cistern sizes, a reduction of approximately 15% for cisterns may be a reasonable value to use for planning.

The effectiveness of a local-scale stormwater-harvesting project will depend on how well the individual property owner maintains and operates their system.

Customers tend to use more harvested stormwater and reclaimed water than potable water because potable water is generally more expensive and restricted. For example, a single-family residence with an in-ground irrigation system connected to potable water uses about 300 gpd for irrigation. However, if the same single-family residence converts to unmetered, flat-rate, reclaimed water irrigation supply without day-of-week restrictions, the residence will use approximately two and one-half times (804 gpd) that amount. In this example, the offset rate would be 37% (300 gpd offset for 804 gpd reclaimed water utilization). SWFWMD's goal is to achieve a 75% offset efficiency (RWSP, SWFWMD 2011).

The effectiveness of a local-scale stormwater-harvesting project will depend on how well the individual property owner maintains and operates their system and reduces their use of potable water. A storage device that is never used is not a worthy investment. There are countless opportunities for residents and businesses to personally implement practices to reduce their use of potable water. Additionally, a range of possibilities exists for funding assistance of local-scale harvesting projects. Below are some of the programs offered through Sarasota County and its partners.

4.8.1 Sarasota County Rain Barrel Harvesting Program

4.8.1.1 Description

In September 2009, Resolution 2009-178 was passed that allowed Sarasota County Air and Water Quality to implement a rain barrel water conservation program by making rain barrels available for purchase by Sarasota County residents for the wholesale cost of $37.00 each. The rain barrels are 55-gallon, food-grade quality, recycled polyethylene barrels. Harvested stormwater collected in the barrels is considered non-potable.

To implement the program, Air and Water Quality staff partnered with UF/IFAS Sarasota County Extension (http://sarasota.extension.ufl.edu/FYN/Rainbarrel.shtml). The County Extension received grant funding from SWFWMD for a part-time Florida Yards and Neighborhoods Homeowner Outreach Educator. Public education and monthly workshops have been scheduled every year since 2010. Workshop dates and locations are listed on the website.

Residents can register for upcoming classes at http://sarasota.ifas.ufl.edu/. The following topics are included as part of public education to residents:

- Rainwater harvesting can reduce the use of potable water and provide cost savings on water and wastewater utility bills.
- Rain barrels help reduce stormwater runoff by diverting and storing runoff from impervious areas such as roofs, decreasing the undesirable impacts of runoff.
- The use of rain barrels is a sustainable practice that conserves water.

4.8.1.2 Recommendation

Jones Edmunds recommends that the County continue to partner with SWFWMD and UF/IFAS to offer rain barrel education courses and rain barrels at a reduced rate. The County could encourage and support local-scale rain barrel stormwater-harvesting projects through some form of funding assistance or homeowner rebate program.

4.8.2 Sarasota County Septic to Cistern

4.8.2.1 Description

In June 2009 the County Health Department implemented a procedure for converting abandoned septic tanks into cisterns based on Rule 64E-6.011, FAC. This conversion allows a single-family residence to convert an abandoned septic tank to a cistern by permit within 90 days of connecting the building plumbing to sanitary sewer. Laboratory sampling and health department inspection are required for this procedure, and the water collected in the tank must be used for non-potable irrigation purposes only.

4.8.2.2 Recommendation

Jones Edmunds recommends that the County target areas identified in their septic replacement program. The County should educate residents on the benefits of stormwater harvesting and provide support and instructions on the process. Direct targeting will engage homeowners and continue to show a return on the outreach investment.

4.8.3 Irrigation Utilities for New Development

4.8.3.1 Description

Sarasota County has successfully worked with several communities to establish an irrigation utility at the beginning of a new development, construct a central irrigation system, and limit or prohibiting individual groundwater wells through deed restrictions. This structure requires an active management strategy and resource management to ensure that the type of water used follows the principles and hierarchy established by Water Policy 3.3.4. Demand management strategies include limitations on the amount of water and time of day for irrigation, appropriate plant placement, and drought-tolerant plant selections. Also, demands have been adjusted by the changing community perspective with a general shift away from traditional lawns to a more natural landscape.

As examples, Palmer Ranch, Lakewood Ranch, Stonybrook of Venice, and the Grand Paradiso communities were planned and developed with sustainable community principles. A development-wide piping system designed to supply reclaimed water and use stormwater harvesting to irrigate yards and common areas was installed during construction. A private irrigation utility was set up to administer and maintain the system and serve the customers. Community wells are used to supplement supplies when demands cannot be met through other means. The community wells also have meters to track the amount of groundwater used. Grand Paradiso has a development-wide restriction that does not allow private wells. Encouraging the establishment of private utilities and following the prioritization and hierarchy for supplies outlined in Water Policy 3.3.4, will help the County achieve its sustainability goals as well as offset potable water demand.

4.8.3.2 Recommendation

Jones Edmunds recommends continuing to work with developers to implement irrigation utilities and sustainable community practices.

4.8.4 Public Education on Water Conservation Practices

4.8.4.1 Description

Public education is an important component to water supply planning. The County should continue to educate residents on water conservation practices, such as those listed on its website: http://www.scgov.net/EnvironmentalServices/Water/Conservation/TopWaterUsers.asp

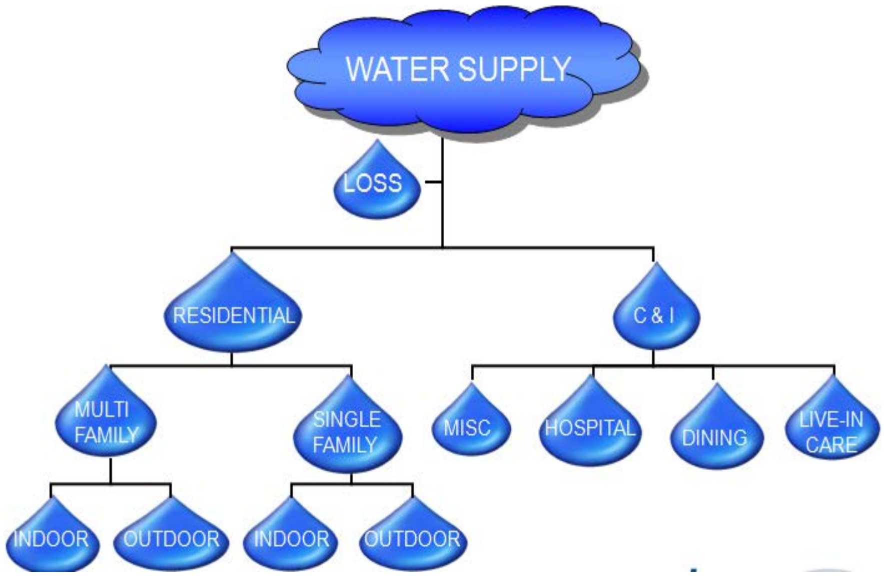
What can you do to save water indoors:
- *Search for and fix leaks.*
- *Install low-flow toilets, faucets, and showerheads.*
- *Flush less (do not use the toilet as a trash can).*
- *Turn off water while brushing your teeth.*
- *Take shorter showers.*
- *Use less water for baths.*
- *Operate appliances only when full.*
- *Purchase water-efficient appliances.*

What can you do to save water outdoors:
Search for and fix leaks:
- *Faucets, hoses, and connections.*
- *Sprinkler systems.*
- *Swimming pools.*
- *Service connection lines.*

Irrigate properly:
- *Check local water restrictions.*
- *Water only when needed.*
- *Water in morning or evening.*
- *Evaluate alternative methods such as micro-irrigation.*

4.8.4.2 Recommendation

Jones Edmunds recommends that the County continue its public education practices related to water conservation and enforce the Landscape Efficiency Ordinance (No. 2001-081), which focuses on irrigation system efficiency and limiting plants requiring the most supplemental irrigation for new developments as well as horizontal additions to residential buildings (Sarasota County Ordinance 2001-181, 2001).



4.8.5 Potable Water Demand-Side Management Analysis

4.8.5.1 Description

Evaluating water supply savings potential from customer or demand-side measures requires understanding how water is being used in homes and businesses served by the County utilities. Once the end uses are accounted for, more cost-effective conservation measures can be selected and incentivized by the County to reduce water demands. The County should evaluate demand-side water savings for the following future development conditions:

1. Existing development—This scenario defines the current potential for demand-side management and will be used to estimate the potable water reductions that can be realized through retrofits and programs directed at the existing customer base. This scenario will include estimates of water savings from projects currently being implemented by the County.

2. In-fill of existing development—This scenario will estimate the potential water reductions possible from approved developments that have infrastructure in place with vacant lots to be built on.

3. Approved development without buildings—This scenario will estimate the long-term potential for demand-side management in the County from developments that have been approved but do not have active demands.

4. Conditions at end of planning horizon—This scenario will estimate the long-term potential for demand-side management in the County from developments that have yet to be planned.

The costs and benefits from County demand management programs can be compared against other alternative water supplies.

4.8.5.2 Recommendation

Jones Edmunds recommends that the County partner with the potable water utilities to perform a Demand-Side Management Analysis. SWFWMD has several programs to analyze this information, such as the Conserve Florida and Utility Service Programs. The Analysis should include the following components:

- Data Collection.
- Profile Water Use and Users.
- Estimate Water Use for Four Scenarios.
- Identify Potential Demand-side Management Measures.
- Estimate Potable Water Demand Reductions and Costs.
- Report Findings.

4.8.6 Florida Water Star℠

4.8.6.1 Description

Florida Water Star℠ in Sarasota County
(picture courtesy of SWFWMD)

Florida Water Star℠ is a voluntary certification program for builders and developers designed to increase water efficiency in landscapes, irrigation systems, and indoors. SWFWMD is encouraging good water stewardship to the building industry by offering this recognition program that focuses on water efficiency and water quality protection. Florida Water Star℠ is tailored to the needs of Florida's water resources and is easily integrated into other green certification programs such as Energy Star®, the Florida Green Building Coalition's green standards, and the U.S. Green Building Council's LEED® program.

What are some of the features of Florida Water Star^{SM}?

- ❖ Requires micro-irrigation and mulch in plant beds.
- ❖ Limits high-volume irrigation system to 50 to 60% of planted landscape area.
- ❖ Requires high-performance water-conserving appliances and fixtures.
- ❖ Requires points related to water quality issues for homes built near water bodies.
- ❖ Requires landscapes for the right plant in the right place.

How does Florida Water Star^{SM} certification benefit new homebuyers?

- ❖ Answers their interest in being “green.”
- ❖ Saves them money on utilities.
- ❖ Decreases landscape maintenance costs.
- ❖ Increases resale value.

4.8.6.2 Recommendation

Jones Edmunds recommends that the County continue to work with SWFWMD to encourage participation in the Water Star^{SM} Program.

5.0 CONCLUSION

Subregional-scale stormwater-harvesting opportunities in the Sarasota Bay Watershed exist largely as projects that can provide a non-potable irrigation source or supplement. Subregional-scale projects will typically serve one or two larger users (e.g., a school). Sustainable supplies are relatively plentiful throughout the watershed since the water budget analysis indicates greater average annual discharge under existing conditions than under historical conditions and because of an abundance of potential withdrawal locations. Because of the relatively small storage footprint required for a stormwater-harvesting system, an abundance of potential storage locations throughout the watershed would also rely on retrofitting existing ponds or constructing new ponds on available property.

Transmission/distribution is one of the most limiting factors for stormwater-harvesting opportunities in this watershed. Irrigation systems that use stormwater cannot be connected to potable distribution systems because of concerns over potential contamination of the potable source. Retrofitting most existing urban land uses (e.g., residential development) with separate or disconnected irrigation systems is typically cost-prohibitive. Therefore, subregional opportunities were limited to areas where separate distribution systems already exist or where retrofitting the distribution system may not be cost-prohibitive.

Jones Edmunds recommends stormwater-harvesting projects at the regional and subregional scales.

Nine of the potential project sites were deemed viable locations for projects designed to reduce potable water use (Table 5-1). Implementing these projects and programmatic recommendations will reduce potable water demand and reduce runoff that will in turn reduce the amount of nutrients leaving the site and entering nearby water bodies.

Jones Edmunds will project benefits, including pollutant-load reductions, develop conceptual plans and cost estimates, and provide project and program rankings for the selected project sites in Task II-7 (Project Analysis).

Table 5-1 Recommended Water Supply Projects		
ID	Site Name	Recommended
01	Airport Ponds	No
02	Bay Haven Elementary School	✓
03	Booker High School	✓
04	Arlington Park and Aquatic Complex	✓
05	Orange Avenue Park	✓
06	Ken Thompson Park	✓
07	Gillespie Park	✓
08	City of Sarasota Wastewater Treatment Plan	No
09	12th Street Pond	No
10	Martin Luther King Park	✓
11	Robert Taylor Community Complex	✓
12	Lime Lake Park	✓
13	Marion Anderson Place	No

6.0 REFERENCES

Anderson, D. L., and R. J. Otis. (2000). Integrated Wastewater Management in Growing Urban Environments. In: Managing Soils in an Urban Environment, Agronomy Monograph No. 39. R.B. Brown, J. H. Huddleston, and J. L. Anderson, Ed. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, WI. pp. 199 – 250.

Carollo Engineers, Inc. (2011). *Draft Water Supply Master Plan*. Prepared for: Sarasota County, Sarasota, FL.

Janicki Environmental, Inc. (2010). *Numeric Nutrient Criteria for Sarasota Bay*. 2010. Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

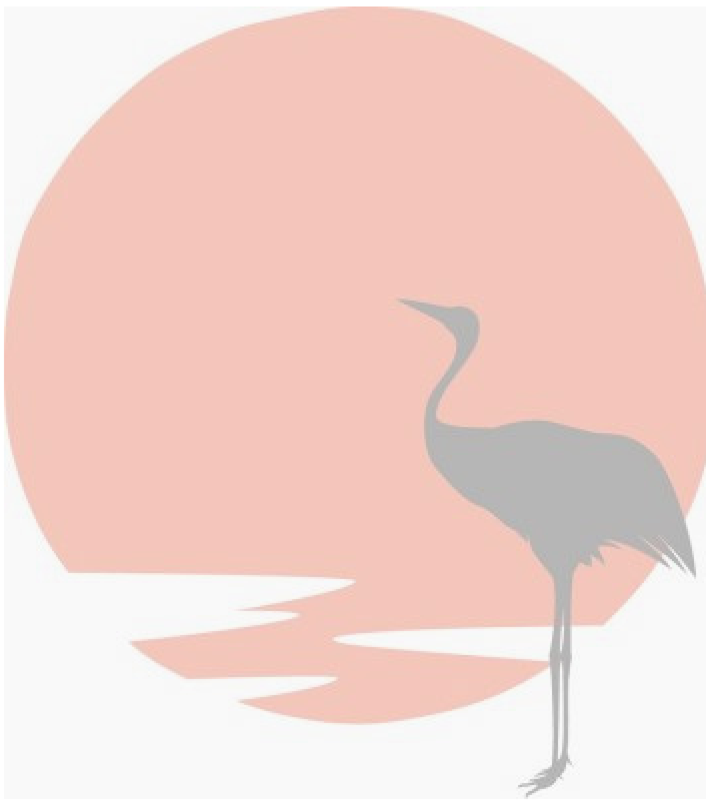
Jones Edmunds & Associates, Inc. (2009). *Sarasota County Pollutant Loading Model Development Simple-Monthly Calibration Report*. Prepared for: Sarasota County, Sarasota, FL and Southwest Florida Water Management District, Brooksville, FL.

Jones Edmunds & Associates, Inc. (2008). *Sarasota County Pollutant Loading Model Development Design Report.* Prepared for: Sarasota County, Sarasota, FL and Southwest Florida Water Management District, Brooksville, FL.

Appendix C

Water Quality

Appendix C
Water Quality



December 2012

Sarasota County | Southwest Florida Water Management District | Jones Edmunds | Janicki Environmental, Inc.

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1.0 WATER QUALITY IN SARASOTA BAY AND ITS WATERSHED

The value of the Sarasota Bay ecosystem (Figure 1-1) depends in great part on the prevailing quality of the estuarine waters of the bay. In turn, the bay water quality depends on the effective management of the anthropogenic activities that shape the Sarasota Bay watershed and the tributary waters that drain this watershed and eventually enter the bay.

Water quality is characterized by a number of parameters that can affect the suitability of the aquatic habitats for essential biologic elements of the estuarine ecosystem as well as other designated uses such as recreational and commercial activities. These parameters include:

- Salinity—A measure of the dissolved salts in bay waters. Spatial and temporal variations in salinity are driven by freshwater inputs and communication with the Gulf of Mexico. Salinity tolerances can vary significantly among different plant and animal taxa. Variation in salinity can, therefore, affect the spatial and temporal distributions of these organisms.
- Chlorophyll—A measure of the amount of algae in the water. Spatial and temporal distributions depend on nutrient loading and circulation (i.e., flushing). Chlorophyll affects water clarity and dissolved oxygen, and nuisance algal blooms can affect fishes and other biota.
- Water Clarity—A measure of the amount of light that reaches the bottom. Water clarity depends on chlorophyll, turbidity, water color, and suspended sediments and affects seagrass growth and reproduction.
- Dissolved Oxygen (DO)—A measure of the amount of O_2 dissolved in the water. Spatial and temporal DO distributions depend on water temperature, salinity, amount of algae and decomposing organic matter, and degree of vertical stratification in the water column. DO affects habitat suitability for fish and bottom-dwelling organisms (benthos).
- Nutrients—Typically nitrogen and phosphorus measured as concentrations, i.e., of the amount of nitrogen and phosphorus in the water or as loading (expressed as amount per unit time). Nutrient sources include atmospheric deposition, stormwater runoff from fertilizer, pet waste, and point sources. Nutrient over-enrichment drives algal growth and potential bloom conditions.

Figure 1-1 Sarasota Bay and Watershed

This appendix has been produced to provide critical insight into the water quality of Sarasota Bay and its tributaries. Informed decisions regarding management of the anthropogenic activities that mark the linkage between the bay and its watershed depend on a clear understanding of this linkage. Thus, this document provides the basis for the overall water quality management plan (WQMP) and addresses the following topics:

- The current status and temporal trends in water quality in the bay and its tributaries.
- The relationship between freshwater inputs and salinity in the bay.
- Estimation of current and future pollutant loadings to the bay.
- Identification of pollutant-loading "hot spots" in the Sarasota Bay watershed.
- Examination of the relationships between in-bay nutrient concentrations and watershed loadings with chlorophyll and DO concentrations in Sarasota Bay.
- Establishment of water quality levels of service for the bay and its tributaries.
- The review of recently proposed revisions to DO criteria and an examination of the factors that affect DO in the bay and its tributaries.

The following discussion presents some of the salient findings found in subsequent sections of the water quality appendix.

1.1 WATER QUALITY STATUS AND TRENDS

Knowledge of water quality status and trends is an essential element of a watershed management plan. Effective management is supported by the assessment of the current status in relation to existing regulatory standards/criteria and resource management targets. Early detection of negative trends in water quality can allow resource managers to respond before water quality conditions become unacceptably degraded. Assessment of the effectiveness of various water quality management strategies is often achieved by the detection of positive trends in water quality.

1.2 ESTUARINE WATER QUALITY

Achieving the water quality standards and targets within Sarasota Bay assures resource managers that key targets such as the seagrass targets established by the Sarasota Bay Estuary Program (SBEP) can be met. Suitable habitats for fishes and other biota can also be expected to be maintained.

Sarasota Bay is currently meeting all critical regulatory standards and resource management targets by which the estuary's water quality is assessed. These include:

- The chlorophyll target established by SBEP.
- The recently established estuarine numeric nutrient criteria (NNC) for both nitrogen and phosphorus.

- The recently proposed revisions to Florida DO standards for estuarine waters.

The period of record for water quality within Sarasota Bay is 1998–2009. The following temporal trends in water quality were detected:

- Significant decreasing trends were observed in the total phosphorus (TP), total suspended solids (TSS), and turbidity concentrations over the period of record.
- No significant trends in chlorophyll *a*, total nitrogen (TN), or water clarity were found over the period of record.

Additionally, no open water portions of the estuary have been deemed impaired under Florida's Impaired Waters Rule (IWR) (Chapter 62-303, FAC). Therefore, despite changes in the anthropogenic influences within its watershed, water quality within Sarasota Bay has been effectively protected by the management programs being implemented by Sarasota County and other stakeholders.

1.3 TRIBUTARY WATER QUALITY

Tributary streams are one of the major links between the estuary and its watershed. These tributaries convey both baseflow and stormwater runoff to the estuary. In the context of the estuarine ecosystem, these tributaries, therefore, influence bay water quality and circulation by delivering nutrients and freshwater to the estuary. Tributaries can be classified as either freshwater or tidal (marine waters with conductivity greater than 1,500 µS/cm). The tidal tributaries provide valuable nursery habitat for the early life stages of numerous fish as well as benthic invertebrates. There are four major tributaries to Sarasota Bay – Whitaker Bayou, Hudson Bayou, Bowlees Creek, and Cedar Hammock Creek (Figure 1-2).

Water quality data are collected at three freshwater stations in Whitaker Bayou. No temporal trends were found in any of the water quality parameters examined (salinity, chlorophyll *a*, TN, TP, or DO) in any of these stations. Despite the lack of trends, the marine segment of Whitaker Bayou has been deemed impaired by the Florida Department of Environmental Protection (FDEP) under the IWR (Chapter 62-303, FAC). Whitaker Bayou waterbody ID (WBID) 1936 impairments include fecal coliform, DO, and historical chlorophyll *a*; the latter two impairments are attributed to elevated nitrogen concentrations.

Figure 1-2 Sarasota Bay Tributaries

Water quality has been monitored at three sites in Hudson Bayou, including two freshwater and one tidal site. A modest increasing temporal trend was observed in TN concentrations at Hudson Bayou Station HB7 (the upstream-most site); a concomitant increase in DO concentrations at Station HB7 was observed over the same sampling period. Similar to WBID 1936 in Whitaker Bayou, impairments due to elevated fecal coliform, low DO, and elevated chlorophyll *a* concentrations have been documented in Hudson Bayou WBID 1953.

No temporal trends in either chlorophyll *a* or TN were evident in Bowlees Creek, but the overall concentrations were higher than in Whitaker Bayou or Hudson Bayou. TP concentrations were similar among all three tributaries. Despite high nutrients and chlorophyll *a*, Bowlees Creek generally maintained DO concentrations between 4 and 8 mg/L, but DO concentrations have been generally lower since 2007.

Water quality impairments have been documented by FDEP in other waterbodies within the Sarasota Bay watershed, including West Cedar Hammock WBID 1885 and Longboat Key WBID 1916, which have both been deemed impaired due to low DO conditions attributed to either high levels of TN or biochemical oxygen demand (BOD).

TN and TP concentrations for 2006–2010 from the three freshwater sampling sites in Whitaker Bayou and two freshwater sites in Hudson Bayou were compared to the FDEP NNC for the West Central Nutrient Watershed Region. Concentrations in both tributaries were well below the TN freshwater standard of 1.65 mg/L in all years. Whitaker Bayou was also well under the TP standard of 0.49 mg/L. Hudson Bayou had TP concentrations higher than 0.49 mg/L in 1 year; however, to not meet the standard the concentration must be exceeded in any 2 years within a consecutive 3-year period. Thus, both tributaries met the NNC.

DO levels for 2006–2011 in freshwater and tidal segments of Whitaker Bayou and Hudson Bayou were also compared to FDEP's recently proposed revised DO standards. Whitaker Bayou freshwater and marine segments both met the standards in all years. The Hudson Bayou freshwater segment did not meet the proposed standard in any year, and the marine segment did not meet the standard in 2006–2009.

1.4 CURRENT AND FUTURE POLLUTANT LOADINGS

Water quality problems in either the estuary or tributary coastal streams are frequently a function of pollutant inputs, or loadings, from the watershed. Thus, the source, location, and timing of these loadings must be identified to better manage resources in the streams and the estuary. The objective of the current and future pollutant loading analysis was to present the approach, data used, and summary of results associated with examining the current and future nutrient and suspended solids loads for the Sarasota Bay watershed.

The loading sources were estimated using the Sarasota Bay SIMPLE model developed by Jones Edmunds & Associates for Sarasota County and supported by SBEP. The sources include:

- Atmospheric deposition.
- Direct runoff (stormwater runoff).
- Baseflow (shallow groundwater).
- Irrigation.
- Septic tanks.
- Point sources.

Current loadings were estimated for 1989–2008 by subbasin (Figure 1-3). Future loadings were estimated by applying the same precipitation record as used for the current estimates to a future land use setting based on expected land use changes.

Significant results and conclusions from these estimates include:

- Current Loading Estimates:
  - The variability in total hydrologic load (freshwater inputs) to the bay is mainly a function of precipitation, which drives atmospheric deposition, stormwater runoff, and to a degree baseflow.
  - Similar to the pattern in annual precipitation, a slightly decreasing trend in TN load to the bay was observed over 1989–2008.
  - Because loading is largely driven by precipitation, that all loads are higher during the wet summer months is not surprising.
  - Atmospheric deposition (precipitation to the bay surface) is the major source of freshwater to the bay, accounting for over half of all freshwater inputs over the period of record for current and future conditions. This result is not surprising given that the area of the Sarasota Bay watershed is relatively small in relation to the area of the bay itself.
  - Direct runoff accounted for over half of TN loadings to the bay from 1989 through 2008. Atmospheric deposition contributed approximately 30% and baseflow (shallow groundwater) contributed approximately 15–17% of the TN load during that period.
  - Direct runoff is responsible for just over half of all TP loadings to the bay, and baseflow contributes another 27–29%.
  - Almost 90% of TSS loads to the bay originate from direct runoff.
  - Other sources (point sources, septic tanks, and irrigation) collectively account for less than 20% of any current loading estimate.
  - Eleven basins are within the Sarasota Bay watershed. Unit area loadings (UAL) were estimated by dividing the annual watershed loading (i.e., direct runoff + baseflow) by the area of a basin to allow comparison of the watershed loadings from basins with widely varying areas. The largest TN and TP UALs were found for the Cedar Hammock Creek, Whitaker Bayou, and Hudson Bayou basins.

Figure 1-3 Sarasota Bay Subbasins

- Future Loading Estimates:
  - The estimated increase in loadings from the current to the future conditions can be mainly attributed to land use change because the same precipitation was used for current and future loadings.

1.5 SALINITY-FLOW RELATIONSHIPS

Another critical element of the linkage between an estuary and its watershed is the timing and magnitude of freshwater delivery to the estuary. Freshwater inputs are an important determinant of the eventual spatial and temporal patterns of estuarine circulation and salinity. Salinity influences habitat suitability, as estuarine biota display a wide range of preferences and tolerances for inherently variable salinity regimes. Salinity also affects circulation in the bay. Water density increases with increasing salt content, which can result in vertical stratification of the water column and affect the degree to which reaeration of bottom waters occurs. Estuarine circulation also influences responses of the estuary to pollutant loadings by determining estuarine residence times.

Freshwater inputs to Sarasota Bay for current and historical conditions were estimated using the Sarasota Bay SIMPLE model. The relationship between freshwater inputs and ambient salinity within Sarasota Bay was examined by plotting the mean monthly estuarine salinity against the current month's inputs and a series of cumulative freshwater inputs. As expected, the relationship between salinity and freshwater inputs is inverse, i.e., salinity in the bay decreases as freshwater inputs from the watershed increase. Salinity displayed the strongest relationship with the 3-month cumulative freshwater inputs.

Questions have arisen as to whether changes in the freshwater inputs from historical levels have significantly altered the salinity regime in Sarasota Bay. The historical and current freshwater flow regimes are similar at the inputs less than the 30th percentile, i.e., at the lower flows. The greatest differences between the historical and current inflows are found at the higher flows. Since these higher flows most commonly occur during the summer months, current estuarine salinities are likely lower than those during the summer months in the historical period. However, these differences are relatively small and do not significantly affect Sarasota Bay.

1.6 WATER QUALITY LEVELS OF SERVICE (LOS)

Effective management of water quality in Sarasota Bay and its tributaries can be achieved by clearly understanding how these waters respond to changes in water quality. This knowledge allows water quality levels of service (LOS) to be established. Levels of service can be preventative and *elicit* management responses when exceeded, or regulatory that *require* specific management actions. Both types of water quality LOS have been recommended for Sarasota Bay and its tributaries.

2.0 ESTUARINE WATER QUALITY STATUS AND TRENDS

2.1 OBJECTIVE

This section presents the approach, data used, and summary of results associated with examining the water quality status and trends in the Sarasota Bay estuary.

2.2 APPROACH

Ambient water quality data were examined to identify any significant temporal or spatial trends in Sarasota Bay. Seasonal Kendall Tau trend tests were used to identify significant temporal trends. Spatial trends were examined using graphical plotting techniques.

2.3 DATA USED

- Ambient water quality data provided by Sarasota and Manatee Counties.
- SBEP water quality targets and NNC.

2.4 RESULTS

2.4.1 Temporal Variation – Monthly

Figures 2-1 through 2-7 plot the mean monthly water quality data. Mean monthly salinity for Sarasota Bay as a whole for 1998 through 2010 ranged from approximately 30 parts per thousand (ppt) to over 40 ppt (Figure 2-1). Salinity, like several other parameters in an estuary including nutrients and chlorophyll *a*, are influenced by the magnitude of freshwater inputs. Higher freshwater inputs result in higher pollutant loading to the estuary. Also, estuarine circulation and residence times are affected by freshwater inputs.

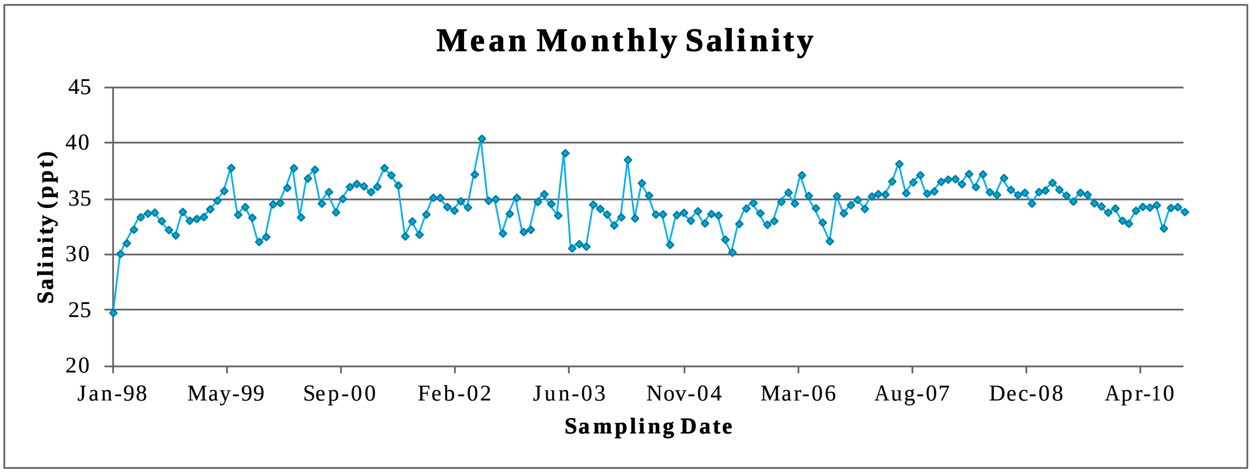


Figure 2-1 Mean Monthly Salinity in Sarasota Bay

[Figure 2-2](#) presents mean monthly chlorophyll *a* concentrations for Sarasota Bay for 1998 through 2010. Values exceeding 10 µg/L occurred during 10 months, reaching a maximum of close to 16 µg/L in summer 2001. No significant trend in the monthly chlorophyll *a* concentrations occurred over the period of record.

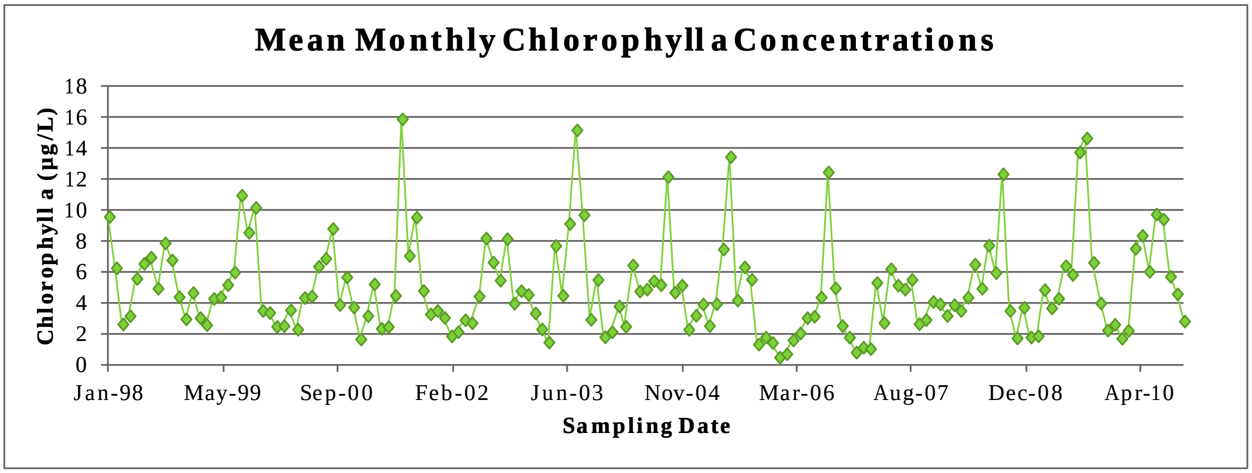


Figure 2-2 Mean Monthly Chlorophyll *a* Concentrations in Sarasota Bay

Figure 2-3 shows Sarasota Bay mean monthly TN concentrations for the same period. The great majority of TN concentrations fall between 0.2 and 0.5 mg/L. Only four monthly values exceeded 0.6 mg/L, with the maximum exceeding 1.0 mg/L in 2004. No significant trend in the monthly TN concentrations occurred over the period of record.

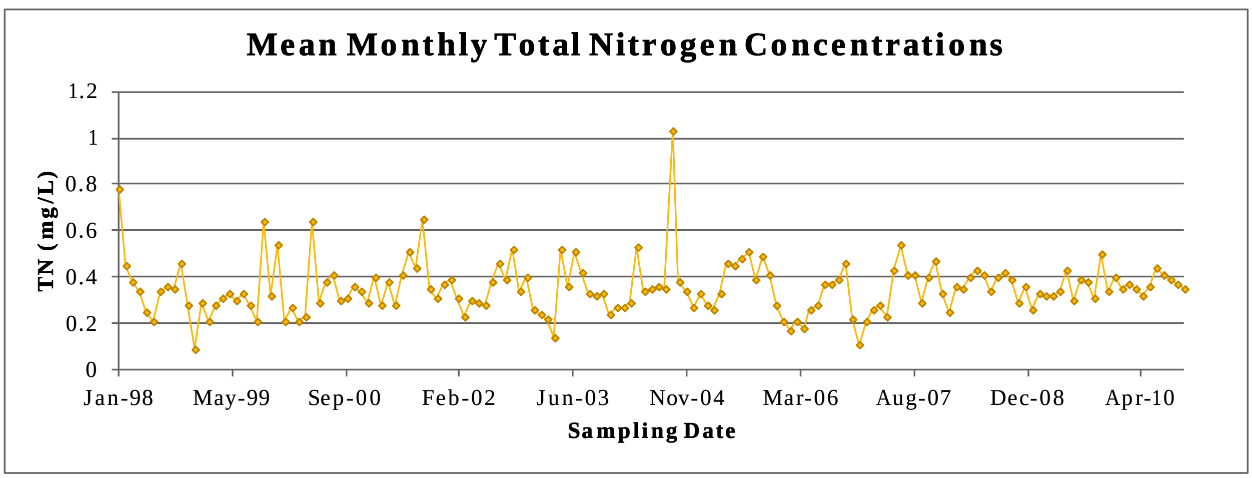


Figure 2-3 Mean Monthly TN Concentrations in Sarasota Bay

Figure 2-4 shows TP values for Sarasota Bay. The monthly concentrations were less variable than TN, with most values between 0.08 and 0.18 mg/L. Six monthly values exceeded 0.25 mg/L, and only one exceeded 0.3 mg/L. A maximum monthly value of over 0.8 mg/L occurred in summer 2002. A significant decreasing trend in the monthly TP concentrations occurred over the period of record.

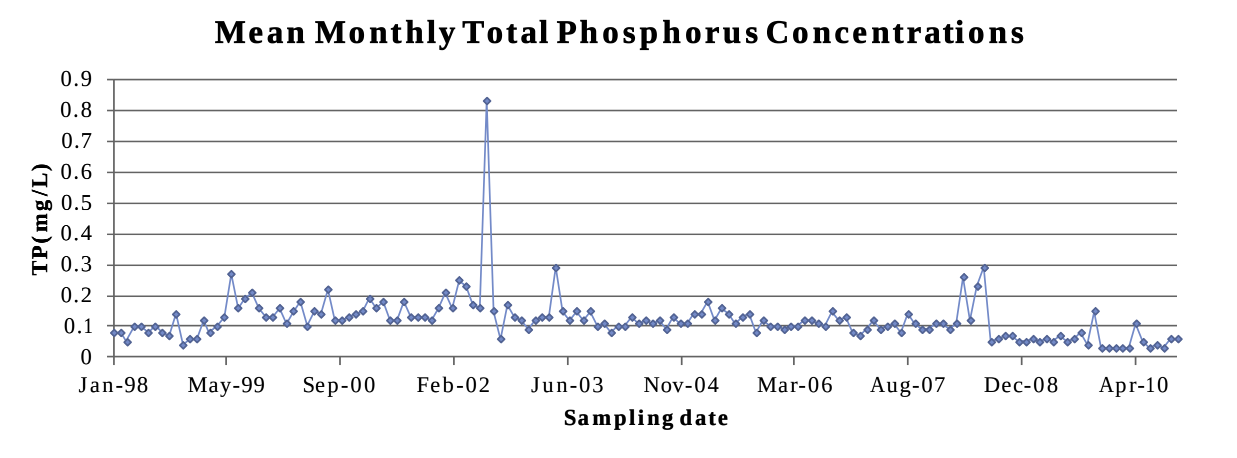


Figure 2-4 Mean Monthly TP Concentrations in Sarasota Bay

Figure 2-5 presents monthly TSS values for Sarasota Bay. These data reflect a reduction in the temporal variation in TSS over the period of record, particularly after 2003. TSS concentrations have varied less since the occurrence of the highest concentration (0.69 mg/L) in 2006. In general, TSS concentrations varied between 7 and 25 mg/L. A significant decreasing trend in the monthly TSS concentrations occurred over the period of record.

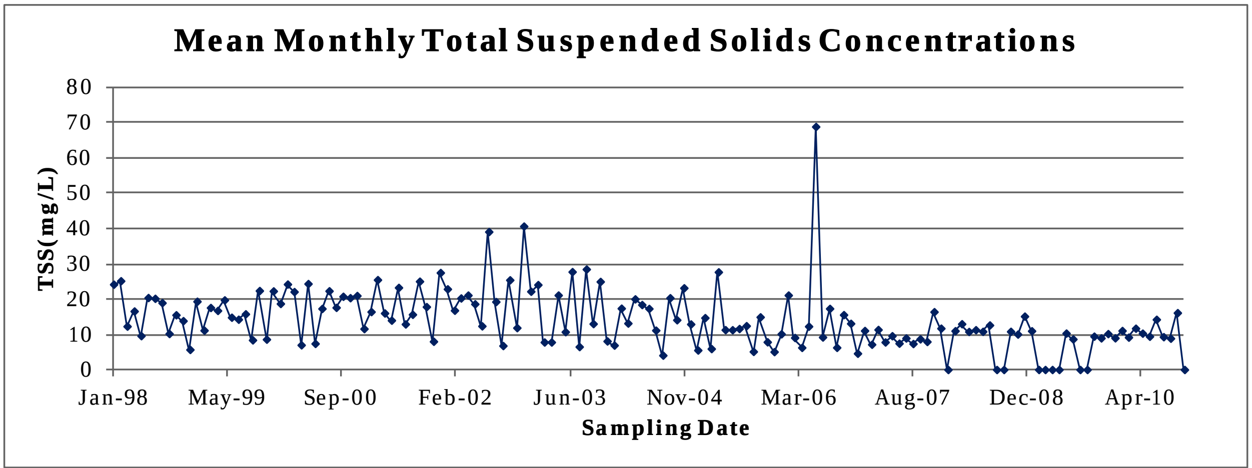


Figure 2-5 Mean Monthly TSS Concentrations in Sarasota Bay

Figure 2-6 shows turbidity concentrations in Sarasota Bay. The majority of monthly means were less than 5 NTU. Values occasionally spiked above 6 NTU and reached a maximum of approximately 13 NTU in 2001. Similar to TP and TSS, a significant decreasing trend in monthly turbidity concentrations occurred over the period of record.

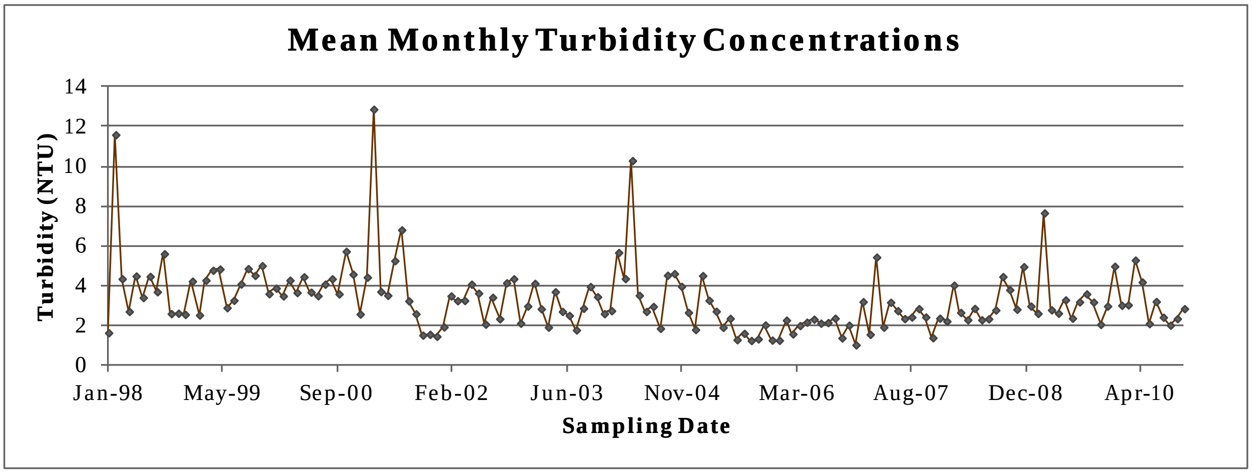


Figure 2-6 Mean Monthly Turbidity Concentrations in Sarasota Bay

Figure 2-7 presents light attenuation coefficient (K_d) values for Sarasota Bay. K_d is a measure of light attenuation in a water column. Higher K_d values indicate greater light attenuation, i.e., less light reaches the bottom waters. K_d values varied between 0.33 to over 1.4 as measured in 1/meter, or m^{-1}. No statistically significant trend in K_d values occurred.

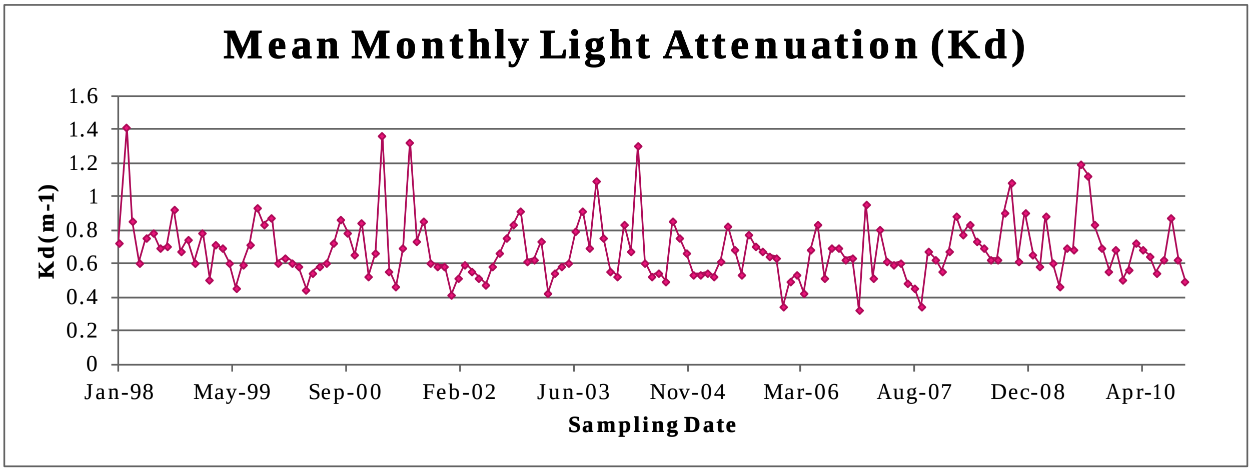


Figure 2-7 Mean Monthly K_d in Sarasota Bay

Figures 2-8 through 2-14 present within-year variation in the various water quality parameters in Sarasota Bay. The box-and-whisker plots present the variation within each calendar month and across calendar months from 1998 through 2009. The line in the middle of the box is the mean, and the top and bottom edges of the box represent the 75th and 25th percentiles of monthly values, respectively. The whisker top and bottom are the 95th and 5th percentiles, respectively. The crosses represent extreme single measurements.

Figure 2-8 shows within-year variation in salinity for Sarasota Bay. Clearly, low salinity values (33–34 ppt) generally occurred during the wet summer months (June–September) and higher salinities (35–36+ ppt) during the dry season when freshwater inputs are lowest.

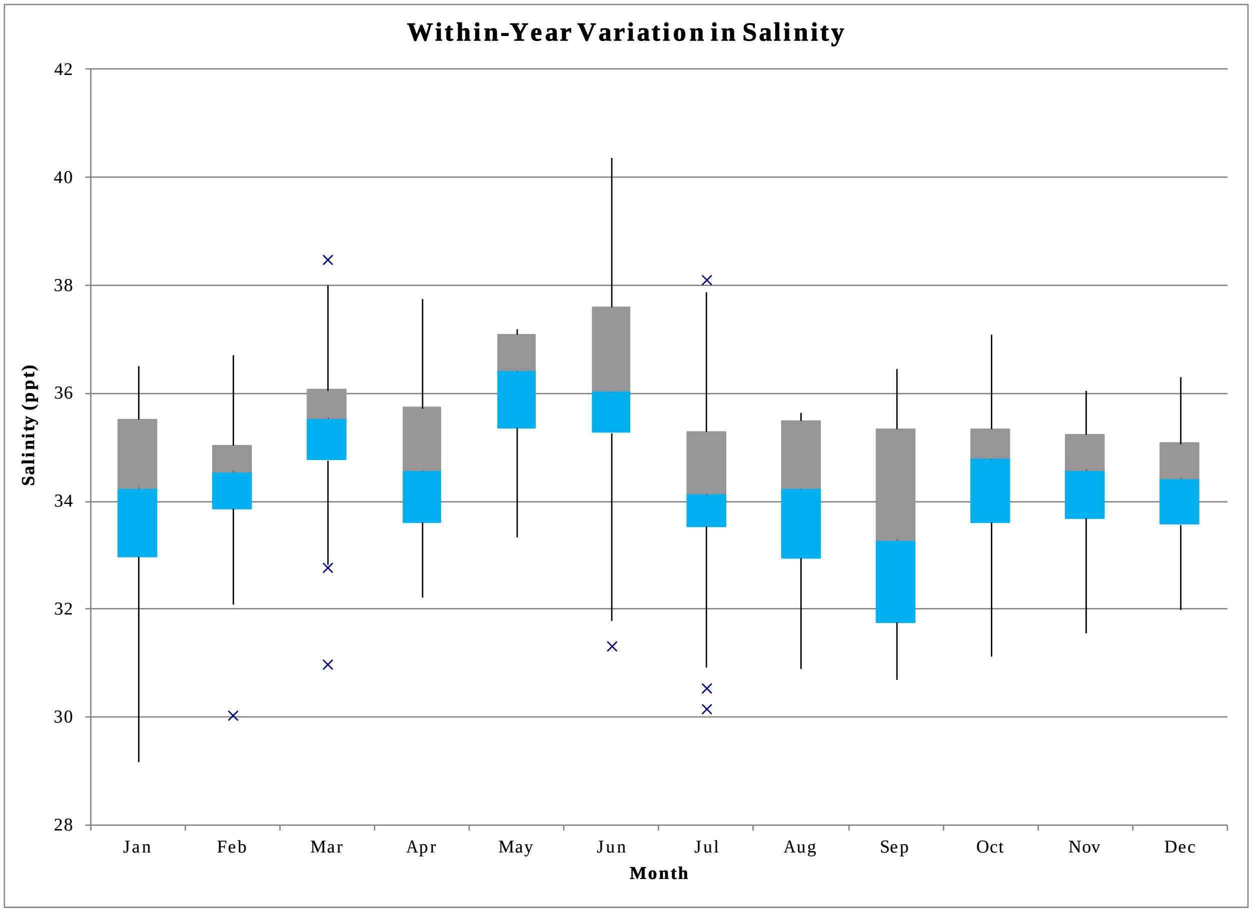


Figure 2-8 Within-Year Variation in Salinity in Sarasota Bay

Figures 2-9 shows within-year variation in chlorophyll *a* for Sarasota Bay. Higher mean chlorophyll *a* concentrations (to over 8 µg/L) occurred July through October when water temperatures, solar illumination, and nutrient loading are high. Dry season mean values remain between 2 and 4 µg/L. The variation within a calendar month was also greater during the summer months.

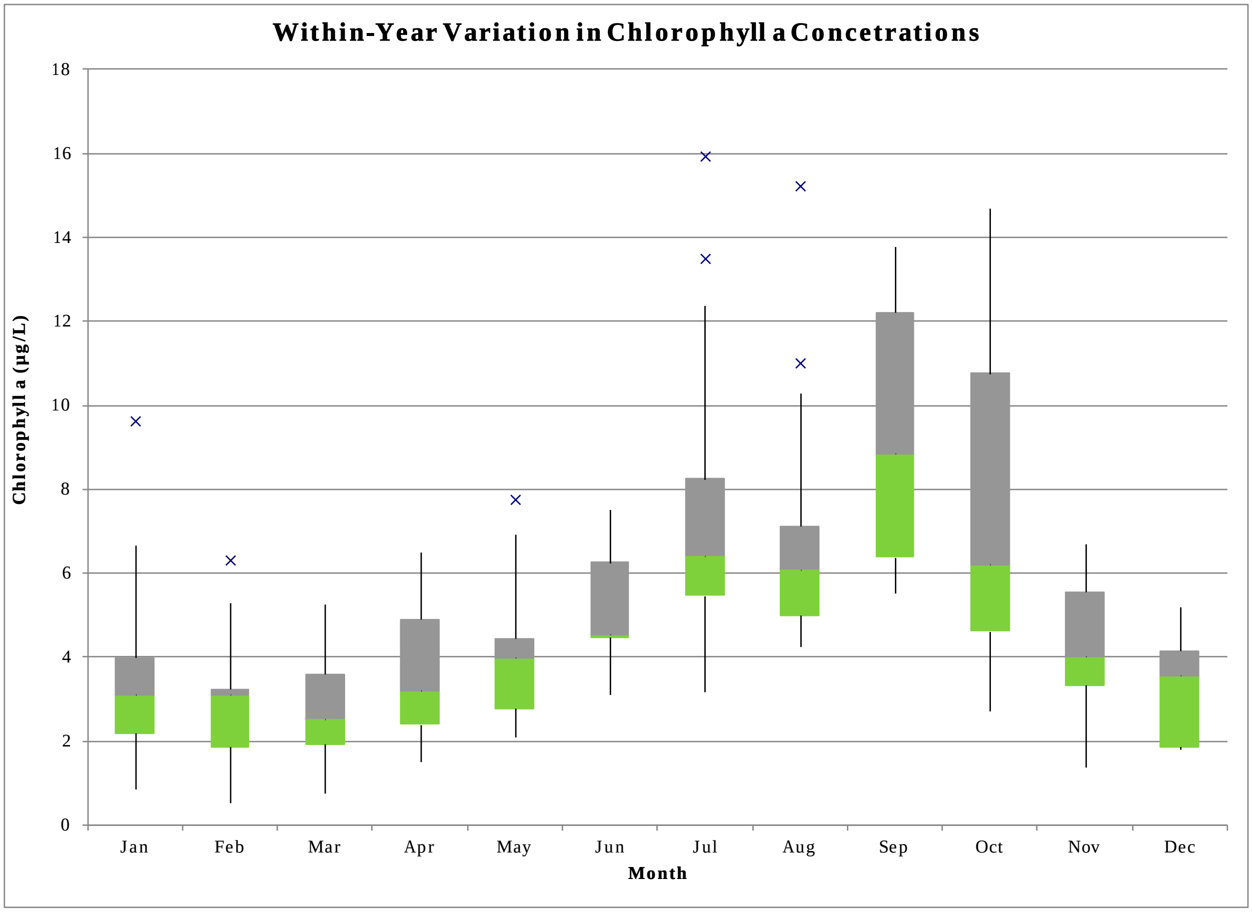


Figure 2-9 Within-Year Variation in Chlorophyll *a* Concentrations in Sarasota Bay

Figure 2-10 shows the within-year variation in TN concentrations for Sarasota Bay. Generally, little variation in TN concentrations was observed across months. Somewhat higher concentrations, above 0.35 mg/L, were observed during the summer months, with dry season concentrations typically between 0.25 and 0.35 mg/L.

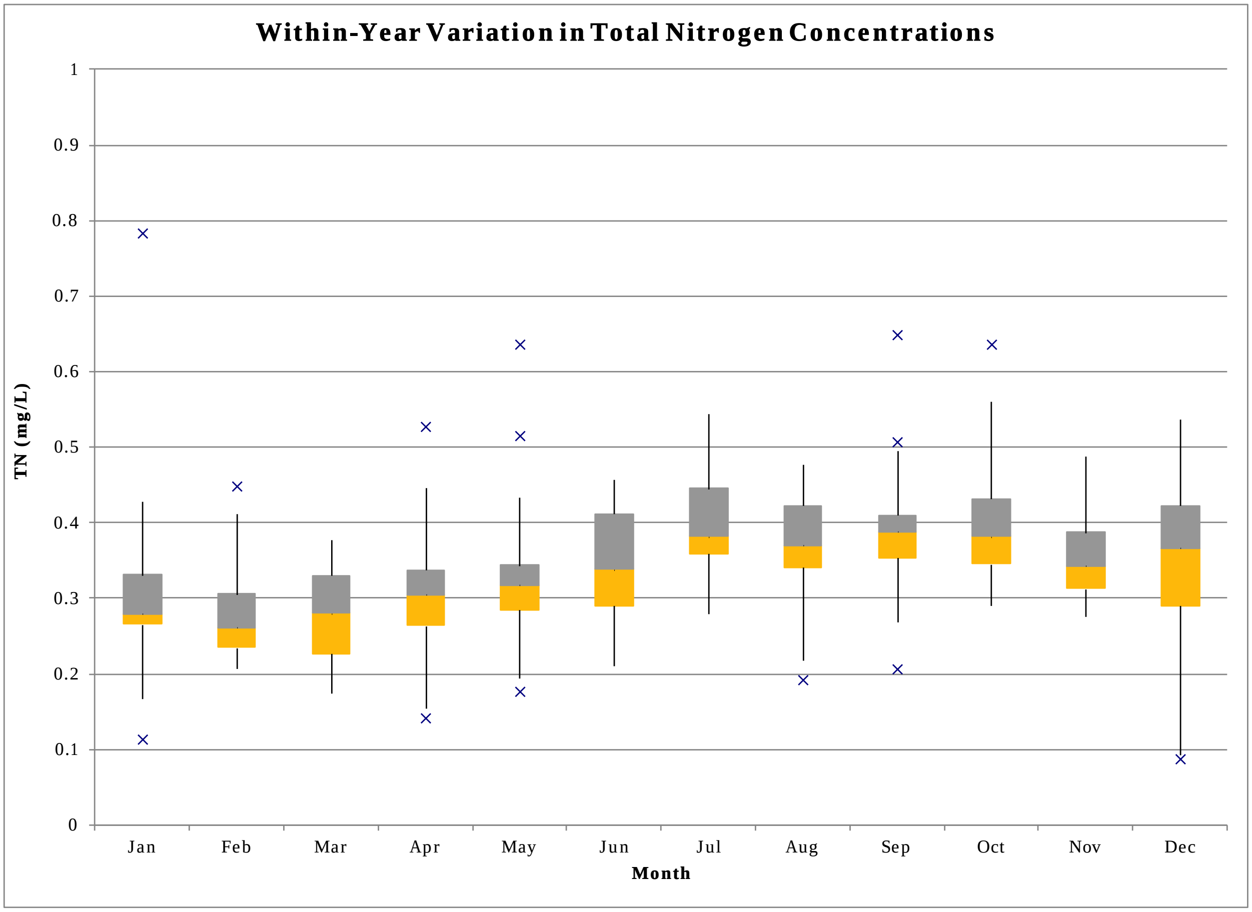


Figure 2-10 Within-Year Variation in TN Concentrations in Sarasota Bay

Figure 2-11 shows the within-year variation in TP concentrations for Sarasota Bay. Similar to the TN concentrations, little variation in TP concentrations was observed across all months.

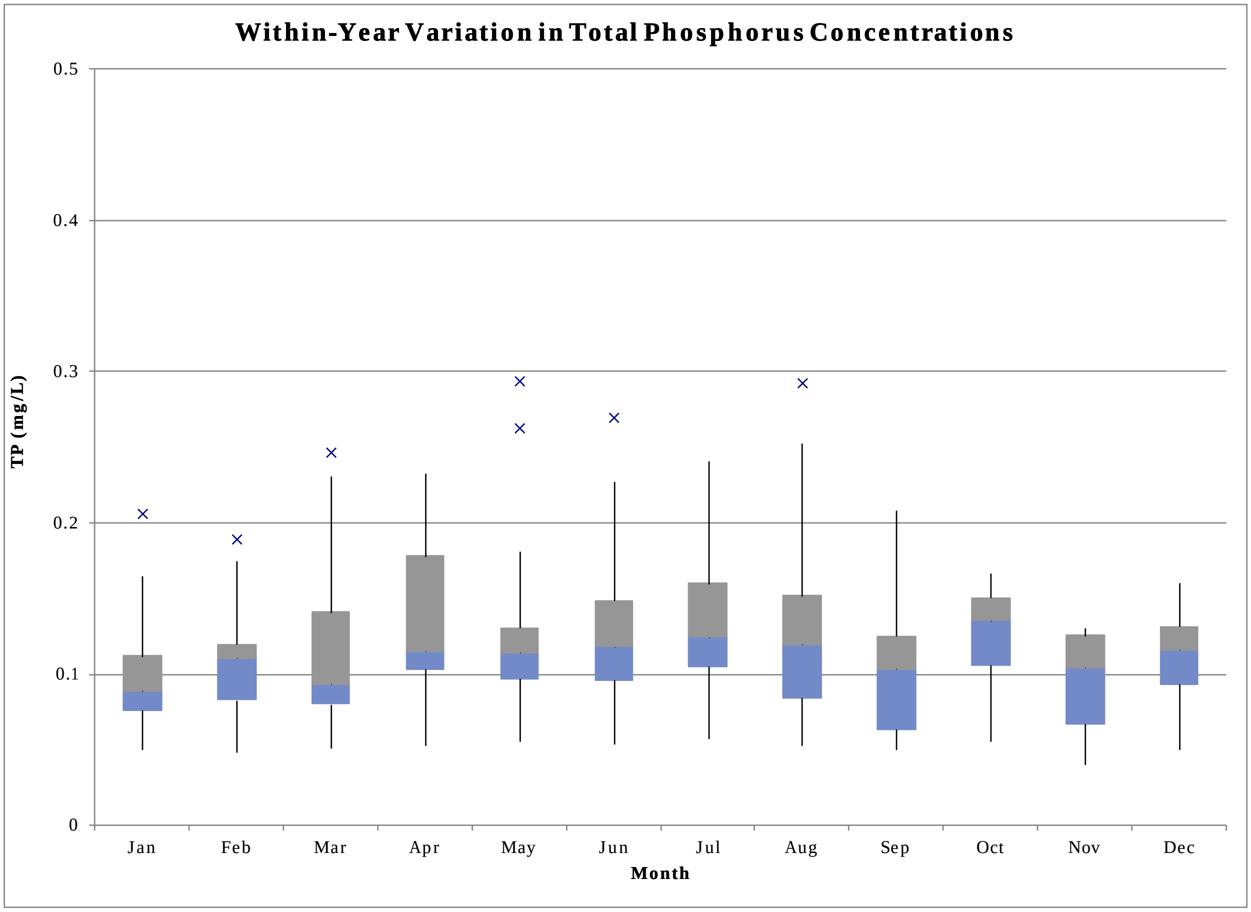


Figure 2-11 Within-Year Variation in TP Concentrations in Sarasota Bay

Figure 2-12 presents the within-year variation in TSS concentrations for Sarasota Bay. Again, little variation in TSS concentrations was observed across all months. The greatest within-month variation was observed during July.

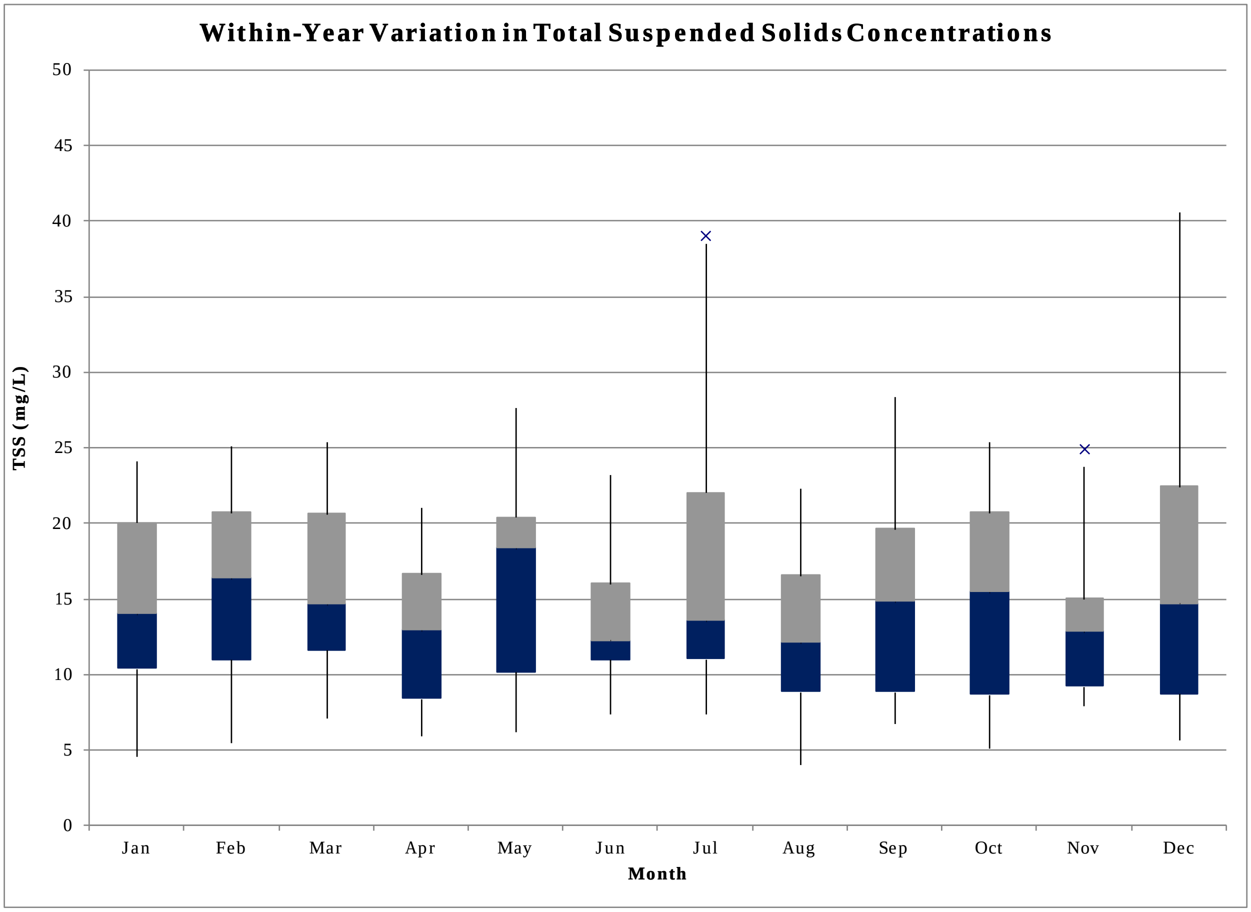


Figure 2-12 Within-Year Variation in TSS Concentrations in Sarasota Bay

Figure 2-13 presents the within-year variation in turbidity for Sarasota Bay. Similar to TN, TP, and TSS concentrations, little within-year variation in the turbidity was observed in Sarasota Bay. The within-month variation in turbidity was greatest from January through April.

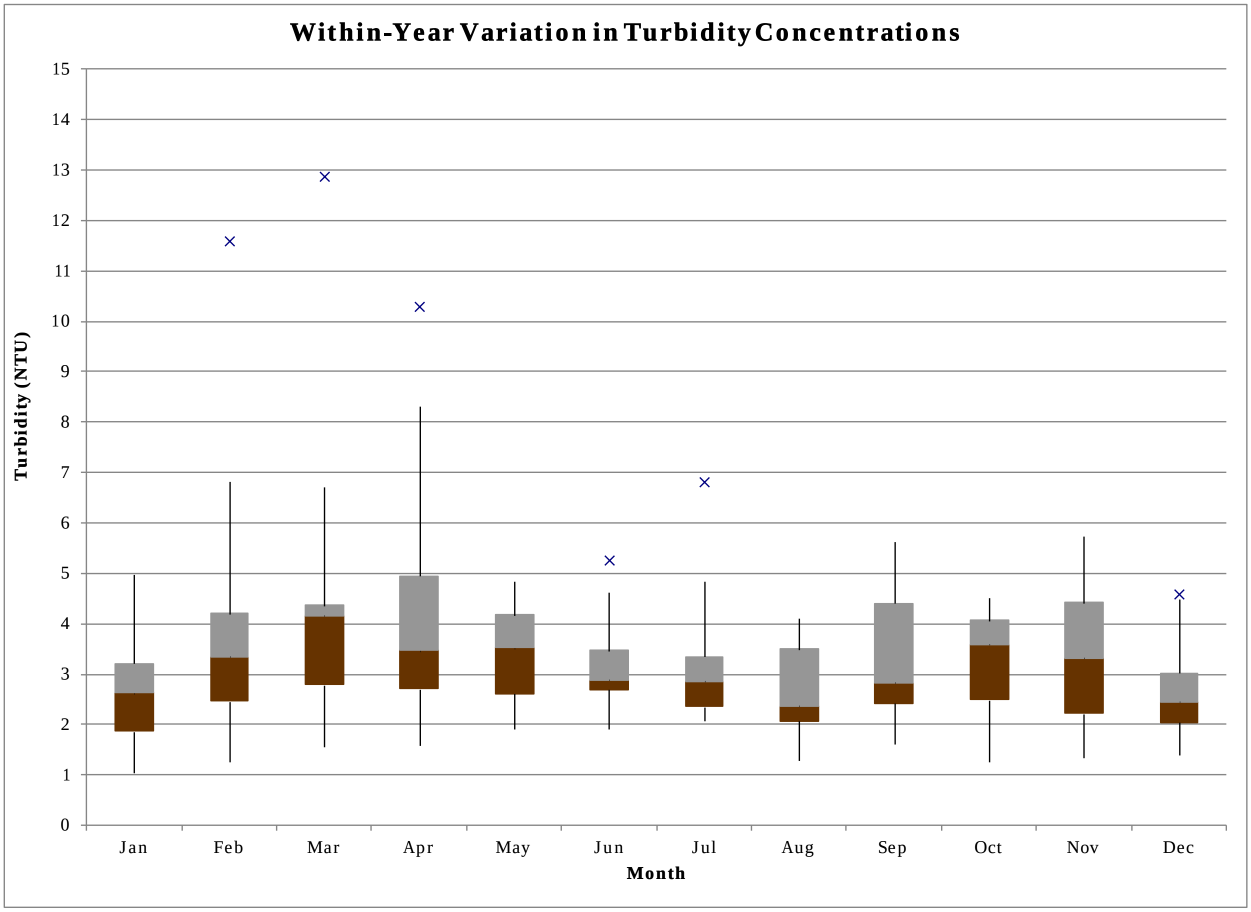


Figure 2-13 Within-Year Variation in Turbidity Concentrations in Sarasota Bay

Figure 2-14 presents the intra-annual variation in Kd. Relatively little variation in light attenuation was observed across months. The greatest light attenuation was observed during September through November. Within-month variation was generally greater during April, September, and October.

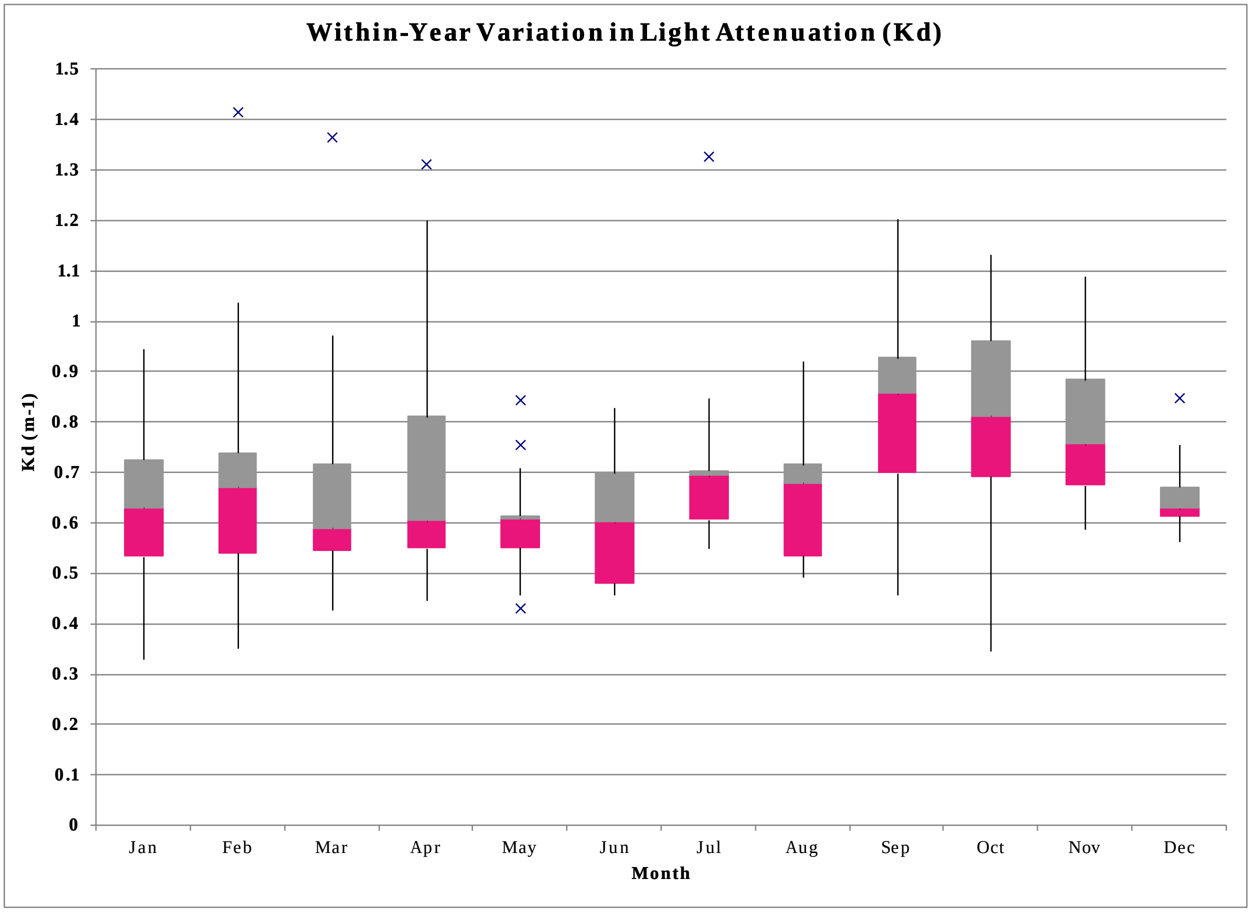


Figure 2-14 Within-Year Variation in Light Attenuation in Sarasota Bay

2.4.2 Trend Analyses

The results of the trend analyses are as follows:

- ❖ Salinity—no significant trend.
- ❖ Chlorophyll *a*—no significant trend.
- ❖ TN—no significant trend.
- ❖ TP—significant decreasing trend.
- ❖ TSS—significant decreasing trend.
- ❖ Turbidity—significant decreasing trend.
- ❖ Light attenuation (K*d*)—no significant trend.

2.4.3 Spatial Variation

Figure 2-15 is a map of the four water quality strata within Sarasota Bay. The strata are based on a bay segmentation scheme developed for SBEP (Estevez and Palmer, 1990) to enhance the analysis of surface water quality data collected by Sarasota County and others. Stratum MC contains the north portion of Sarasota Bay and is bounded to the south by the Sarasota County-Manatee County boundary. Given its location, the MC stratum can be influenced by flows from the Manatee River. Stratum SCUS is the upper stratum within Sarasota County and includes areas distant from Big Pass and New Pass that facilitate tidal interactions with the Gulf of Mexico. SC10 and SC11 are in lower Sarasota Bay adjacent to Roberts Bay North and potentially affected by Philippi Creek.

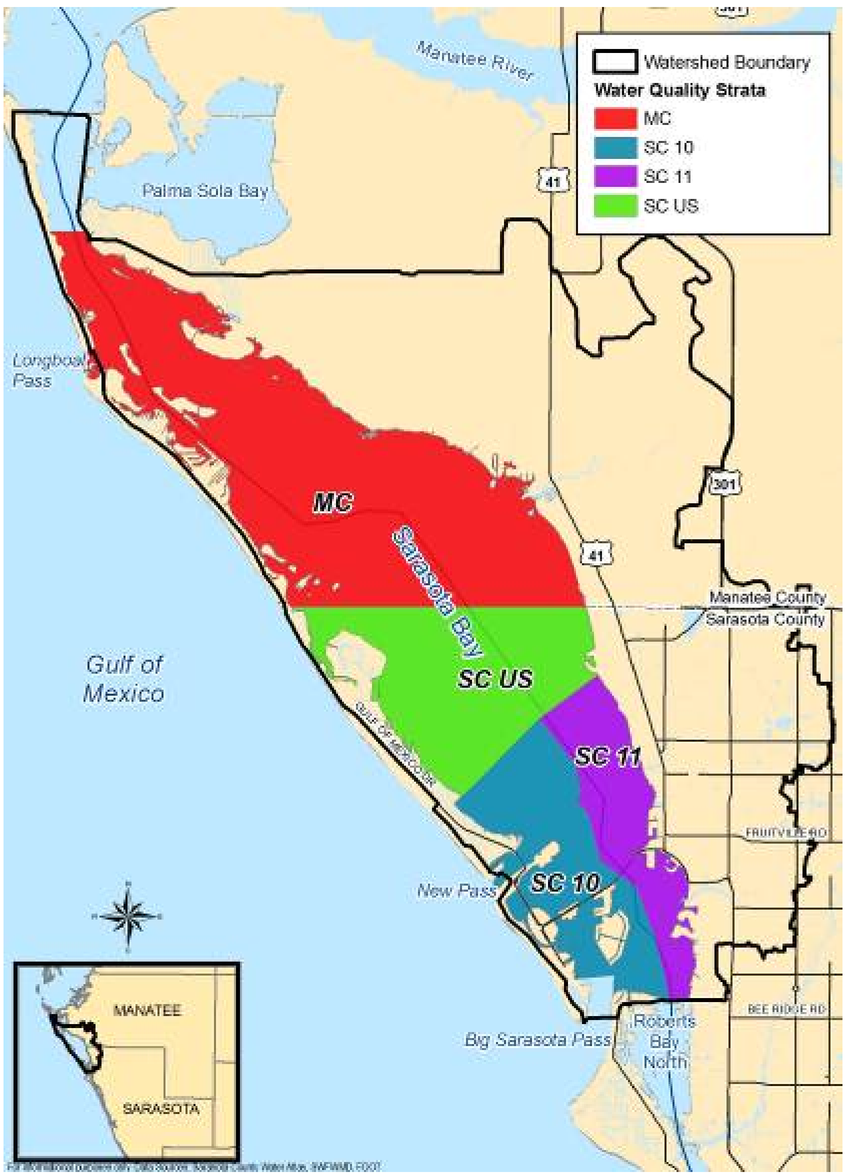


Figure 2-15 Four Water Quality Strata within the Sarasota Bay Estuary

Figures 2-16 through 2-22 present the distributions of water quality data observed in each of the four water quality strata. These plots allow examination of the variation across strata. Also, the within-stratum variation displayed reflects the temporal variation over the period of record within each stratum.

Figure 2-16 shows the within-stratum variation in monthly salinities across the four Sarasota Bay strata. Salinities were typically lower and displayed the greatest within-stratum variation in Stratum MC, likely reflecting the influence of flows from the Manatee River. Salinities were generally similar among the SC10, SC11, and SCUS strata, including the within-stratum variation.

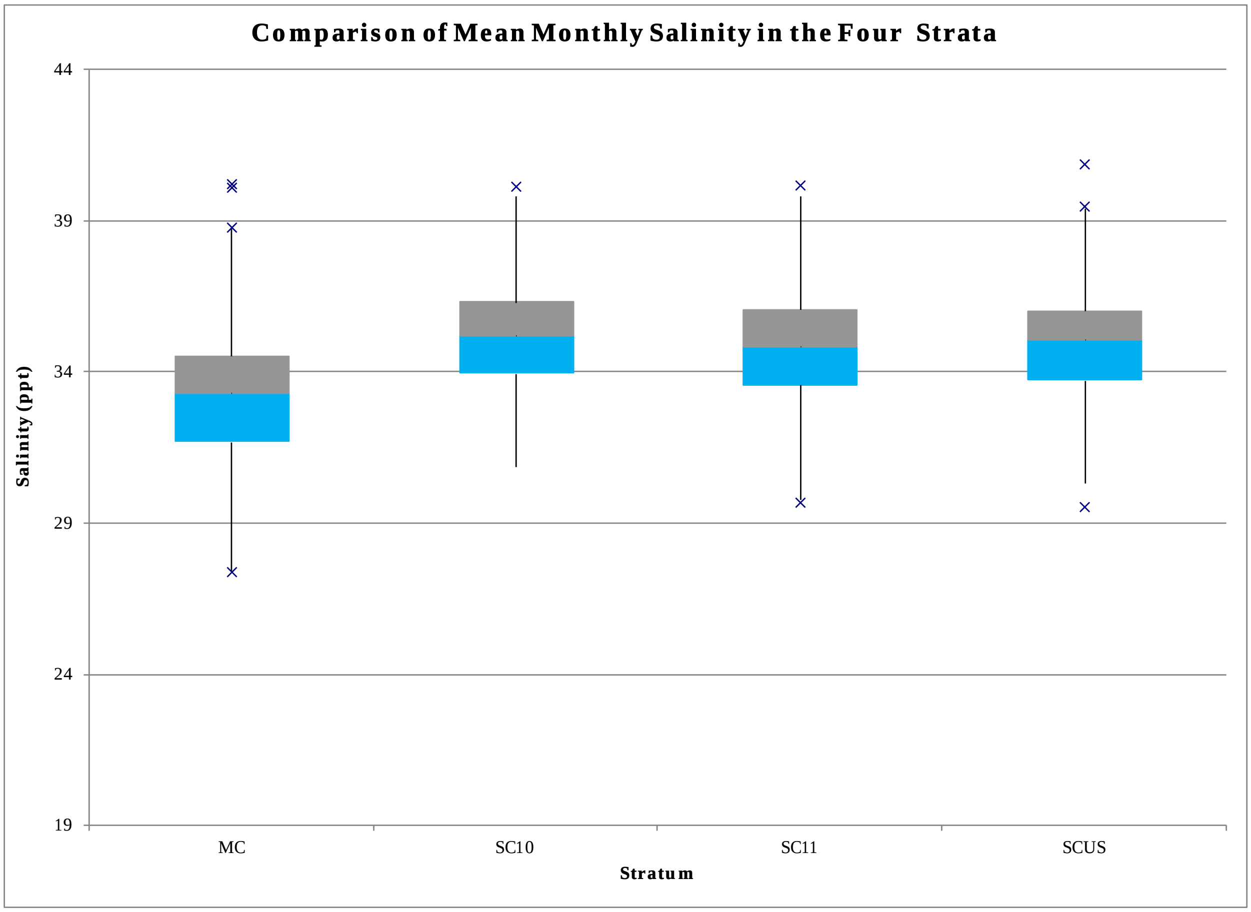


Figure 2-16 Comparison of Mean Monthly Salinity in the Four Strata of Sarasota Bay

[Figure 2-17](#) shows the within-stratum variation in monthly chlorophyll *a* concentrations across the four Sarasota Bay strata. These data indicate relatively little variation in the chlorophyll *a* concentrations in Sarasota Bay. The chlorophyll *a* concentrations in SC10 tend to be somewhat lower and may reflect the influence of the circulation of Gulf of Mexico waters through New Pass.

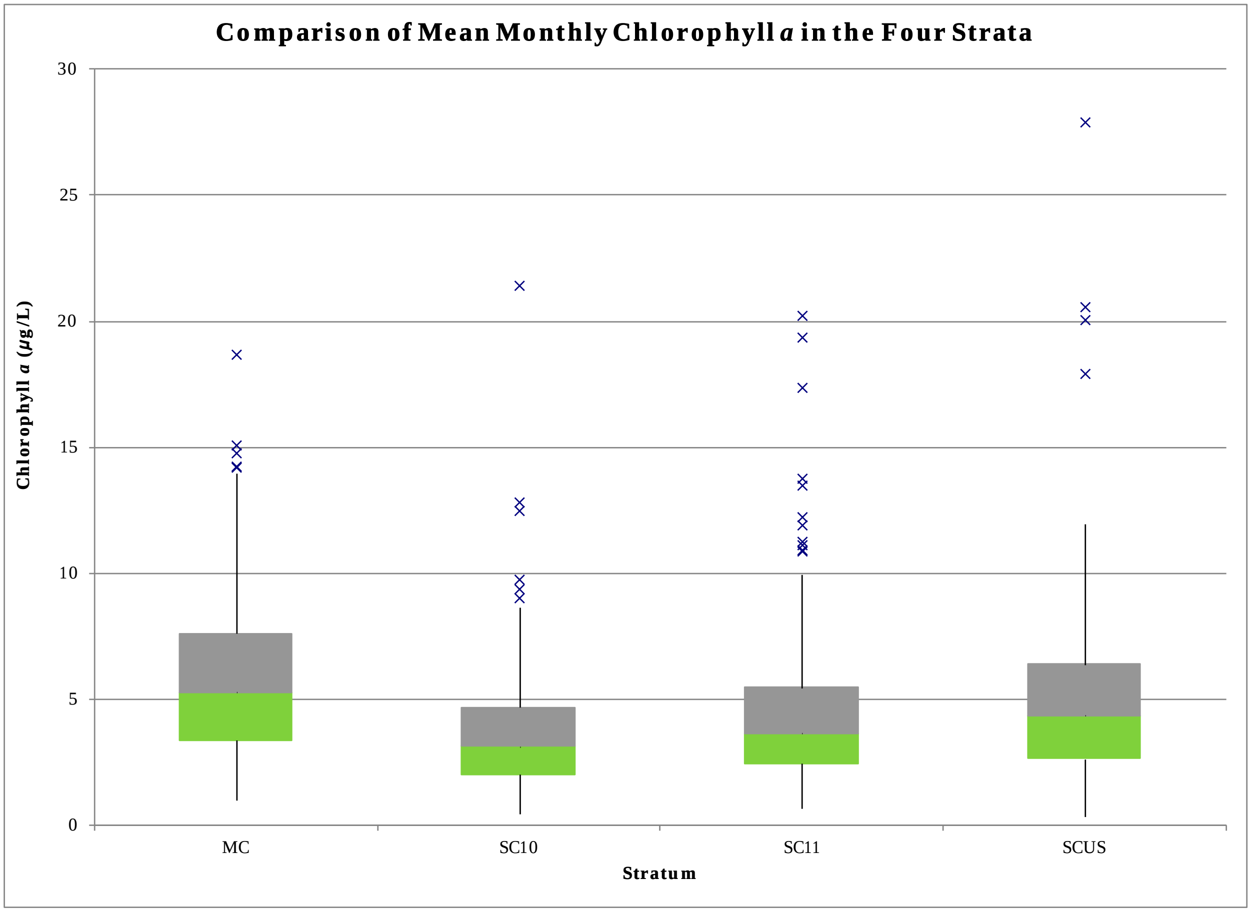


Figure 2-17 Comparison of Mean Monthly Chlorophyll *a* in the Four Strata of Sarasota Bay

Figure 2-18 illustrates the within-stratum variation in monthly TN concentrations across the four Sarasota Bay strata. The TN concentrations were clearly highest in Stratum MC with a mean value of approximately 0.6 mg/L. The within-stratum variation in TN concentrations was also much greater in Stratum MC. The TN concentrations were similar within the SCUS, SC10, and SC11 strata where the mean TN concentrations were approximately 0.3 mg/L.

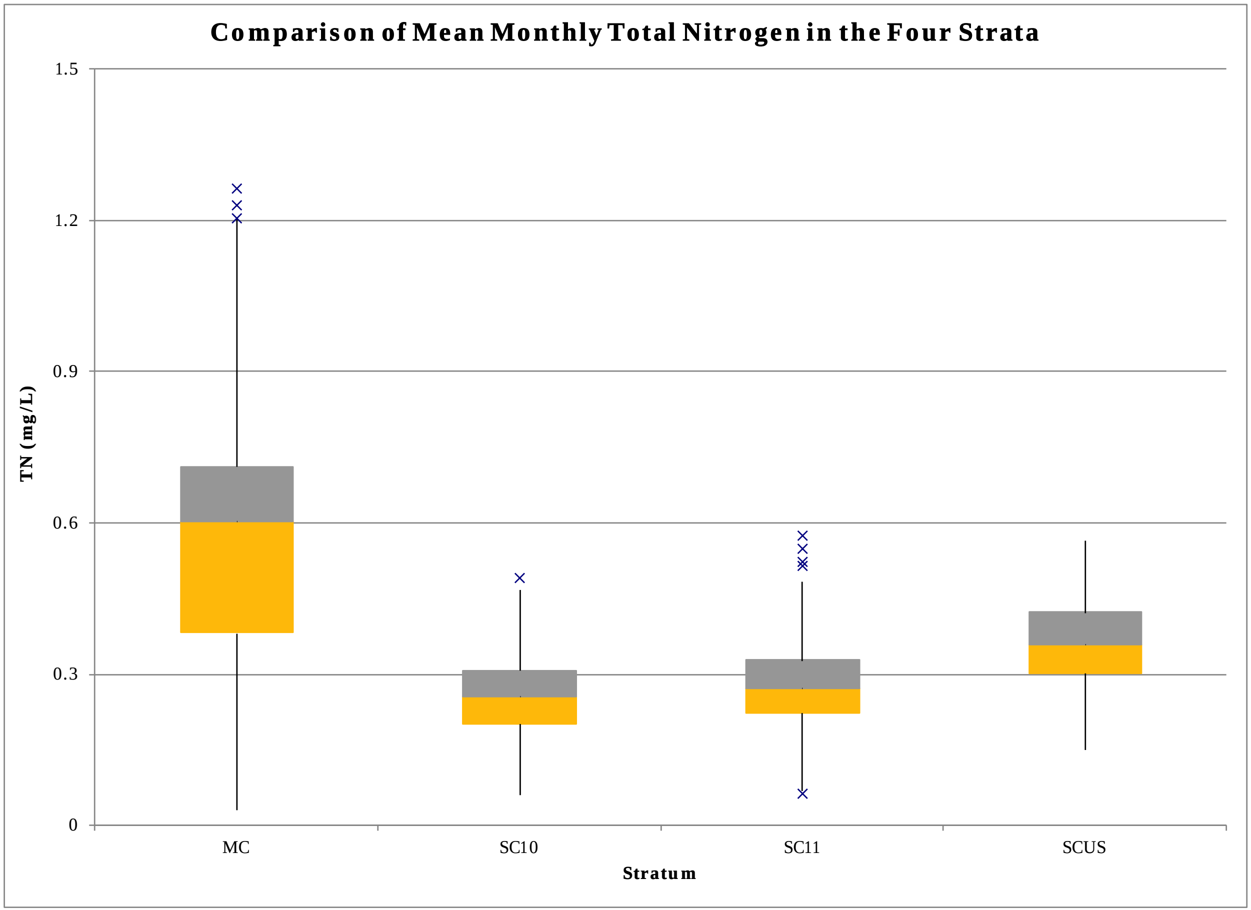


Figure 2-18 Comparison of Mean Monthly TN in the Four Strata of Sarasota Bay

Figure 2-19 shows a very different pattern for TP concentrations across the four Sarasota Bay strata. The TP concentrations were relatively similar across all strata, and the most apparent difference was observed in Stratum MC where the within-stratum variation was greatest.

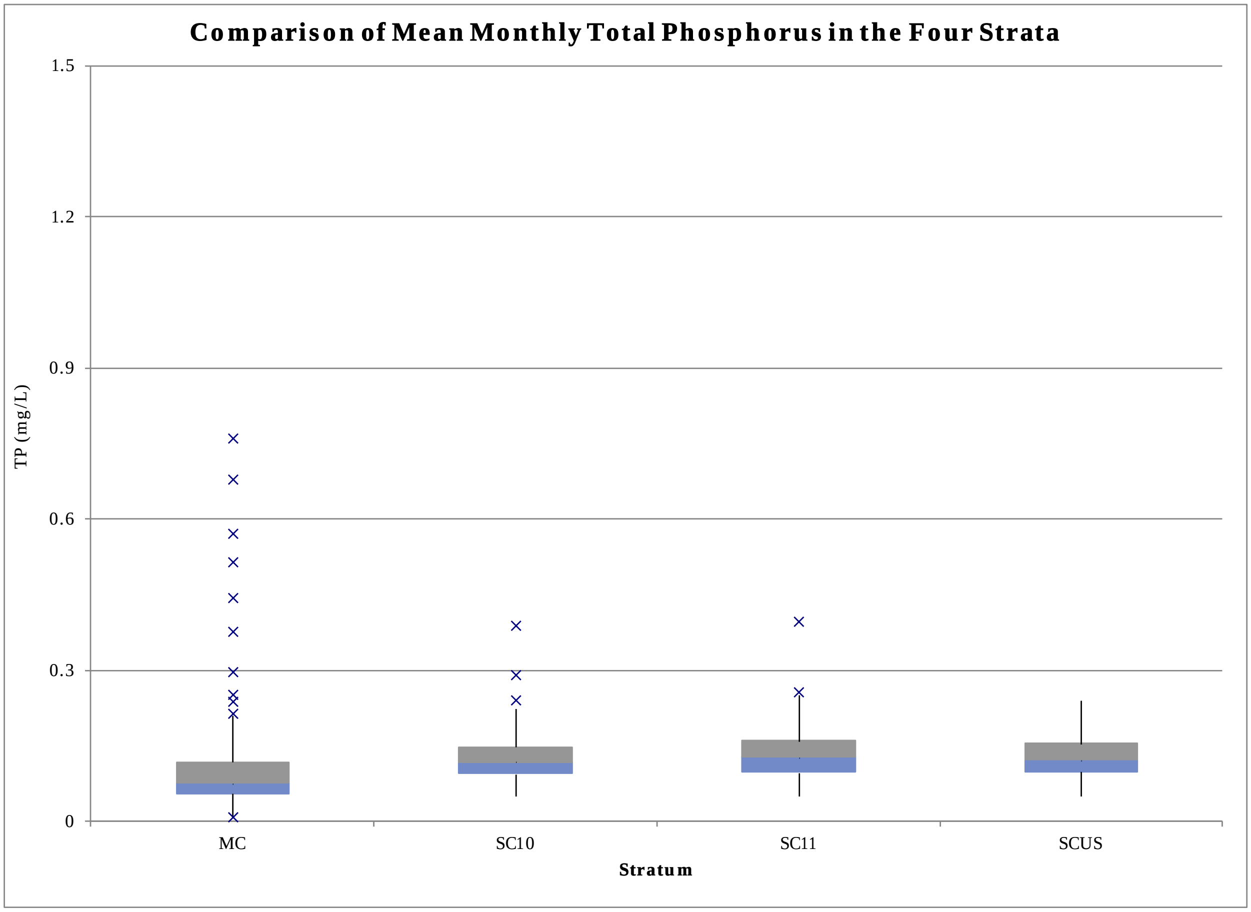


Figure 2-19 Comparison of Mean Monthly TP in the Four Strata of Sarasota Bay

Figure 2-20 presents the within-stratum variation in TSS concentrations across the four strata. A pattern similar to that observed for TP concentrations is apparent. The TSS concentrations in Stratum MC were clearly greatest, including the within-stratum variation.

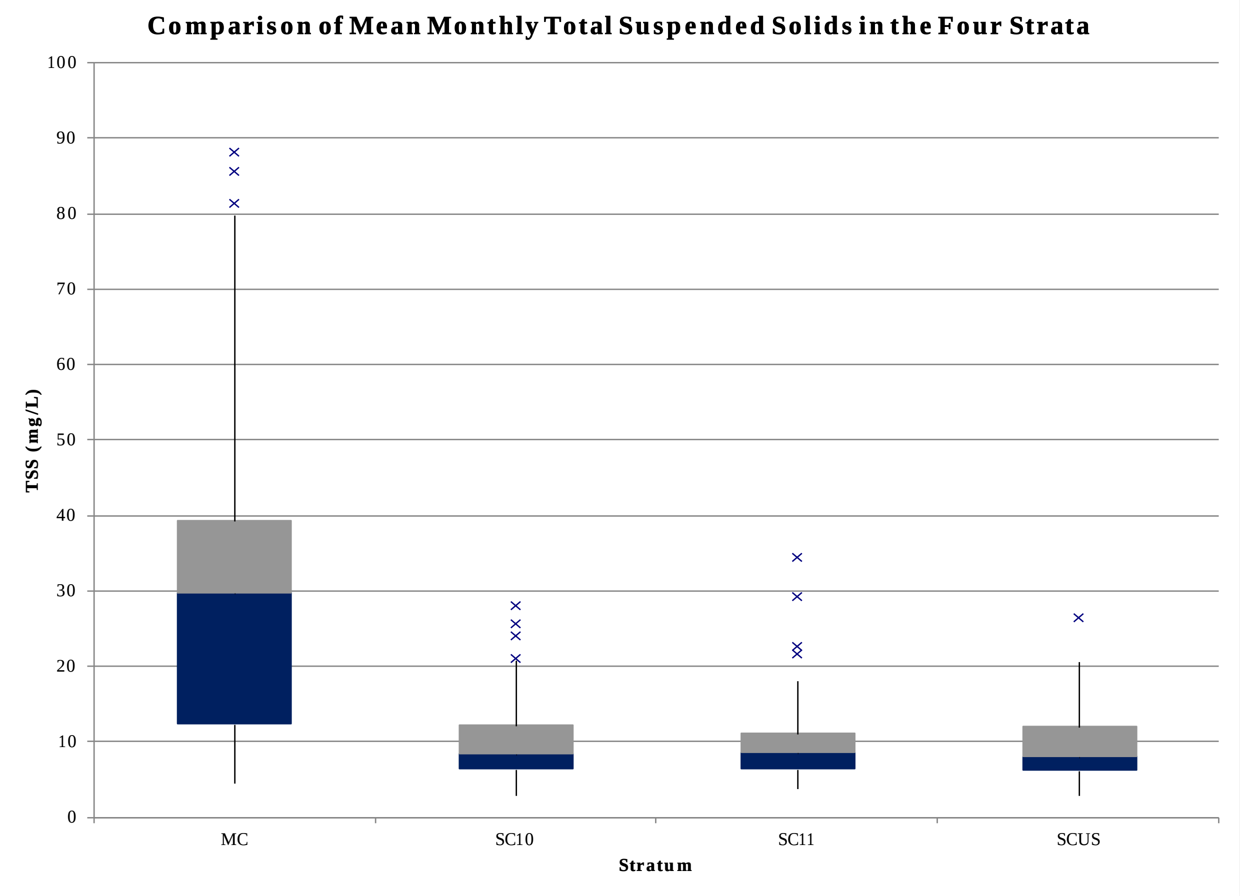


Figure 2-20 Comparison of Mean Monthly TSS concentrations in the Four Strata of Sarasota Bay

Figure 2-21 compares mean monthly turbidity for the four strata. No significant differences was noted, with mean turbidity values between 2 and 3 NTUs.

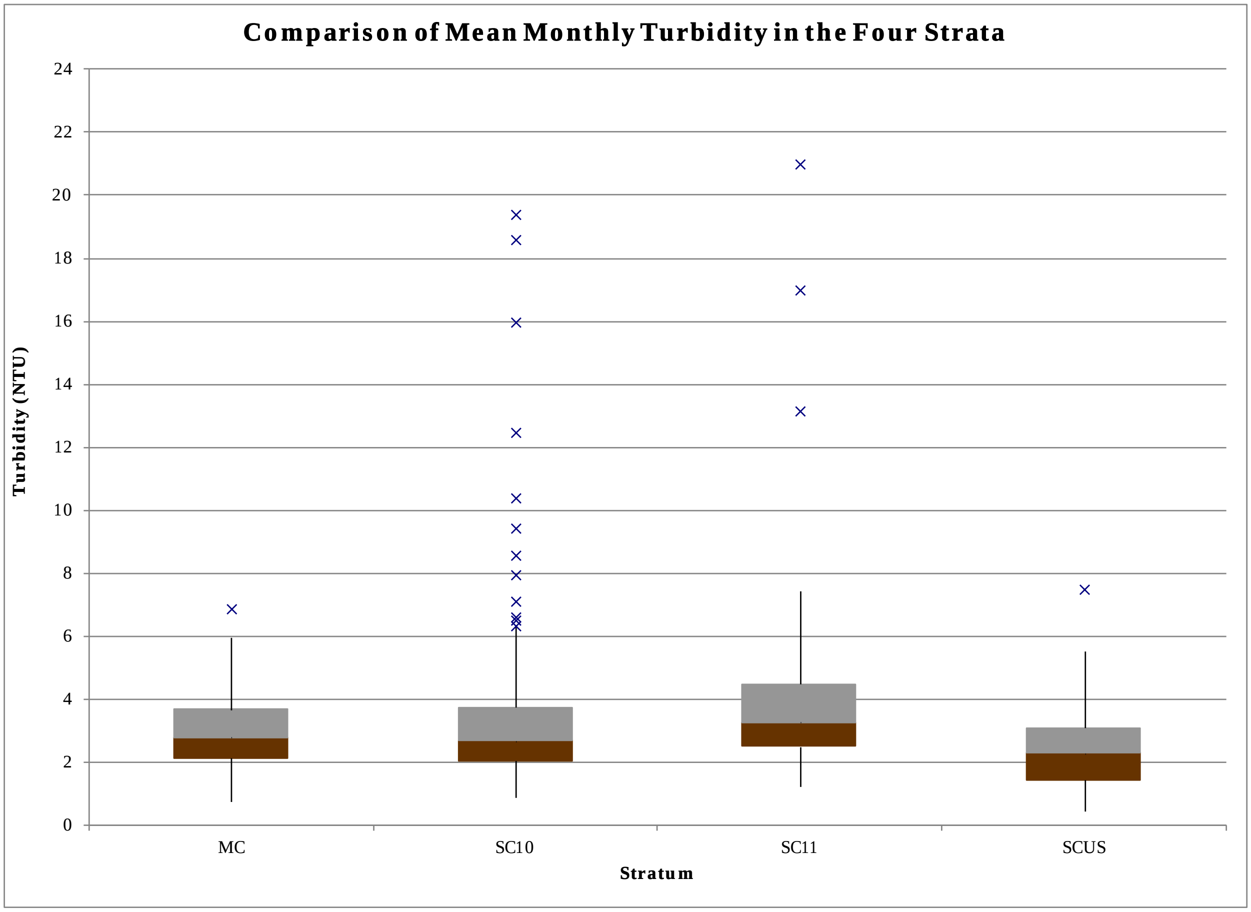


Figure 2-21 Comparison of Mean Monthly Turbidity in the Four Strata of Sarasota Bay

Figure 2-22 similarly show similar light attenuation means across the four strata. Mean values are all in the range of 0.6 to 0.7 m^{-1}.

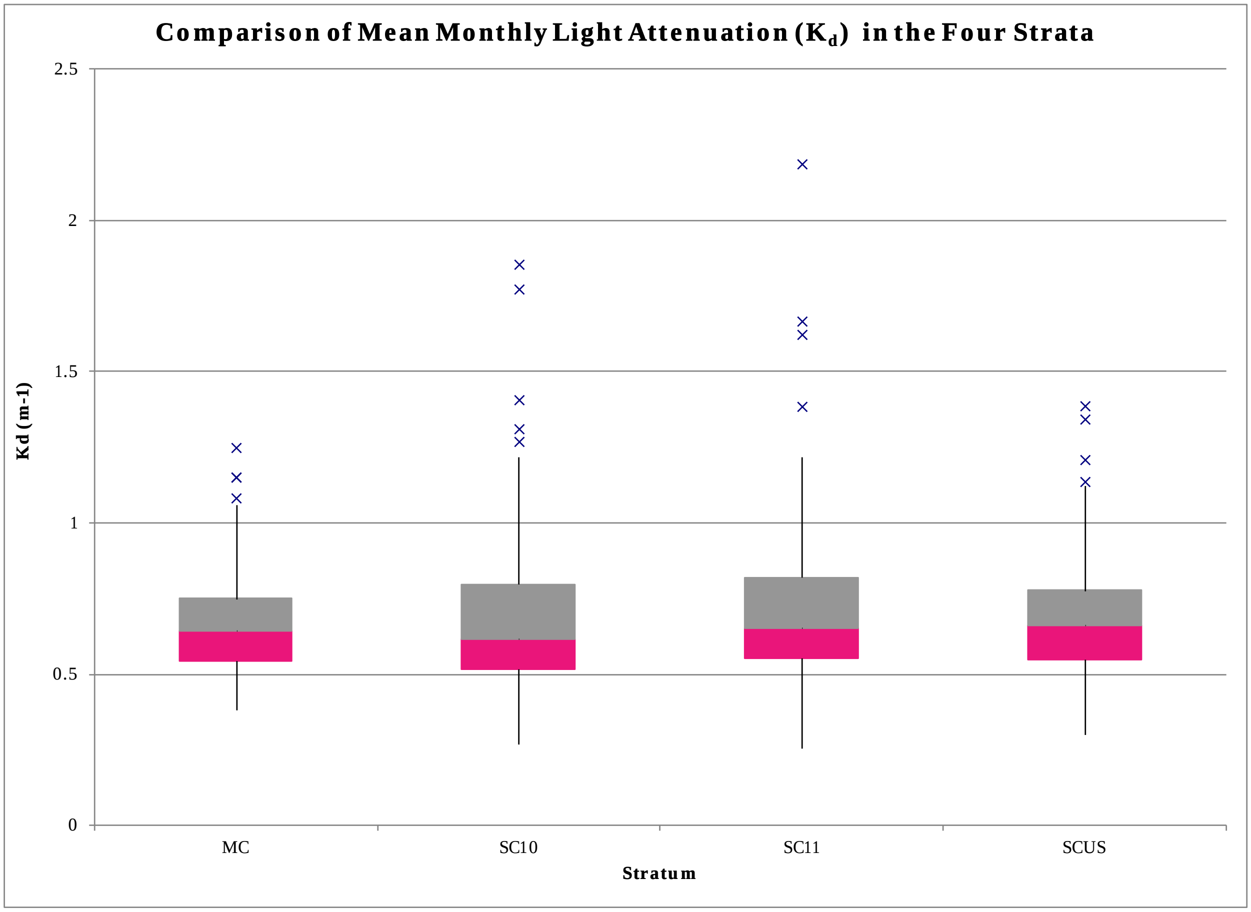


Figure 2-22 Comparison of Mean Monthly Light Attenuation in the Four Strata of Sarasota Bay

2.4.4 Water Quality Status

Water quality status is assessed relative to several endpoints—the chlorophyll *a* target, threshold, and NNC adopted by SBEP (January 15 and June 4, 2010, respectively) and the current State standard for DO in marine waters. These targets are further discussed below in Section 5.4 and Section 6.6.3.

The status of water quality in Sarasota Bay relative to the SBEP chlorophyll *a* target, threshold, and NNC has been examined. Figures 2-23 through 2-26 and Table 2-1 present the results.

Table 2-1 Number of DO Samples and the Number Less than 4 mg/L from Sarasota Bay by Year

Year	Number of DO Samples	Number of DO Samples < 4 mg/L
1995	9	0
1996	56	0
1997	53	0
1998	161	0
1999	180	0
2000	169	0
2001	228	0
2002	237	0
2003	222	2
2004	185	0
2005	235	2
2006	235	1
2007	234	1
2008	236	0
2009	220	0

Figure 2-23 compares the annual geometric mean chlorophyll *concentrations* to the SBEP chlorophyll *a* target and threshold for Sarasota Bay. The target concentration of 5.2 µg/L represents an upper limit of desirable levels of chlorophyll *a* for the bay. The threshold of 6.1 µg/L is the minimum concentration above which adverse impacts to the bay's ecology may become evident. As can be seen, annual chlorophyll *a* concentrations for 1998 through 2010 have been consistently lower than the target, i.e., within the range of desirable levels.

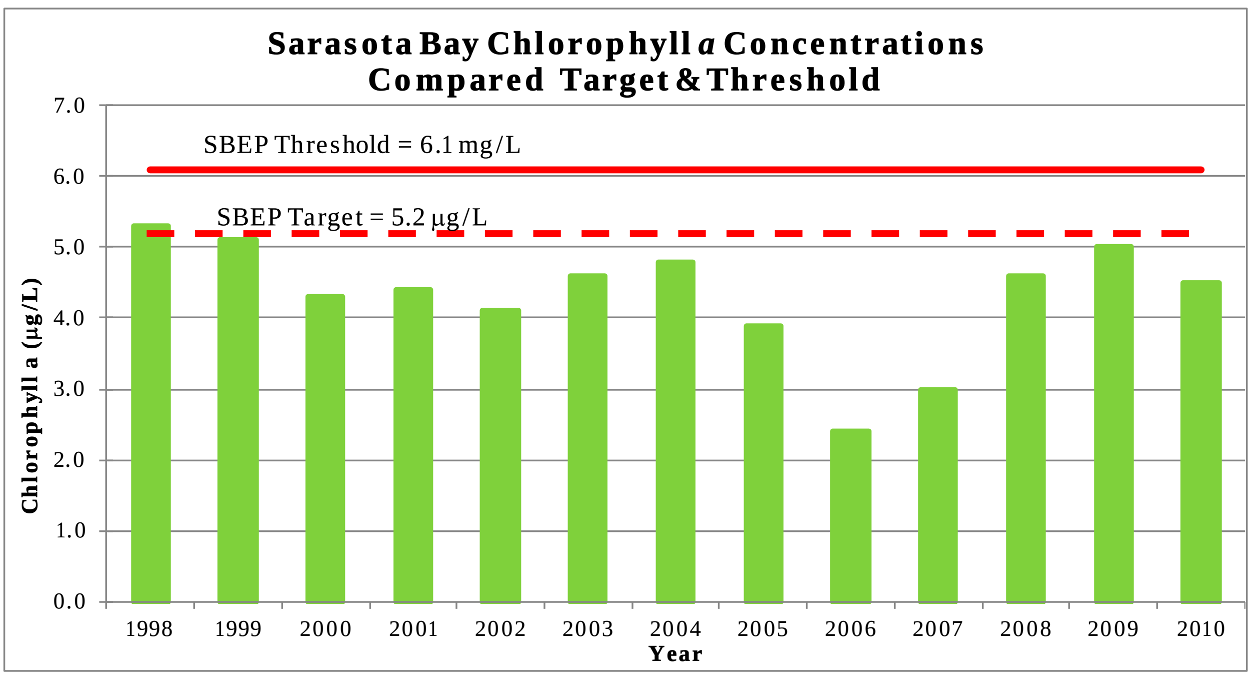


Figure 2-23 Comparison of Geometric Mean Chlorophyll *a* Concentrations to the SBEP Chlorophyll *a* Target (6.1 µg/L) and Threshold (5.2 µg/L) for Sarasota Bay

Figure 2-24 compares the annual geometric mean TN concentrations to the TN numeric criterion developed by SBEP for Sarasota Bay. Ambient TN mean concentrations are below the criterion for all years except 2008. Ambient TN concentrations range from 0.25 to under 0.4 mg/L. The TN criterion, which is calculated each year, is over 0.6 mg/L for all years except 2008.

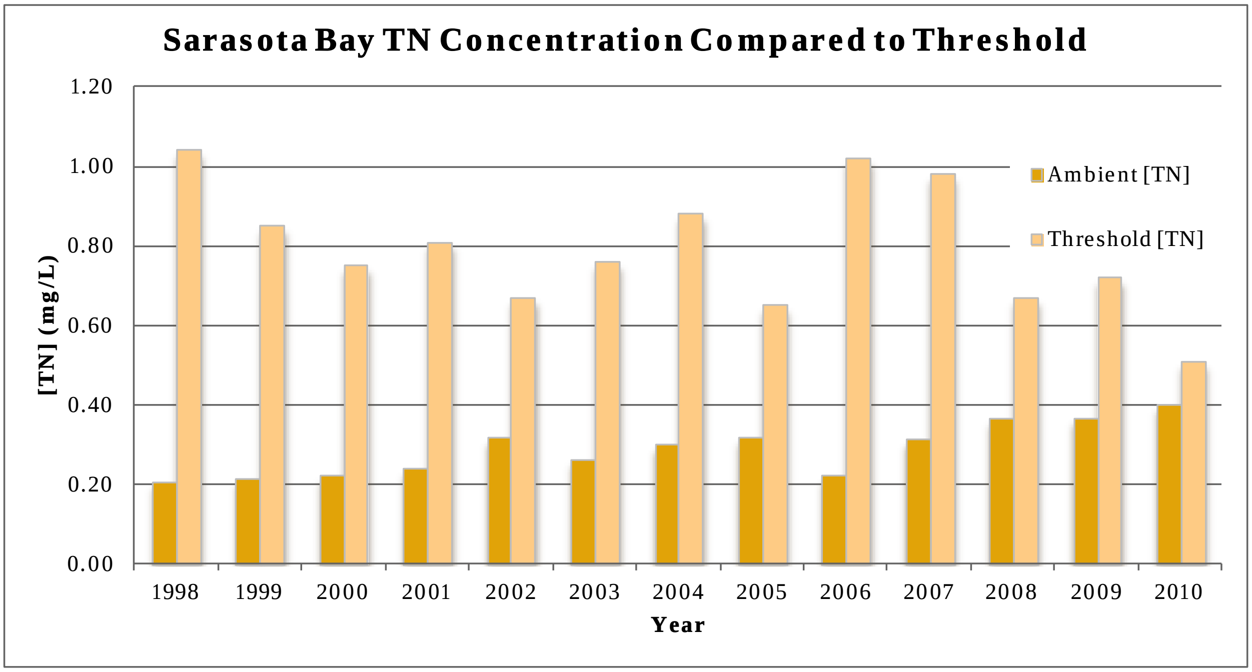


Figure 2-24 Comparison of Geometric Mean TN concentrations to the SBEP TN Numeric Criterion for Sarasota Bay.
TN criterion is calculated annually.

Figure 2-25 compares the annual geometric mean TP concentrations to the TP numeric criterion developed by SBEP for Sarasota Bay (0.19 mg/L). Ambient annual mean TP concentrations do not exceed the numeric criterion. Ambient concentrations remain under 0.18 mg/L and in all but 2 years are below 0.15 mg/L.

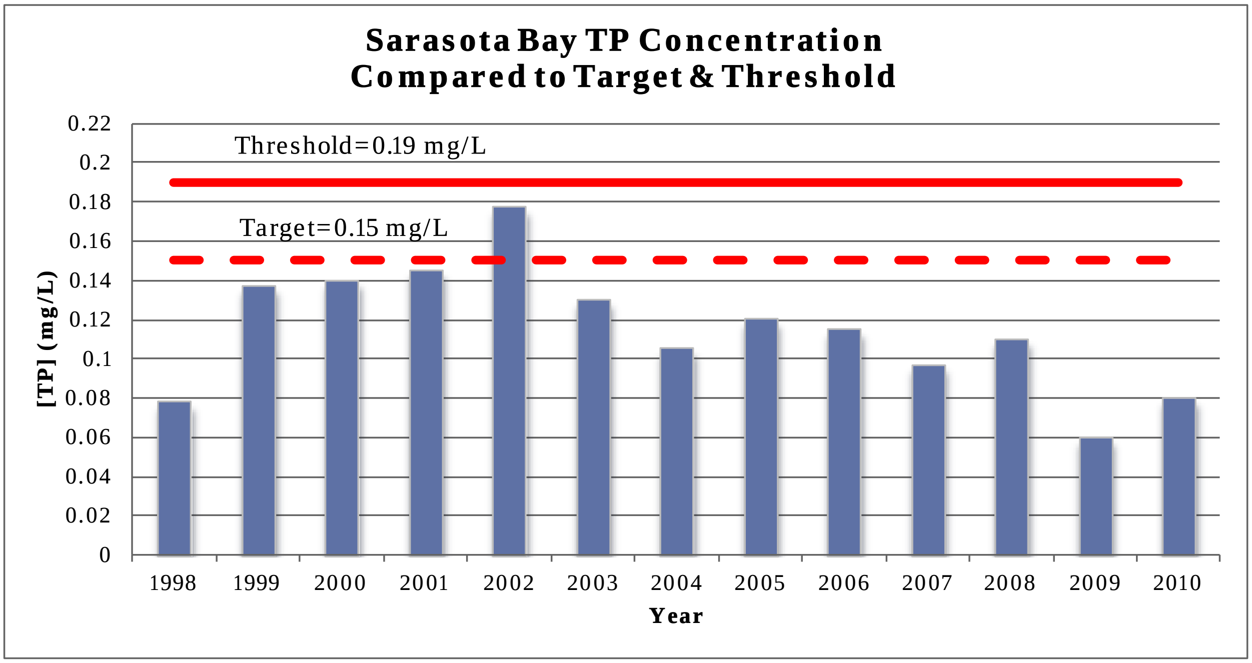


Figure 2-25 Comparison of Geometric Mean TP concentrations to the SBEP TP Numeric Criterion for Sarasota Bay (0.19 mg/L)

The State standard for DO in Class 3 marine waters is 4 mg/L at all places and all times. Generally, the IWR identifies a waterbody as being impaired if the percentage of samples less than 4 mg/L exceeds 10%. Table 2-1 presents the number of DO samples in Sarasota Bay less than 4 mg/L for 1998–2009. The maximum percent of samples not meeting the DO criterion for any year was 0.9%, which occurred in 2003. Thus, the vast majority of samples in Sarasota Bay met the State standard during 1998–2009.

Figure 2-26 summarizes the percentage of DO samples less than 4 mg/L by calendar month in Sarasota Bay for 1998–2009. The percentage of samples less than 4 mg/L never exceeded 2 percent; therefore, at a minimum 98 percent of all DO samples taken in Sarasota Bay within all calendar months met the State standard.

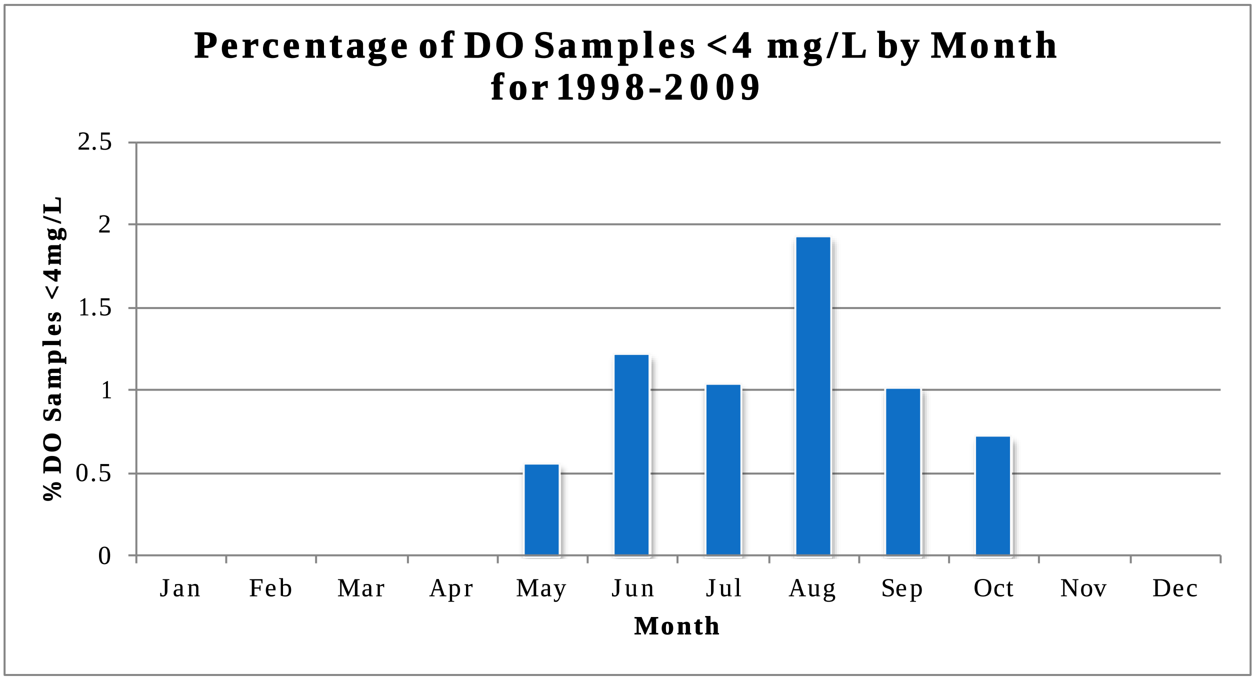


Figure 2-26 Percentage of DO Samples <4 mg/L in Sarasota Bay by Calendar Month for 1998–2009

2.4.5 Data Collection

No data gaps were found during this analysis. Therefore, we do not recommend additional monitoring or data collection.

3.0 TRIBUTARY WATER QUALITY STATUS AND TRENDS

3.1 OBJECTIVE

This section presents the approach, data used, and summary of results associated with examining the water quality status and trends in the Sarasota Bay tributaries.

3.2 APPROACH

Ambient water quality data were examined to identify any significant temporal or spatial trends in Sarasota Bay tributaries. Temporal trends were visually examined because none of the time series is of adequate length to analyze statistically. Spatial trends were examined graphically. The freshwater numeric criteria for TN and TP developed by FDEP were compared to the ambient water quality data from the freshwater portions of these tributaries. Lastly, the statuses of the Sarasota Bay tributaries with regard to the IWR were summarized.

3.3 DATA USED

- ❖ Ambient water quality data provided by Sarasota and Manatee Counties and additional data obtained from the IWR database.
- ❖ Draft revised Rule Chapter 62-302, FAC Surface Water Quality Standards. November 1, 2011 (FDEP, 2011a).
- ❖ NNC briefing for Environmental Regulatory Commission. November 3, 2011 (FDEP, 2011b).
- ❖ Impaired Waters Rule Chapter 62-303. FAC (FDEP, 2011c).

3.4 RESULTS

Figure 3-1 shows the Sarasota Bay tributaries and ambient water quality sampling stations. Tributaries include Hudson Bayou to the south; Whitaker Bayou to the north; and Bowlees Creek, the northernmost tributary to the estuary, in Manatee County.

- ❖ Whitaker Bayou has three sampling stations (WB10, WB11, and WB12). FDEP identified all three as freshwater stations.
- ❖ Hudson Bayou has three sampling stations (HB6, HB7, and HB8). FDEP identified HB6 as tidal and HB7 and HB8 as freshwater.
- ❖ Bowlees Creek has one sampling station (BC1). FDEP identified BC1 as tidal.

Figure 3-1 Locations of the Sarasota Bay Tributary Water Quality Sampling Stations

3.4.1 Temporal and Spatial Variation

3.4.1.1 Whitaker Bayou

Figures 3-2 through 3-7 present variation over time in conductivity, chlorophyll *a*, TN, TP, DO, and color in Whitaker Bayou. Figure 3-2 shows conductivity at the three sampling stations. With very few exceptions, conductivity remained under 1,000 µS/cm, which is less than 2 parts per thousand salinity. All three stations had a single excursion in 1998, with concentrations significantly higher than normal. The downstream station, WB10, also had an extremely high value of 33,000 µS/cm in 2000. Visual inspection of the time series revealed no temporal trend at any station.

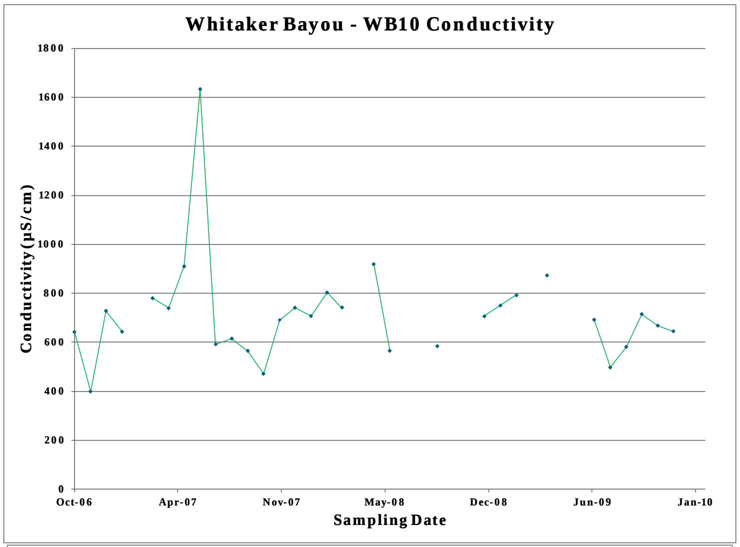
Figure 3-3 shows chlorophyll *a* concentrations from the three Whitaker Bayou stations. The downstream station, WB10, had the lowest concentrations of the three stations, with concentrations of 2 µg/L or less with two exceptions. Station WB11 had higher concentrations, with most concentrations between 1 and 4.5 µg/L and two concentrations over 8 µg/L. Chlorophyll *a* concentrations from Station WB12 generally ranged from less than 1 µg/L to 5 µg/L, with three concentrations over 15 µg/L. Visual inspection of the time series revealed no temporal trend at any station.

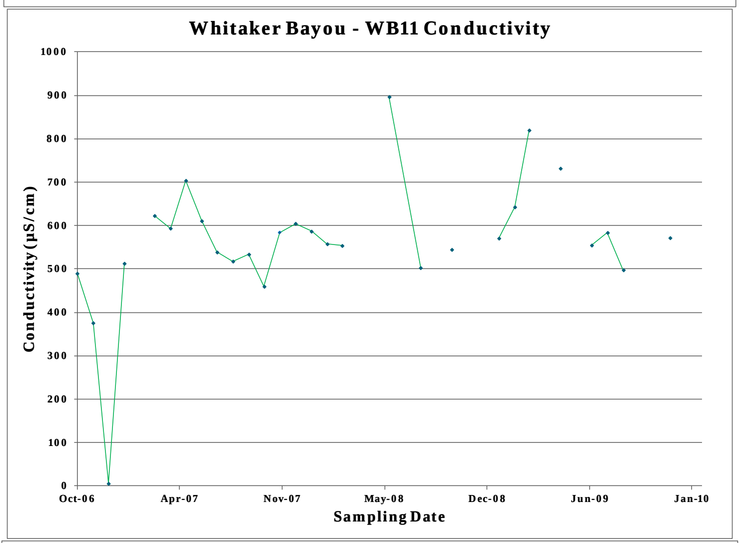
Figure 3-4 shows TN concentrations for Whitaker Bayou. Stations WB10 and WB11 generally remained less than 1.0 mg/L, while Station WB12 had more frequent concentrations between 1.0 and 1.6 mg/L. Visual inspection of the time series revealed no temporal trend at any station. Generally, the temporal variation in TN concentrations was similar among the three stations, perhaps due to changes in precipitation and subsequent streamflow.

Figure 3-5 shows TP concentrations for Whitaker Bayou. Station WB10 generally ranged from 0.15 to 0.4 mg/L, with a maximum of 0.64 mg/L. TP concentrations from Stations WB11 and WB12 were in the same range, with very few concentrations greater than 0.5 mg/L. Visual inspection of the time series revealed no temporal trend at any station.

Figure 3-6 shows DO concentrations in Whitaker Bayou. The data record was discontinuous but indicates that DO concentrations from Station WB10 usually remained above the 4.0-mg/L State standard, with two measurements reported below. DO concentrations from Stations WB11 and WB12 had more low concentrations, but all have the majority of samples above 4.0 mg/L. Visual inspection of the time series revealed no temporal trend at any station.

Figure 3-7 shows color at the three Whitaker Bayou stations. A visual inspection of Station WB10 data showed an increasing trend, with concentrations rising from 40 to 60 PtCo units to 60 to 100 PtCo units. A shift in color appeared to have occurred in 1999, although the period of record is too short to draw firm conclusions. Station WB11 had color concentrations in a similar range, but color at Station WB12 was higher, typically between 70 and 120 PtCo units.





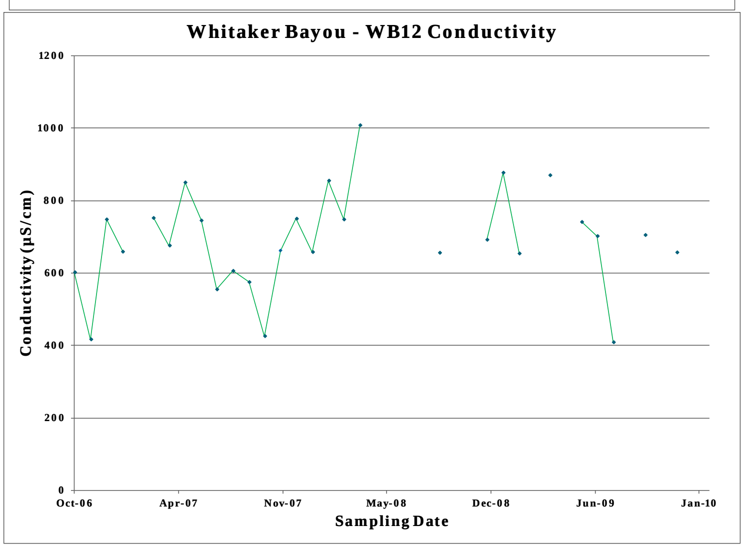


Figure 3-2 Conductivity (µS/cm) Observations from the Whitaker Bayou Water Quality Sampling Stations

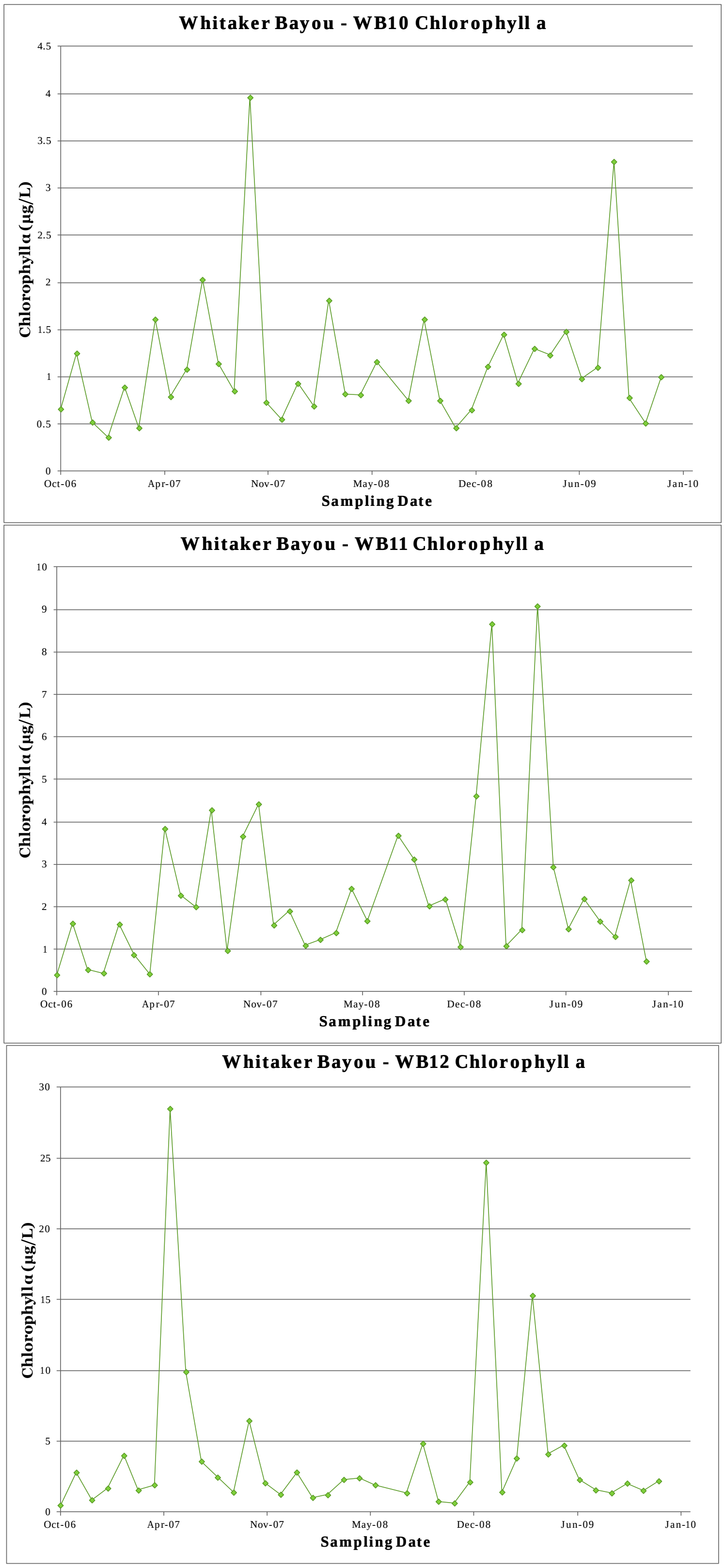


Figure 3-3 Chlorophyll *a* (µg/L) Concentrations from the Whitaker Bayou Water Quality Sampling Stations

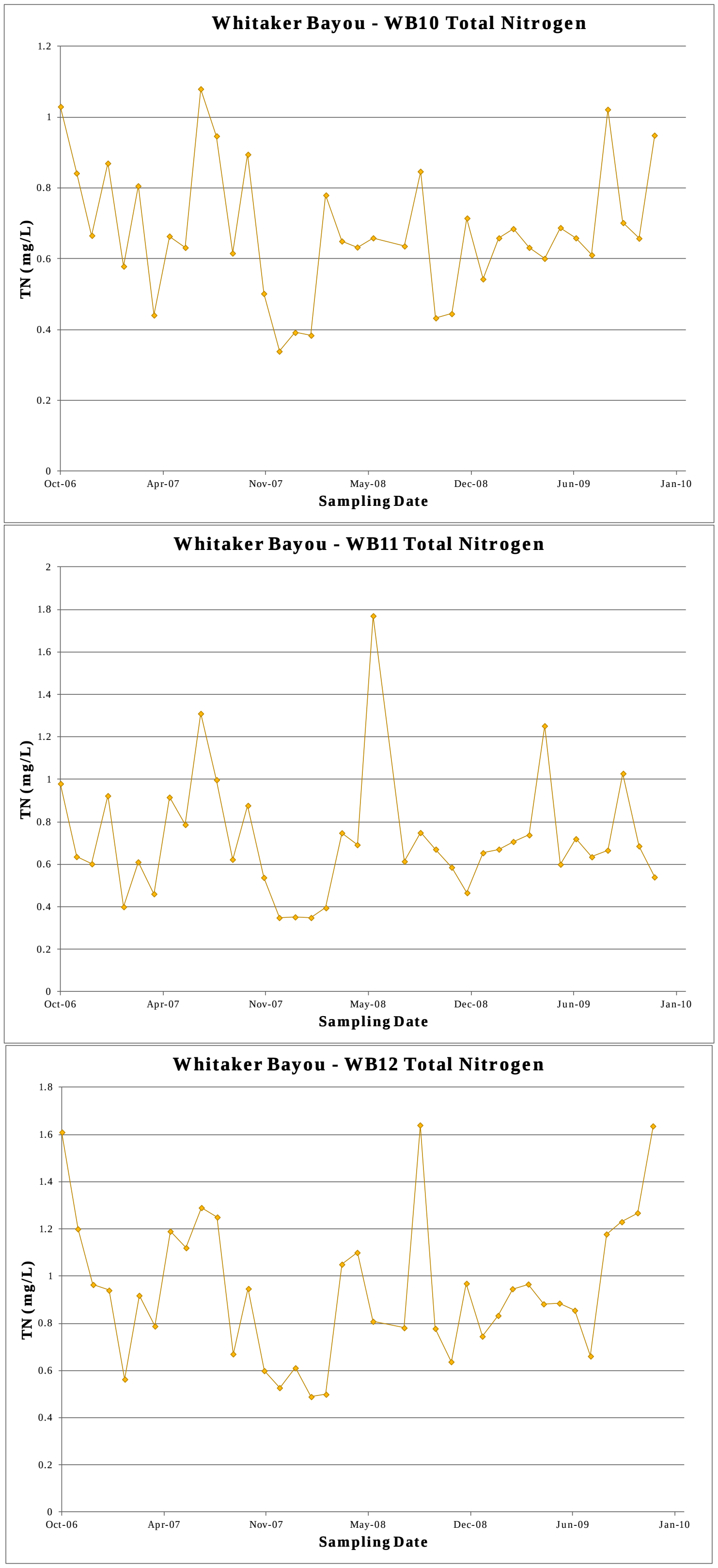
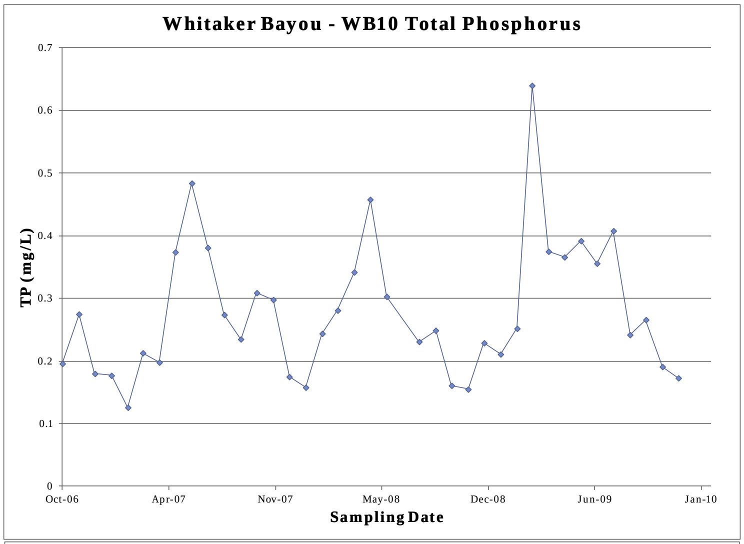
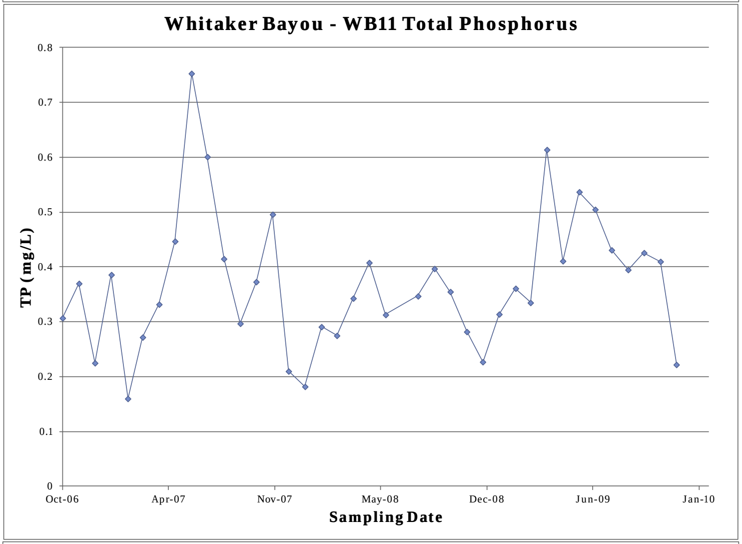


Figure 3-4 TN (mg/L) Concentrations from the Whitaker Bayou Water Quality Sampling Stations





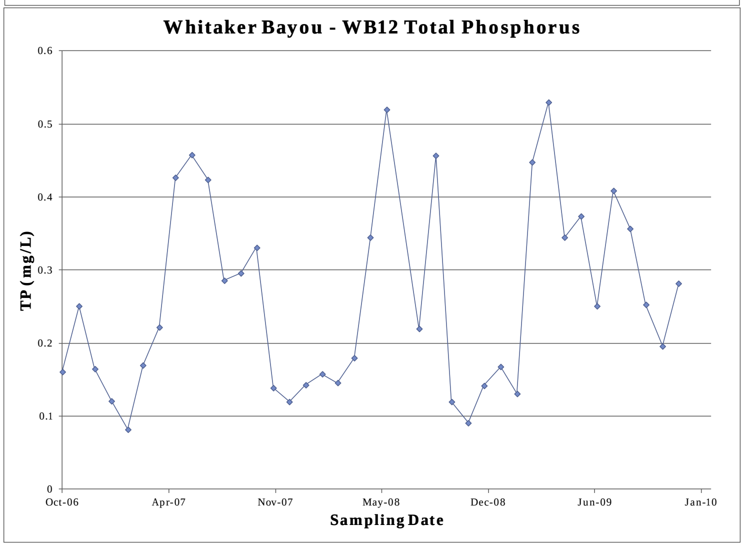
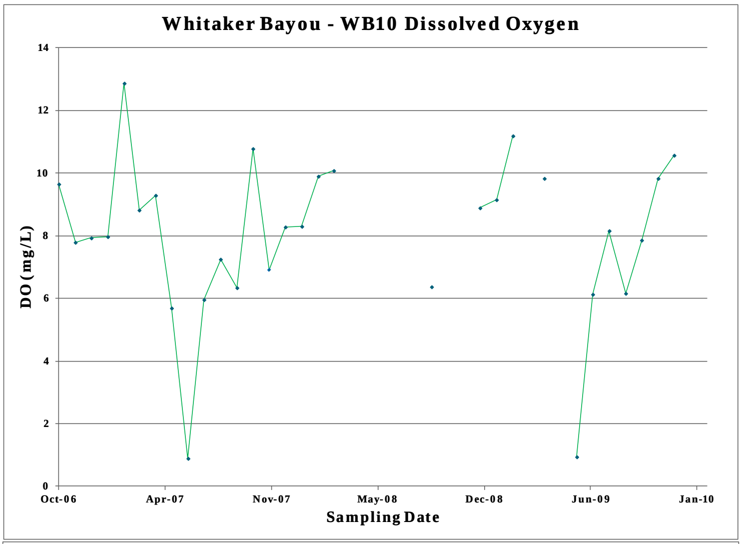
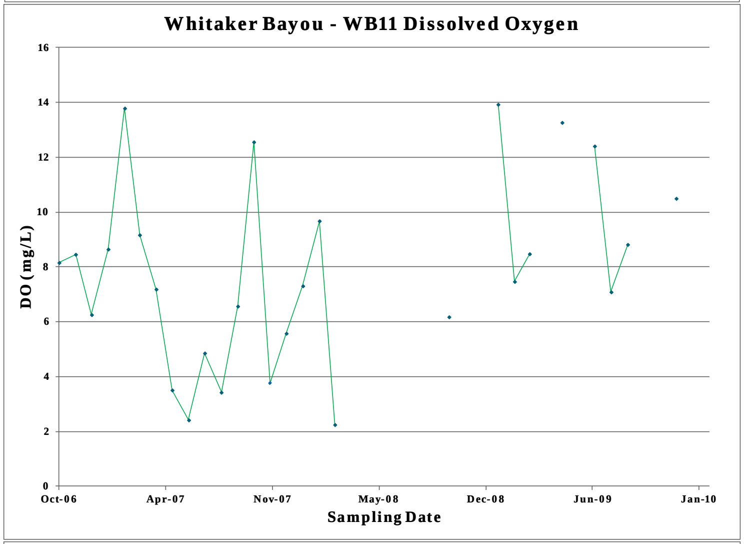


Figure 3-5 TP (mg/L) Concentrations from the Whitaker Bayou Water Quality Sampling Stations





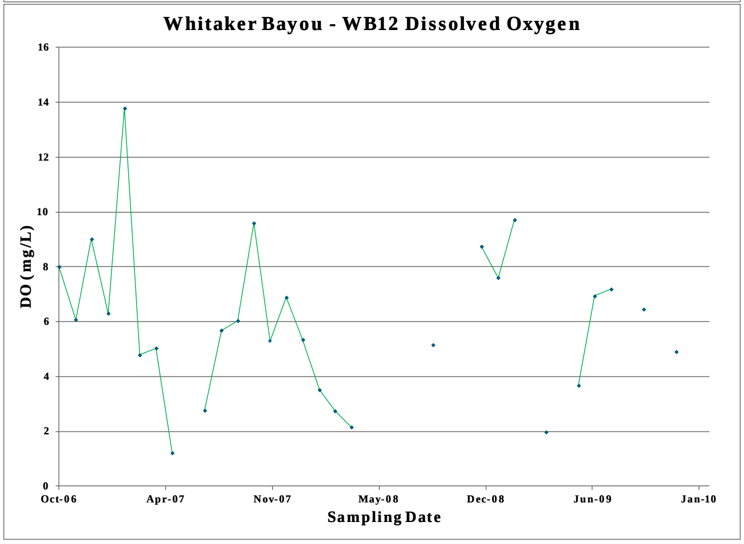
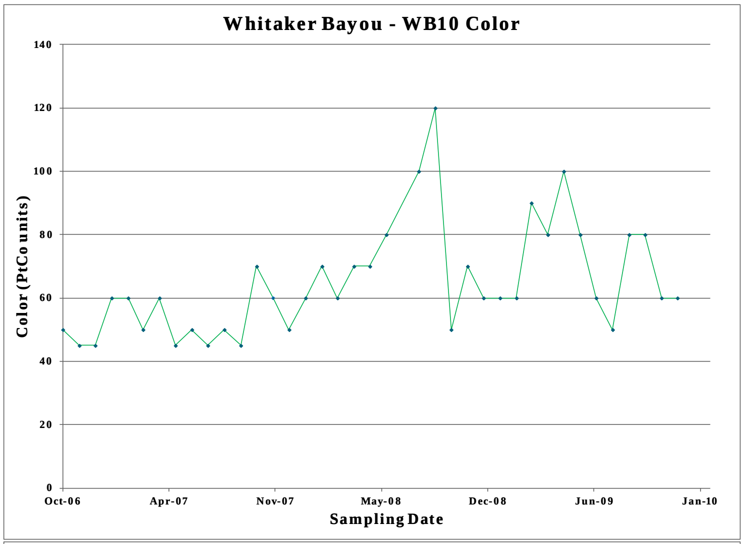
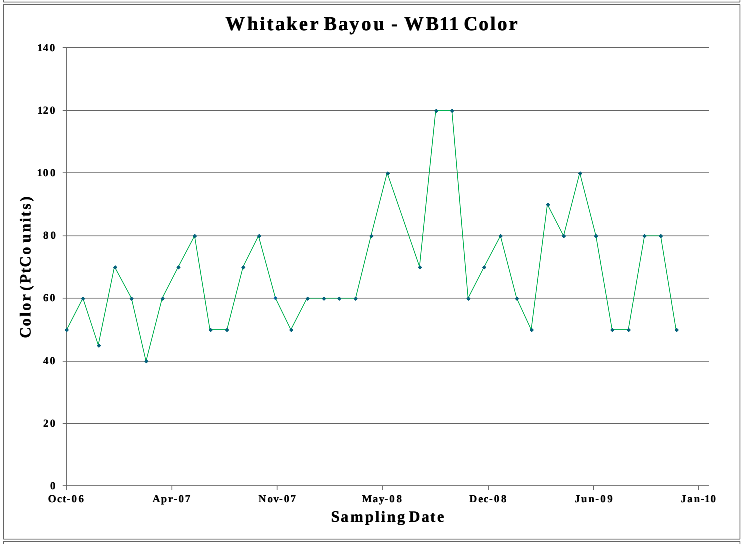


Figure 3-6 DO (mg/L) Concentrations from the Whitaker Bayou Water Quality Sampling Stations





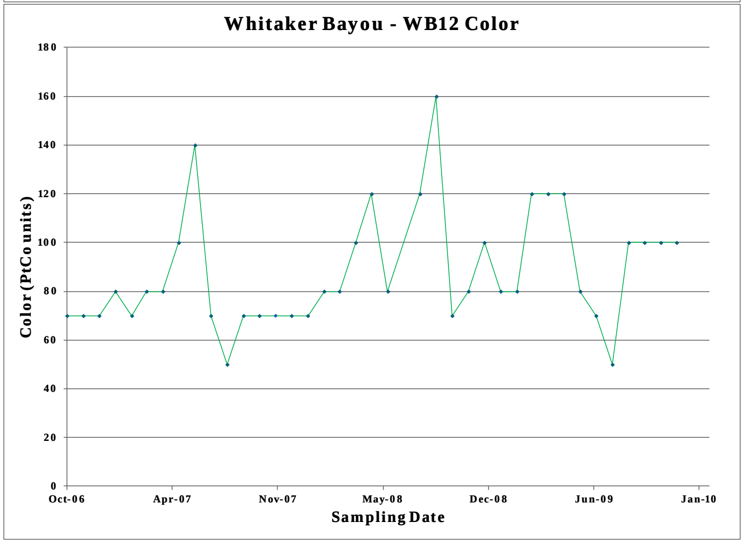


Figure 3-7 Color (PtCo units) Observations from the Whitaker Bayou Water Quality Sampling Stations

3.4.1.2 Hudson Bayou

Figures 3-8 through 3-13 show variation over time in conductivity, chlorophyll *a*, TN, TP, DO, and color in Hudson Bayou.

Figure 3-8 shows conductivity at the three sampling stations. Station HB6, a tidal station, had conductivity consistent with that designation, with most concentrations between 10,000 and 40,000 µS/cm. A wide range of conductivities were observed over time at Station HB6 that likely reflects the influence of time-varying freshwater inputs from the upstream watershed. Except for two events, the conductivities at Stations HB7 and HB8 were typically less than 1,000 µS/cm.

Figure 3-9 presents chlorophyll *a* concentrations from the Hudson Bayou stations. Station HB6 concentrations were generally less than 8 µg/L until 2000. The temporal patterns at Stations HB7 and HB8 were similar to that observed at HB6, with generally low concentrations of chlorophyll *a* until a marked increase in 2000.

Figure 3-10 shows TN concentrations in Hudson Bayou. TN concentration from Stations HB6 and HB8 were generally in the range of 0.6 to 1.2 mg/L, while those observed from Station HB7 were lower. A slight increasing temporal trend in TN concentrations appeared to occur at Station HB7.

Figure 3-11 shows TP concentrations from Hudson Bayou. HB7 had lower concentrations, generally less than 0.5 mg/L, while HB6 and HB8 were higher typically between 0.35 to 0.65 mg/L and 0.45 to 0.90 mg/L, respectively.

Figure 3-12 shows Hudson Bayou DO concentrations. Although the record was discontinuous, DO concentrations from Station HB7 appeared to have an increasing trend over the sampling period with most of the most recent concentrations above 4 mg/L. DO concentrations less than 2 mg/L were frequently observed at Stations HB6 and HB8.

Figure 3-13 shows that color concentrations at all three stations on Hudson Bayou appeared to have a modest increasing trend. Color at Station HB7 was typically lower than that at Stations HB6 and HB8.

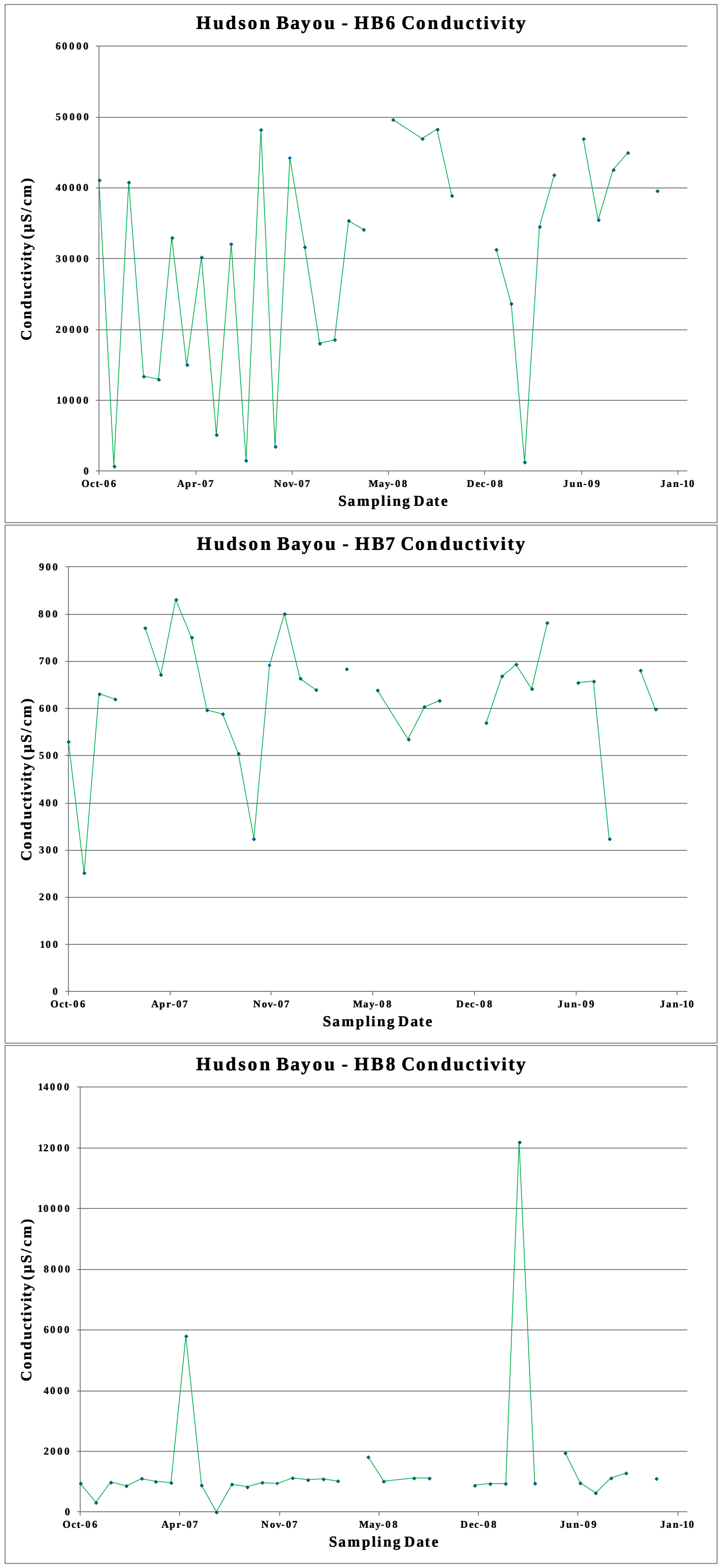
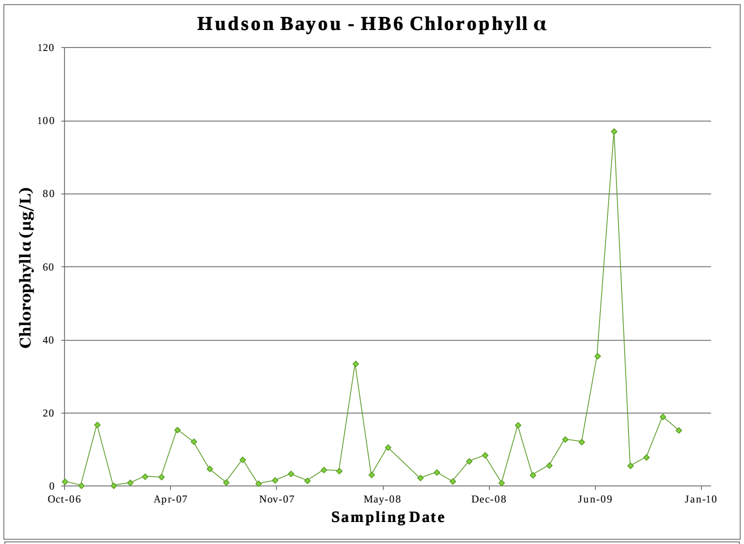
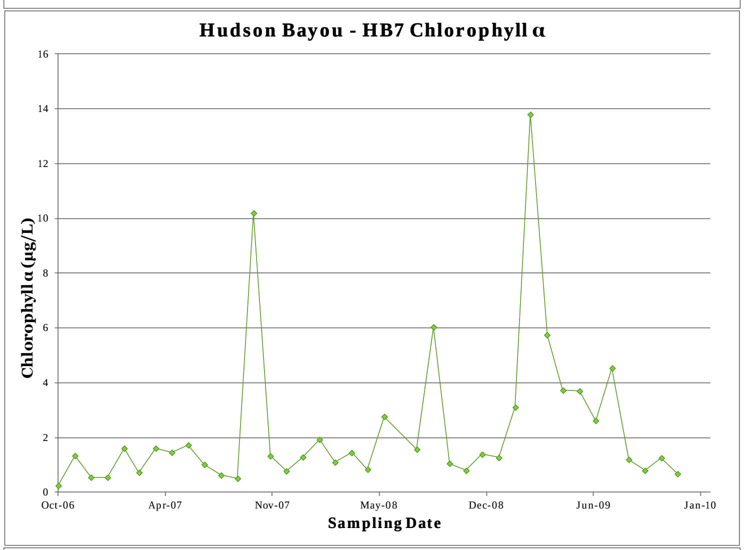


Figure 3-8 Conductivity (µS/cm) Observations from the Hudson Bayou Water Quality Sampling Stations





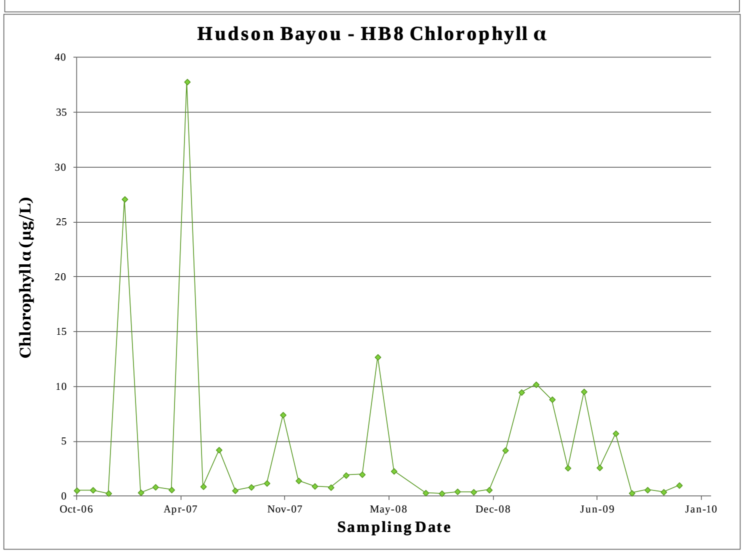


Figure 3-9 Chlorophyll *a* (µg/L) concentrations from the Hudson Bayou Water Quality Sampling Stations

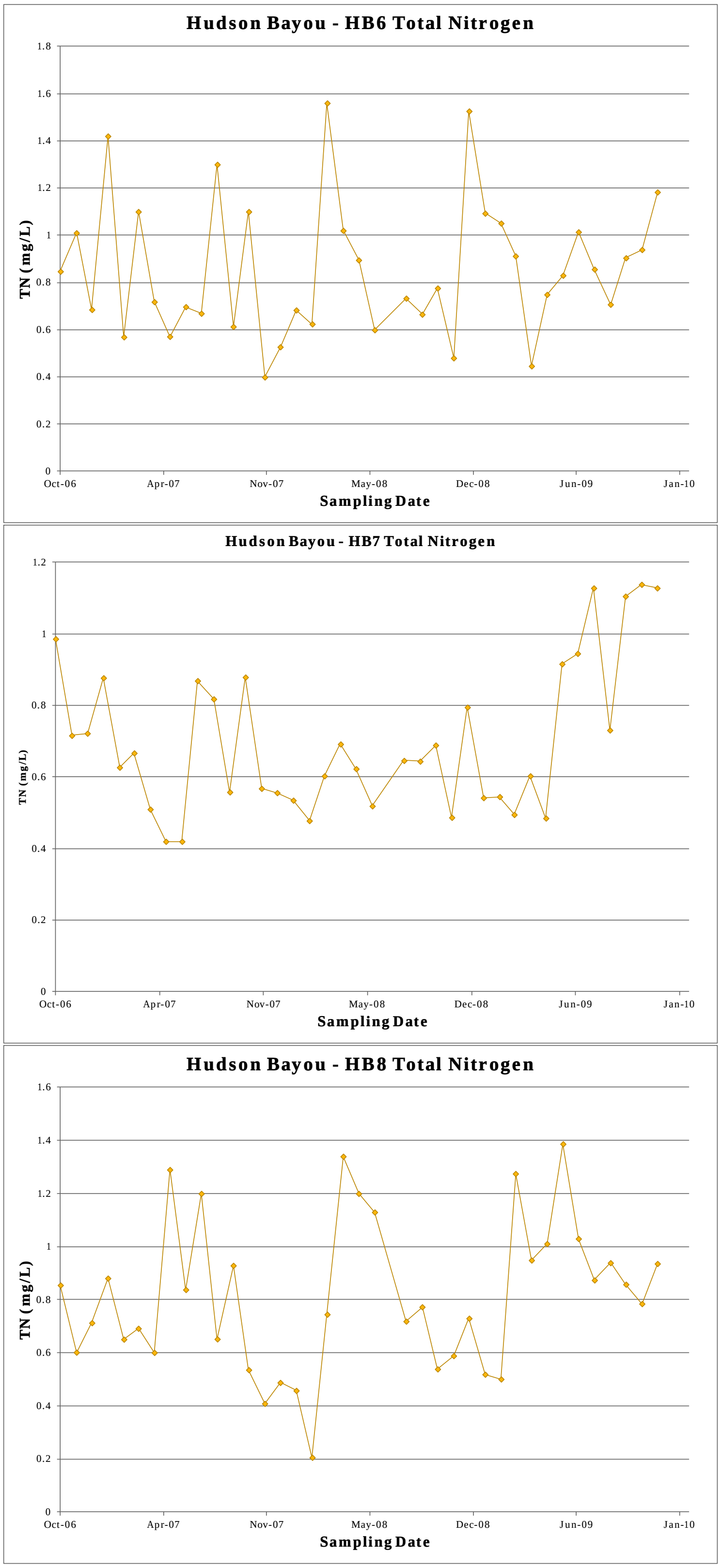


Figure 3-10 TN (mg/L) Concentrations from the Hudson Bayou Water Quality Sampling Stations

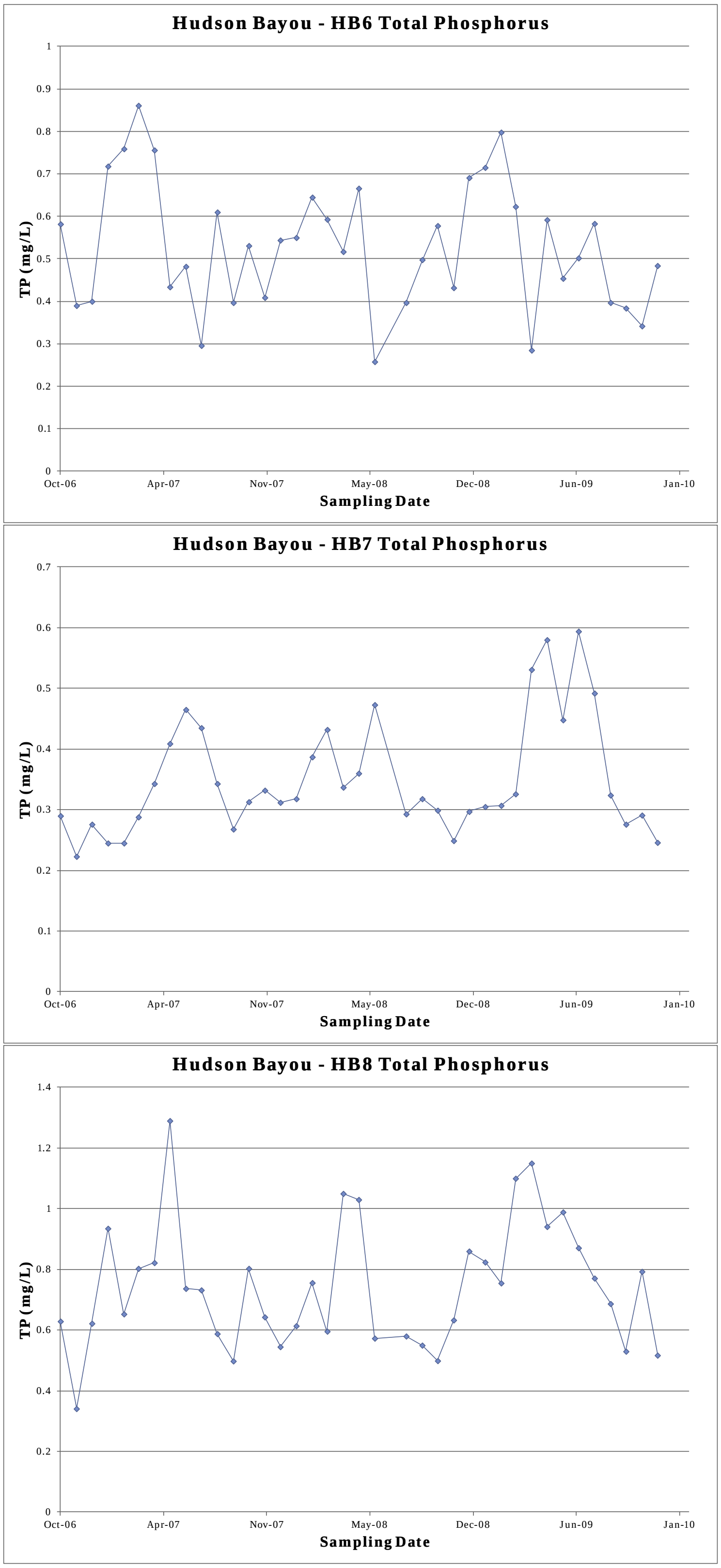


Figure 3-11 TP (mg/L) Concentrations from the Hudson Bayou Water Quality Sampling Stations

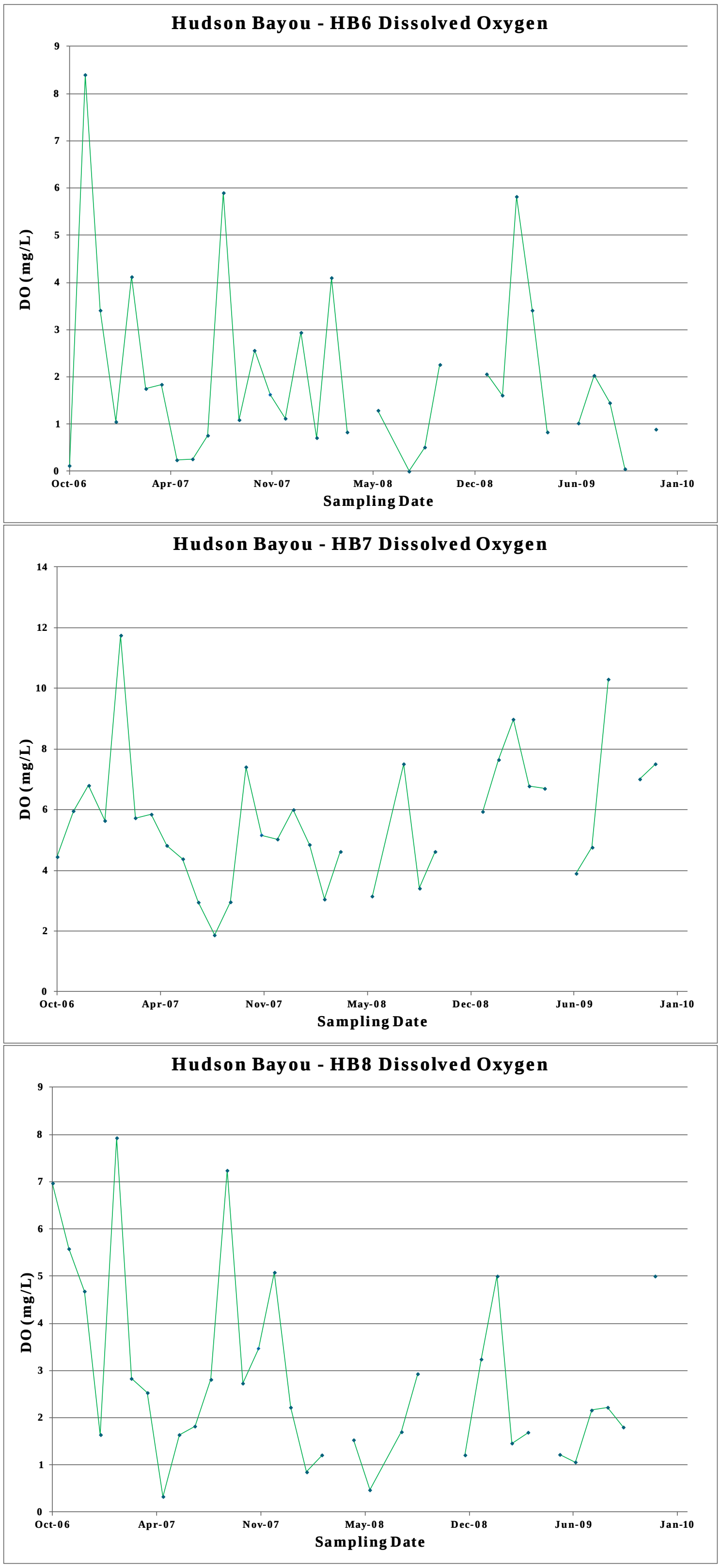


Figure 3-12 DO (mg/L) Concentrations from the Hudson Bayou Water Quality Sampling Stations

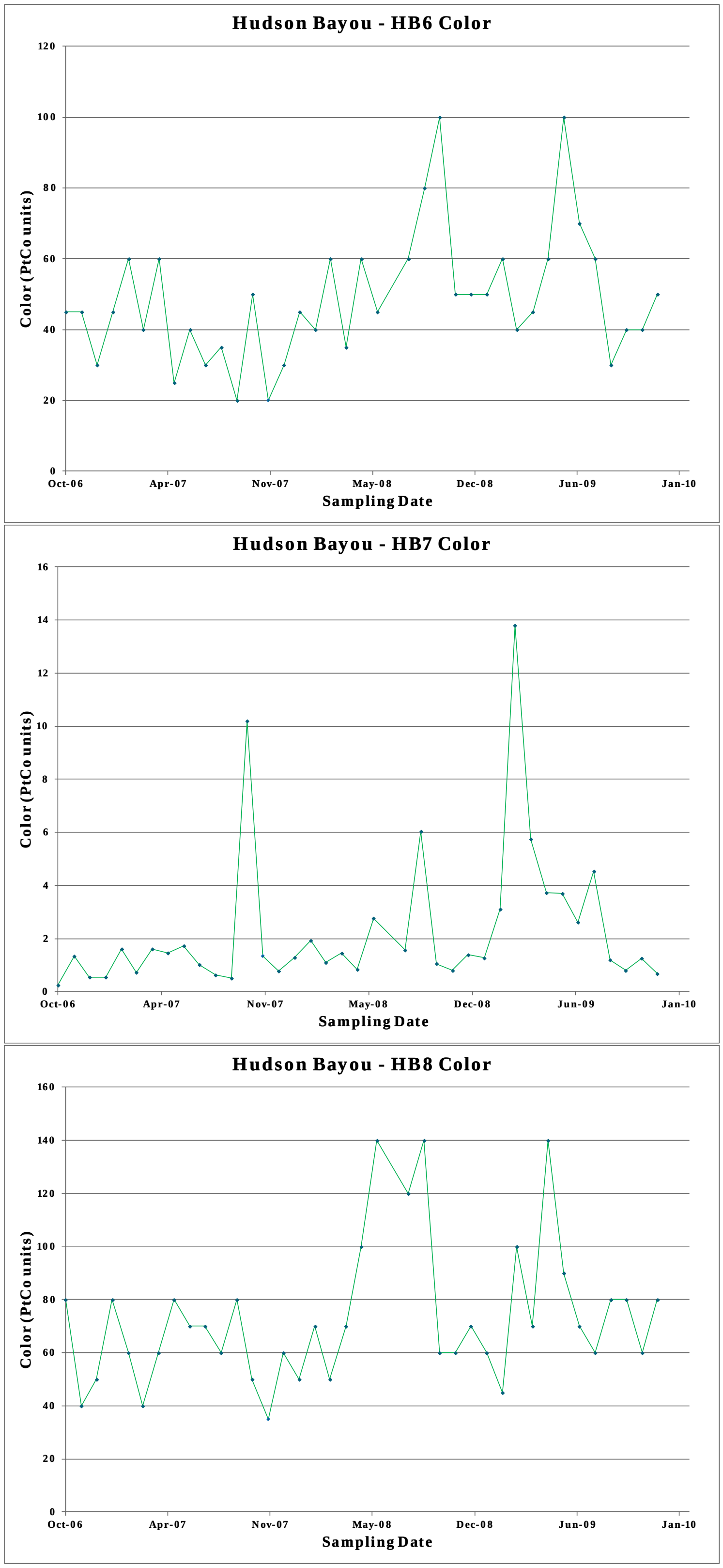


Figure 3-13 Color (PtCo units) Observations from the Hudson Bayou Water Quality Sampling Stations

3.4.1.3 Bowlees Creek

Figures 3-14 through 3-19 present water quality data for Bowlees Creek Station BC1, which is designated as tidal. The period of record for Bowlees Creek was 10 years, which is significantly longer than that of Hudson or Whitaker Bayous.

Conductivity concentrations at BC1 reflect its tidal designation (Figure 3-14). No temporal trend was evident.

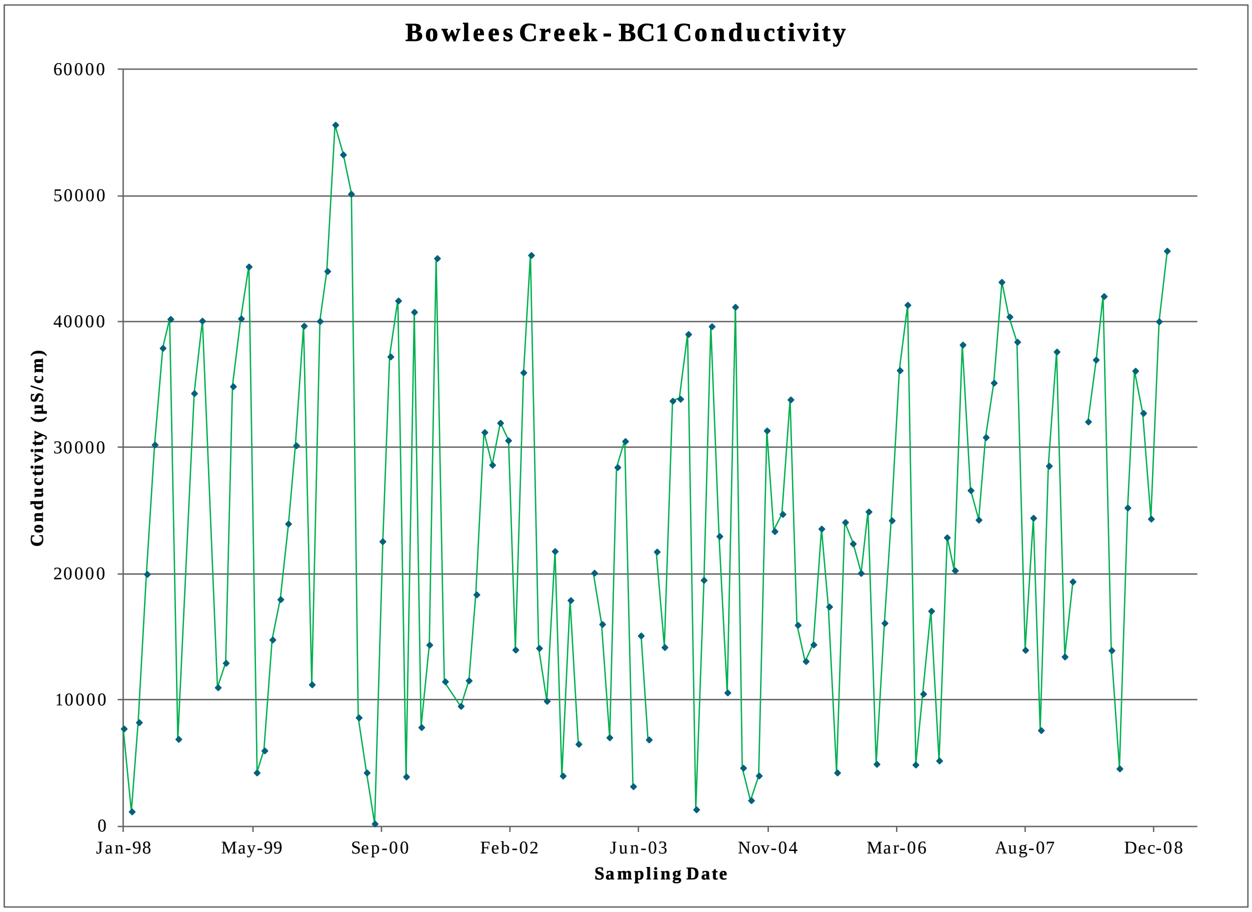


Figure 3-14 Conductivity (µS/cm) Observations from the Bowless Creek Water Quality Sampling Station

Figure 3-15 presents chlorophyll *a* concentrations for Bowlees Creek. These concentrations were significantly higher than those observed from either Whitaker Bayou or Hudson Bayou. Many of the concentrations were between 4 and 20 µg/L, with numerous observations greater than 20 µg/L.

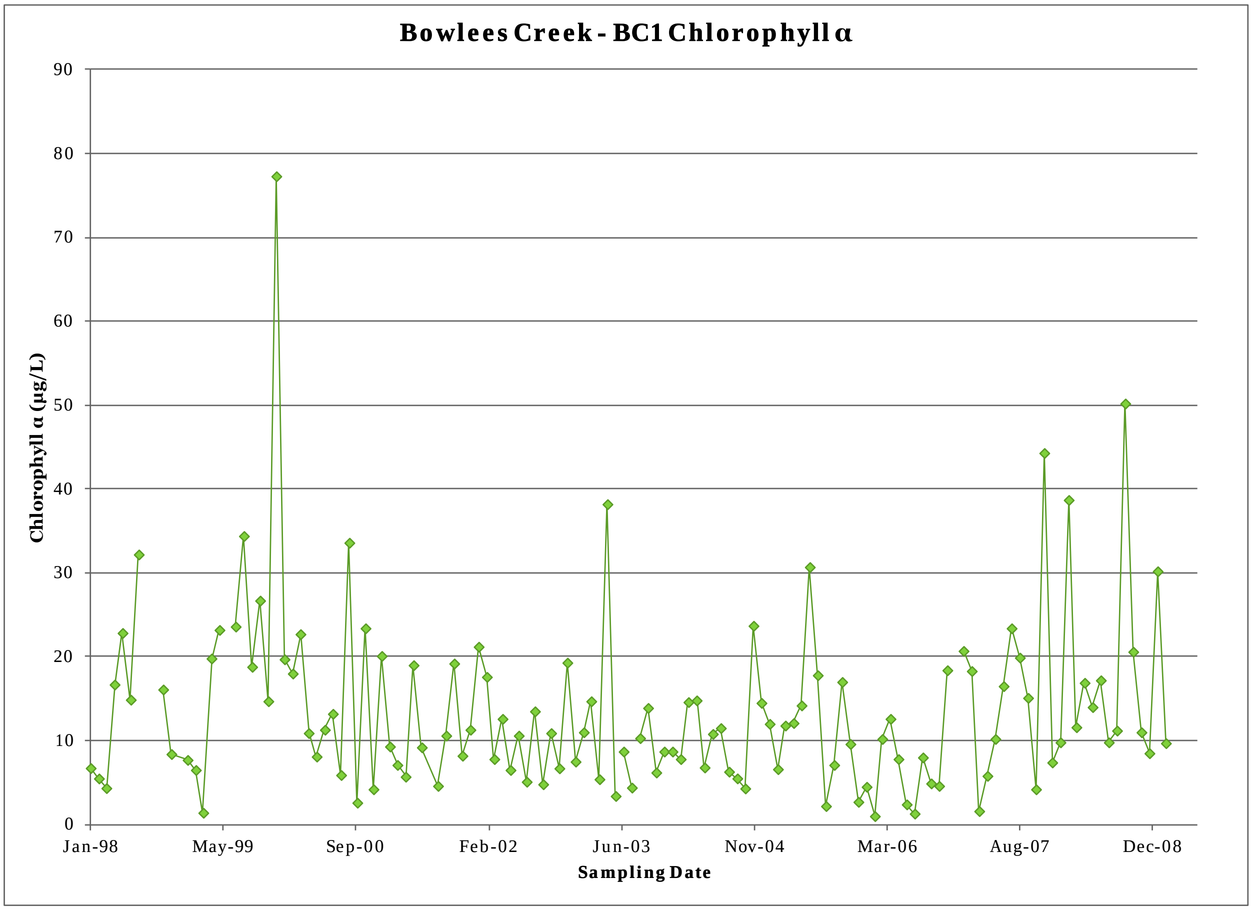


Figure 3-15 Chlorophyll *a* (µg/L) Concentrations from the Bowless Creek Water Quality Sampling Station

Figure 3-16 shows TN concentrations in Bowlees Creek. Most of the concentrations were between 0.6 and 2.0 mg/L, which was also higher than either Whitaker or Hudson Bayous. TN concentrations have been lower since some elevated concentrations were observed at the end of 2005/beginning of 2006. Since that period, the TN concentrations have typically been less than 1.5 mg/L.

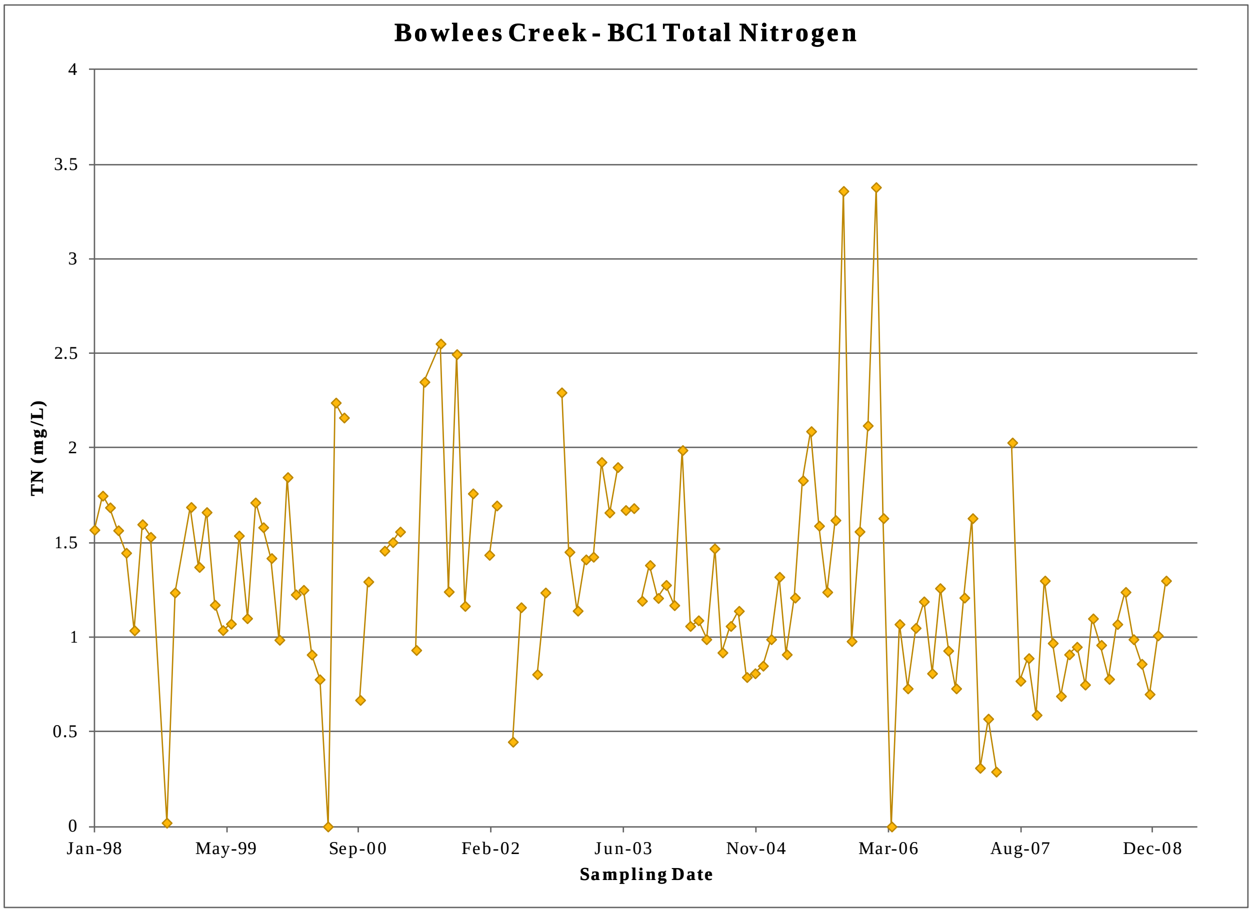


Figure 3-16 TN (mg/L) Concentrations from the Bowless Creek Water Quality Sampling Station

Figure 3-17 shows TP concentrations for Bowlees Creek. These TP concentrations were similar to those observed from Whitaker and Hudson Bayous, with the exception of higher extreme concentrations, with five samples over 1.0 mg/L, from Bowlees Creek. No temporal trend in TP concentrations was evident.

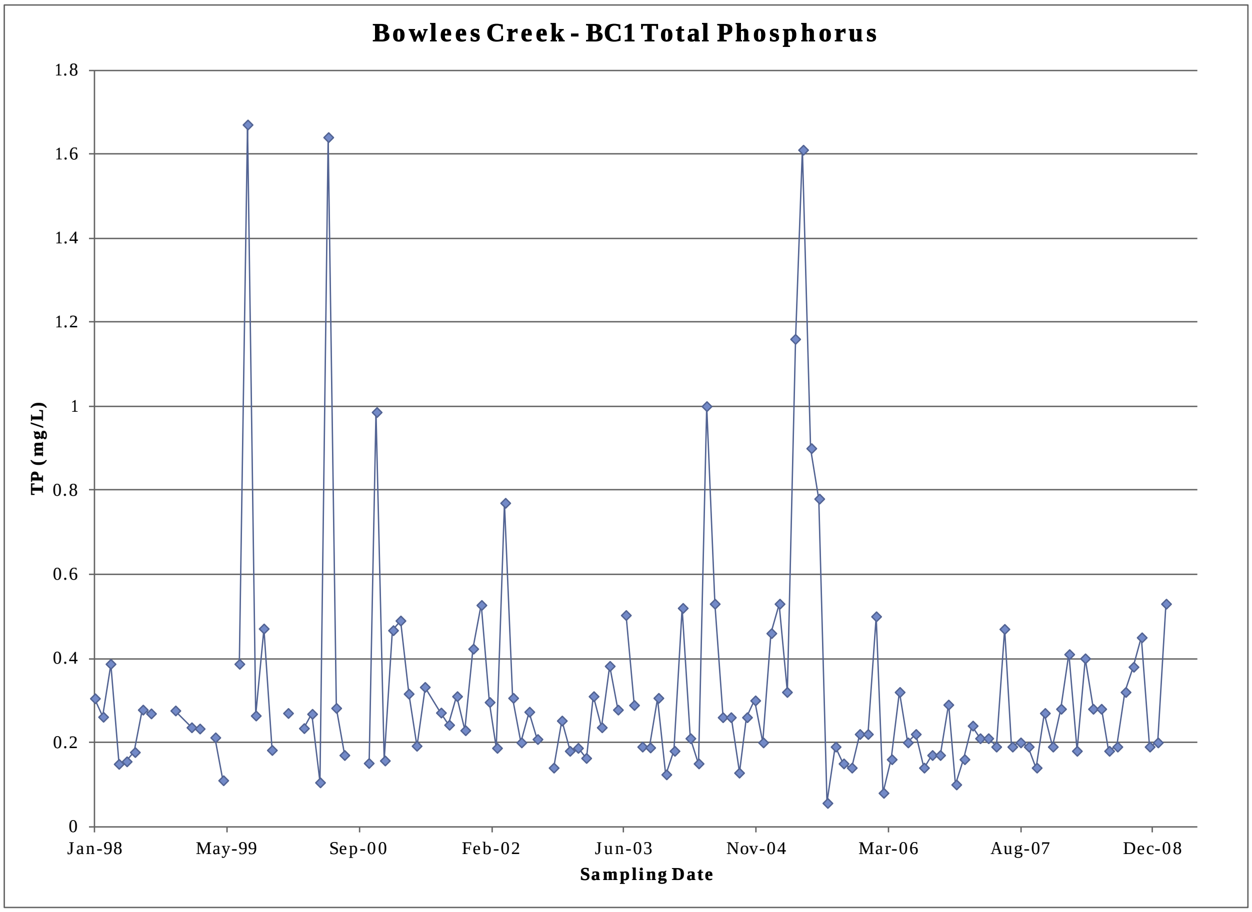


Figure 3-17 TP (mg/L) Concentrations from the Bowless Creek Water Quality Sampling Station

Figure 3-18 shows DO concentrations in Bowless Creek. Despite high nutrients and chlorophyll *a*, Bowlees Creek generally maintained DO concentrations between 4 mg/L and 8 mg/L. Since 2007, DO concentrations were generally lower, with frequent observations less than 4 mg/L.

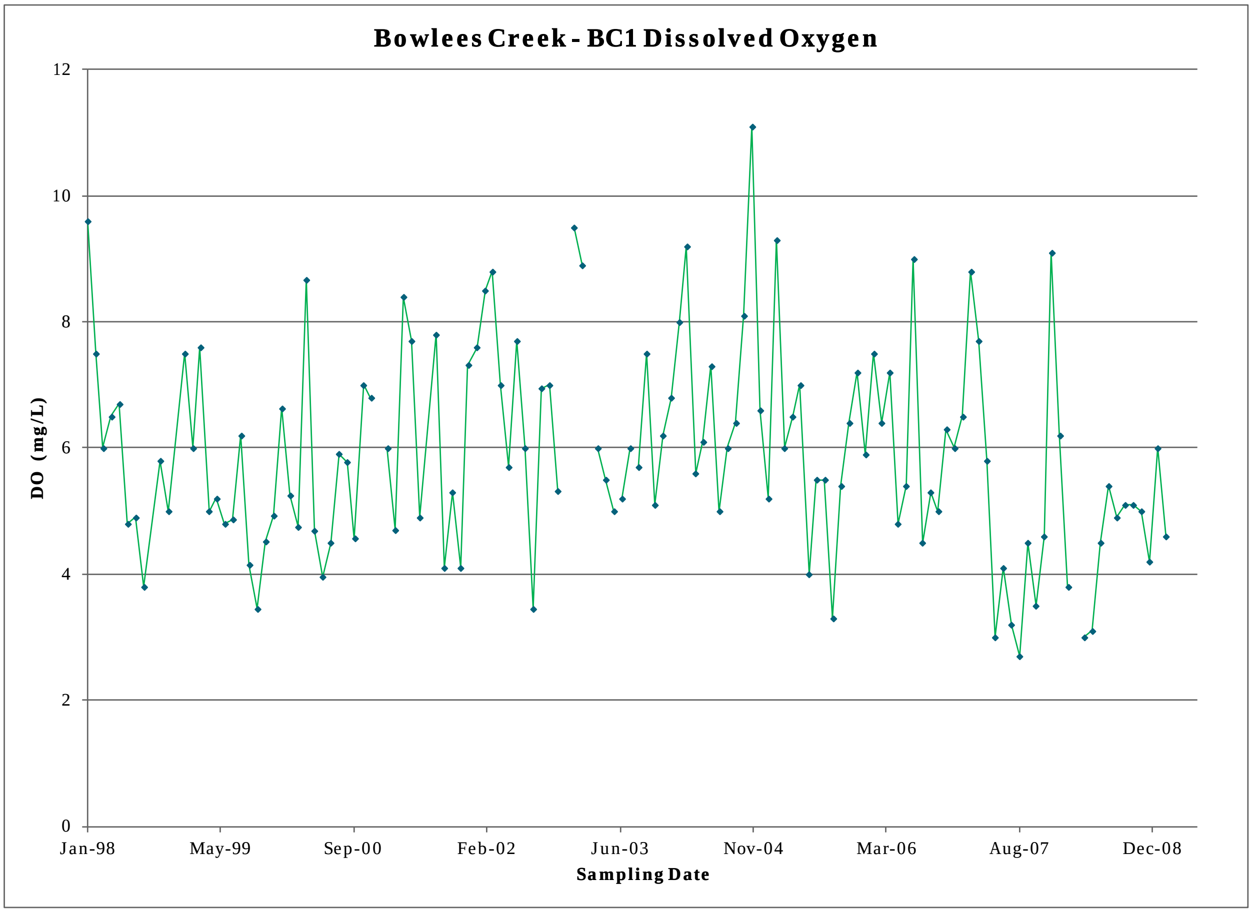


Figure 3-18 DO (mg/L) Concentrations from the Bowless Creek Water Quality Sampling Station

Figure 3-19 shows color in Bowlees Creek. Concentrations were generally between 50 PtCo units and 120 PtCo units, except for the lower color observed during 2004–2005.

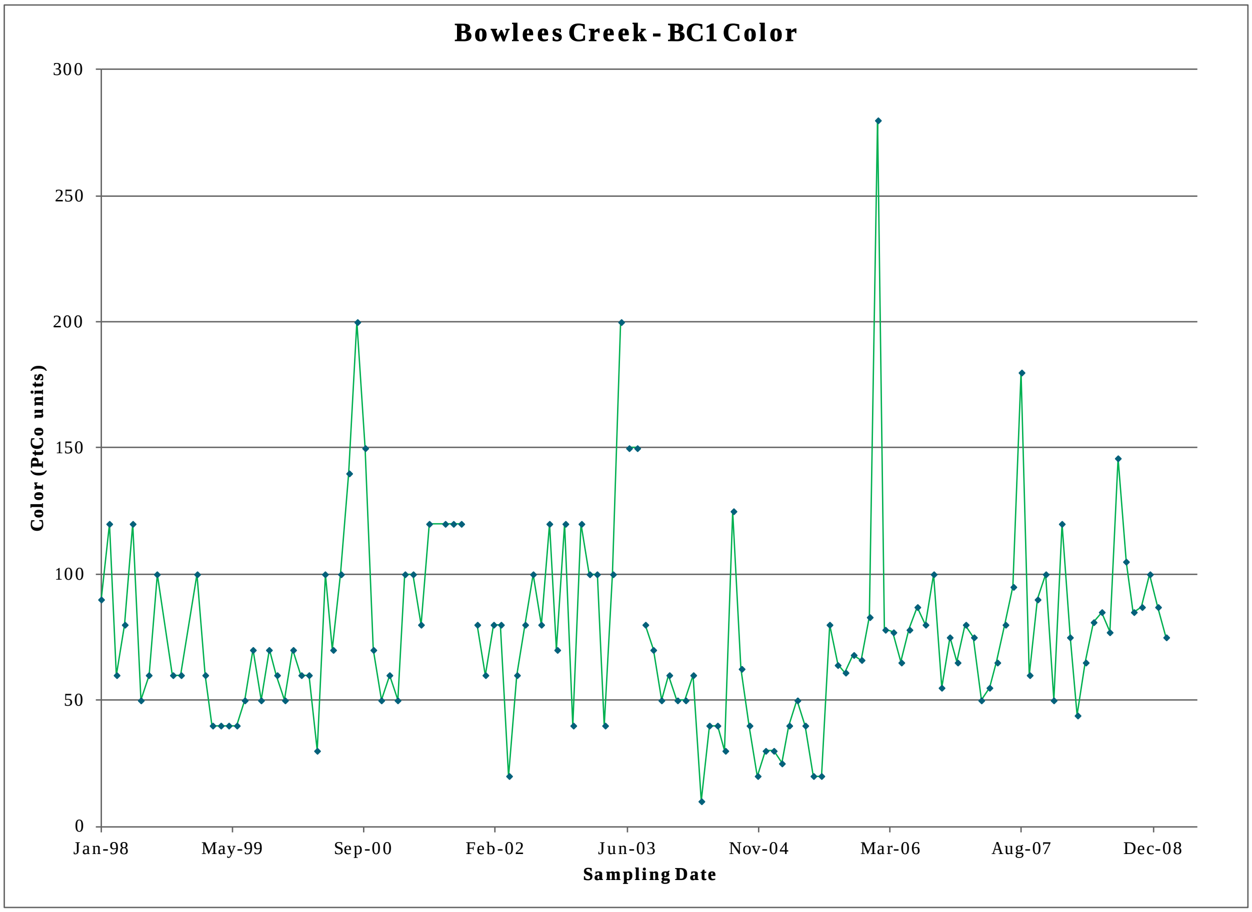


Figure 3-19 Color (PtCo units) Observations from the Bowless Creek Water Quality Sampling Station

3.4.2 Comparison of Freshwater Tributary Ambient Water Quality to FDEP NNC

NNC have been adopted for freshwater streams by FDEP (2012c). Draft TN thresholds for streams were developed based on water quality characteristics of "nutrient watershed regions" within the State. Sarasota Bay tributaries are assigned to the West Central region, shown in Figure 3-20, which has a TN nutrient threshold of 1.65 mg/L and a TP threshold of 0.49 mg/L. To meet the criteria, the annual geometric mean of ambient concentrations may not exceed the criteria more than once in a 3-calendar-year period.

The criteria are applicable for freshwater streams in the Sarasota Bay watershed, specifically the reaches containing sampling stations WB10, WB11, and WB12 in Whitaker Bayou and HB7 and HB8 in Hudson Bayou. Bowlees Creek is tidal and thus is not subject to the freshwater criteria.

Figure 3-20 WBIDs Impaired for TN, TP, DO, or Fecal Coliform in the Sarasota Bay Watershed

3.4.2.1 TN

Table 3-1 shows the annual geometric means of TN for the freshwater reach of Whitaker Bayou, which includes sampling sites WB 10, WB 11, and WB12. The means are below the criterion of 1.65 mg/L for all years (2007 through 2010). Whitaker Bayou was also sampled in 2006 but only for October–December. The geometric mean for that 3-month period is 0.9 mg/L but would not be used to determine conformance with the criterion. Calculating an annual geometric mean for TN or TP using the FDEP (2012a) protocol requires at least four temporally independent samples per year with at least one sample taken between May 1 and September 30 and at least one sample taken during the other months of the calendar year.

Table 3-1 also presents annual geometric means for the freshwater portion of Hudson Bayou, which includes sampling sites HB7 and HB8. The values all meet the proposed threshold.

Table 3-1 Annual Geometric Mean TN and TP Concentrations in Freshwater Sarasota Bay Tributaries

Waterbody	Year	TN (mg/L)	TP (mg/L
Whitaker Bayou	2007	0.73	0.27
	2008	0.65	0.25
	2009	0.79	0.32
	2010	0.01	0.29
Hudson Bayou	2007	0.68	0.49
	2008	0.63	0.47
	2009	0.86	0.55
	2010	1.02	0.49
FDEP NNC		*1.65*	*0.49*

3.4.2.2 TP

Table 3-1 shows that the freshwater portion of Whitaker Bayou meets the TP threshold of 0.49 mg/L. However, the annual geometric mean for freshwater Hudson Bayou equaled the threshold in 2007 and 2010 and exceeded the threshold in 2009 (0.55 mg/L). Because the FDEP (2012a) protocol states that the threshold would not be met if it is exceeded (not equaled) more than once in a 3-year period, Hudson Bayou would meet the threshold.

3.4.3 Impaired WBIDs within the Sarasota Bay Watershed

Although several Total Maximum Daily Loads (TMDLs) have been proposed or adopted for Sarasota County's WBIDs, no TMDLs have been proposed for Sarasota Bay proper or its tributaries. However, several WBIDs within the Sarasota Bay watershed have been identified as impaired, as indicated by the IWR criteria (FDEP, 2011c). Figure 3-20 and Table 3-2 present the WBIDs within the Sarasota Bay watershed that were designated as impaired for TN, TP, DO, or fecal coliform.

Table 3-2 Impaired Waterbodies in the Sarasota Bay Watershed using Impaired Waters Rule Criteria (FDEP, 2011)

WBID	Water Segment Name and County	Waterbody Class	Parameters Assessed	DO / Biology Pollutant of Concern	Pollutant of Concern Median Concentrations (mg/L)	Concentration of Criterion or Threshold Not Met	Priority for TMDL Development	Verified Period (no. exceedances / no. samples)[6]	Comments
1885	West Cedar Hammock Manatee	Class 3 Marine	Dissolved Oxygen (Nutrients)	TN, TP, BOD	TN =1.07 (n=40) TP =0.27 (n=42) BOD =2.3 (n=33)	≥ 4.0 mg/L	Medium	9/40	Impaired with TN, TP, and BOD identified as the causative pollutants.
1885	West Cedar Hammock Manatee	Class 3 Marine	Fecal Coliform			≤ 400 Counts / 100 mL	Low	36/39	Impaired based on the number of exceedances.
1916	Longboat Key Manatee/ Sarasota	Class 3 Marine	Dissolved Oxygen	BOD	TN =0.766 (n=5) TP =0.049 (n=5) BOD =2.9 (n=21)	≥ 4.0 mg/L	Medium	9/21	Impaired with BOD identified as the causative pollutant.
1936	Whitaker Bayou (Tidal) Sarasota	Class 3 Marine	Nutrients (Chlorophyll a)		TN =1.166 (n=14) TP =0.275 (n=14) BOD =2.9 (n=14)	≤ 11 µg/L	High	2008 (39.0 µg/l)	Impaired because annual average Chl-*a* concentrations exceeded 11 µg/L in 2008. Nitrogen is the limiting nutrient based on the TN/TP ratio median of 4.11 mg/L.
1936	Whitaker Bayou (Tidal) Sarasota	Class 3 Marine	Dissolved Oxygen (Nutrients)	TN, TP, BOD	TN =1.166 (n=14) TP =0.275 (n=14) BOD =2.9 (n=14)	≥ 4.0 mg/L	High	7/16	Impaired with TN, TP, and BOD identified as the causative pollutants.

Table 3-2 Impaired Waterbodies in the Sarasota Bay Watershed using Impaired Waters Rule Criteria (FDEP, 2011)

WBID	Water Segment Name and County	Waterbody Class	Parameters Assessed	DO / Biology Pollutant of Concern	Pollutant of Concern Median Concentrations (mg/L)	Concentration of Criterion or Threshold Not Met	Priority for TMDL Development	Verified Period (no. exceedances / no. samples)[6]	Comments
1936	Whitaker Bayou (Tidal) Sarasota	Class 3 Marine	Fecal Coliform			≤ 400 Counts / 100 mL	Low	14/24	Impaired based on the number of exceedances.
1953	Hudson Bayou Tidal Sarasota	Class 3 Marine	Dissolved Oxygen	BOD	TN =0.734 (n=18) TP =0.13 (n=17) BOD =2.2 (n=18)	≥ 4.0 mg/L	Medium	11/21	Impaired with BOD identified as the causative pollutant.
1953	Hudson Bayou Tidal Sarasota	Class 3 Marine	Fecal Coliform			≤ 400 Counts / 100 mL	Low	7/20	Impaired based on the number of exceedances.

Hudson Bayou WBID 1953, Whitaker Bayou WBID 1936, and West Cedar Hammock WBID 1885 have been deemed impaired for fecal coliform based on exceedances of the fecal coliform standard of 400 counts/100 milliliters as shown in Table 3-2.

Hudson Bayou WBID 1953, Whitaker Bayou WBID 1936, West Cedar Hammock WBID 1885, and Longboat Key WBID 1916 have all been deemed impaired for DO. The Hudson Bayou impairment was identified as being caused by elevated BOD concentrations. The Whitaker Bayou and West Cedar Hammock impairments were attributed to elevated BOD, TN, and TP concentrations. BOD was identified as the causative agent for the Longboat Key impairment.

Whitaker Bayou was also identified as impaired for nutrients (TN) because of elevated chlorophyll *a* concentrations. The chlorophyll *a* threshold for marine waters is 11 µg/L. Chlorophyll *a* in samples from Whitaker Bayou exceeded that value by a factor of three in 2008, leading to the impairment determination.

3.4.4 Data Collection

No data gaps were found during this analysis. Therefore, we do not recommend additional monitoring or data collection.

4.0 CURRENT AND FUTURE POLLUTANT LOADINGS

4.1 OBJECTIVE

This section presents the approach, data used, and summary of results associated with examining the current and future nutrient and suspended solids loads for Sarasota Bay.

4.2 APPROACH

The SIMPLE model has a number of modules that estimate hydrologic and pollutant loads from a number of sources. The SIMPLE model was used to estimate hydrologic and nutrient inputs from the following sources:

- Atmospheric deposition (direct precipitation to the open water estuary).
- Baseflow.
- Direct runoff.
- Irrigation.
- Point sources.
- Septic tanks.

The analyses of these data included examining and comparing the spatial and temporal variation in nutrient loads to Sarasota Bay.

4.3 DATA USED

4.3.1 Current

The current nutrient-loading estimates were provided by a SIMPLE model for 1989 through 2008. The modeling was completed for a project funded by SBEP ("Numeric Nutrient Criteria for Sarasota Bay" prepared by Janicki Environmental, Inc. (Janicki Environmental, 2010a). Sources of data and methodologies for current conditions loadings are documented in the report.

4.3.2 Future

A Decision Memorandum defined the methods used to estimate the future nutrient loadings. The future conditions scenario was not defined according to a specific time frame but was developed to incorporate the following assumptions:

- Future land use followed the Jones Edmunds' approach used for the Roberts Bay North Plan in which undeveloped uplands were converted to medium-density residential.

- Future stormwater management assumed that loads from all new medium-density residential lands were reduced by an efficiency consistent with a wet detention pond.
- Stormwater event mean concentrations (EMCs) were the same as those used for the current conditions model runs.
- Rainfall and evapotranspiration estimates were the same as those used for the historical and current conditions model runs.
- Soil coverage was the same as that used for the historical and current conditions model runs.
- The City of Sarasota wastewater treatment plant was the only point source within the Sarasota Bay watershed. This facility disposes of treated effluent via deep-well injection during the wet season (June–September) and distribution to reuse during the dry season. The City of Sarasota was contacted to obtain data to use in estimating future loading rates. Although the plant's direct discharge to Whitaker Bayou is proposed to be taken offline in the future, there is no definitive schedule. Based on population projections, the change in point-source flows over the next decades is projected to be small; therefore, the point-source loads were kept the same as for existing conditions.
- Septic tank GIS-based coverage was the same as current conditions; however, the number of units was adjusted to reflect changing wastewater service areas.
- Atmospheric deposition loadings reflect the 38% future emissions reductions for TN estimated by EPA as a result of power plant cleanups and cleaner automobiles. These load-reduction estimates have been developed by EPA only recently and were not used in estimating loading for the Roberts North Bay or Lemon Bay Watershed Management Plans.

4.4 RESULTS

4.4.1 Comparison of Current and Future Nutrient Loads

4.4.1.1 Annual

Figure 4-1 shows total annual hydrologic loads for current and future conditions. Hydrologic loads during both periods range from approximately 100 to 210 million m^3/year. Except for a slight increase in hydrologic loads under future conditions, very little difference was observed between current and future conditions.

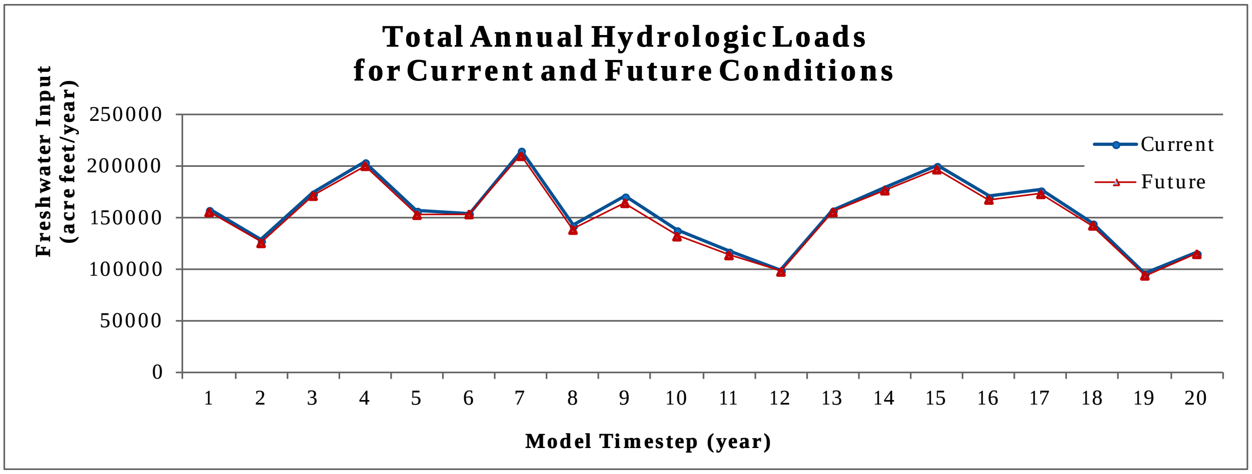


Figure 4-1 Total Annual Hydrologic Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-2 shows annual TN loads for current and future conditions. Comparing the trend in TN loads in Figure 4-2 with hydrologic loads in Figure 4-1 demonstrates the relationship between hydrologic and nutrient loads. TN loads during both periods range from approximately 110 to 250–280 tons/year and are lower under future conditions compared to current estimates as a result of the removal of direct point-source discharges and reductions in emissions expected to lower loads from atmospheric deposition.

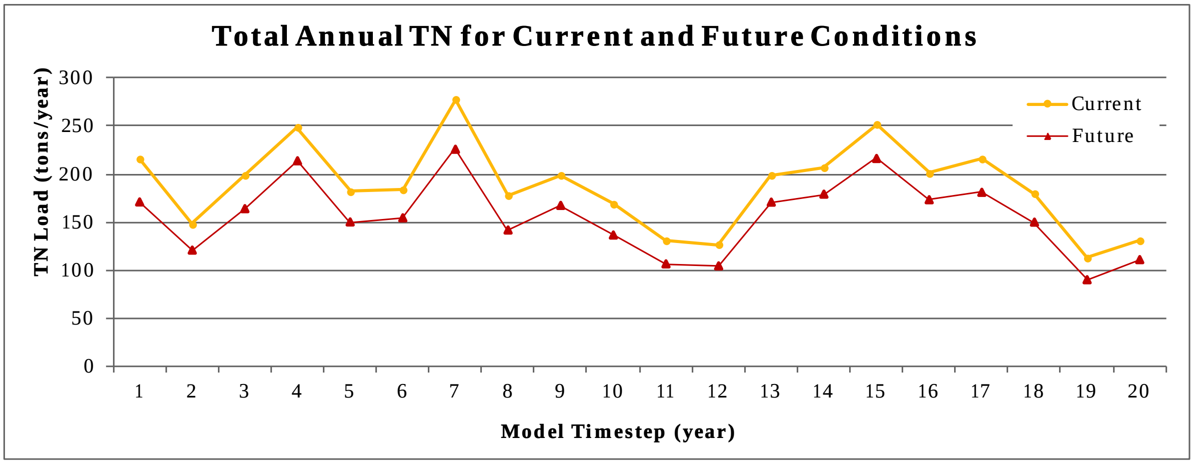


Figure 4-2 Total Annual TN loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-3 shows annual TP loads for current and future conditions. Comparing the trend in TP loads in Figure 4-3 with hydrologic loads in Figure 4-1 demonstrates the relationship between hydrologic and nutrient loads. TP loads range from approximately 18–38 tons/year and are nearly identical for current and future watershed conditions. The relatively small change in TN and TP loading estimates from current to future conditions can be interpreted as reflecting the influence of atmospheric deposition and the current nearly "built-out" state of the Sarasota Bay watershed, which provides low potential for future urban development and associated increased land-based loadings.

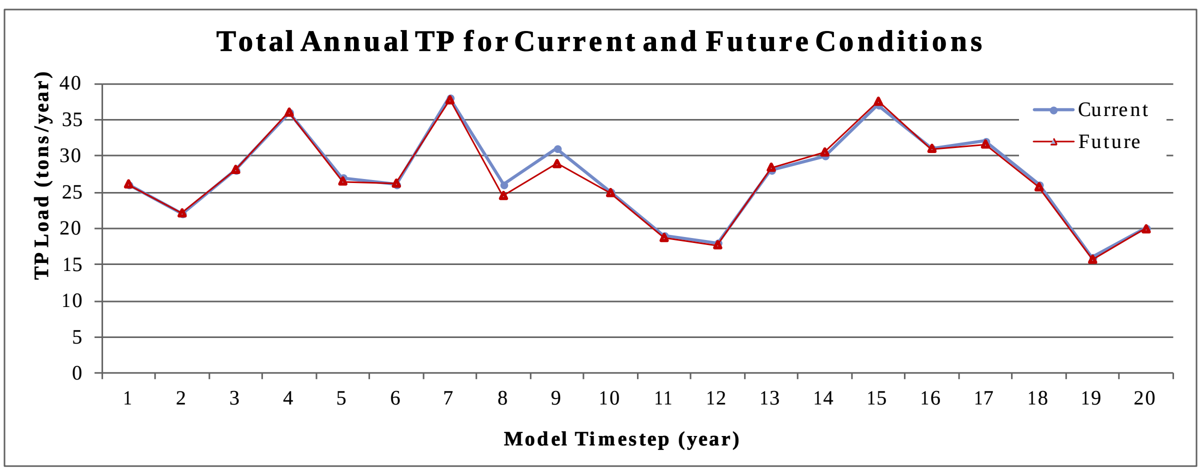


Figure 4-3 Total Annual TP loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-4 shows annual TSS loads for current and future conditions. TSS loads range from approximately 1,500–4,000 tons/year. TSS loads differ very little between current and future conditions. Because TSS loadings are largely a function of watershed land use and soils, the relatively small change in nutrient-loading estimates from current to future conditions can be attributed to the relatively small increase in urban land under future conditions.

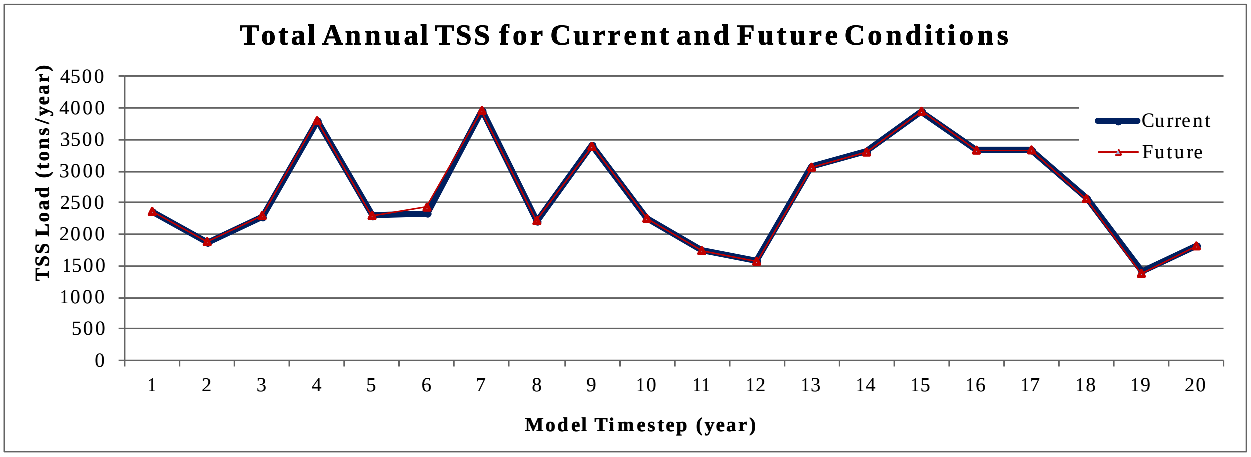


Figure 4-4 Total Annual TSS Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

4.4.1.2 Seasonal

Figure 4-5 shows the seasonal variability in hydrologic inputs under current and future conditions. This figure illustrates the similar wet-dry pattern for both periods, as would be expected since both scenarios used the same precipitation record. June has the most extreme events, but later months during the wet season have higher median hydrologic loads. Monthly hydrologic loads vary nearly two-fold between the wet season (June–October) and the dry season (November–May). No zero-flow months were observed because precipitation-independent sources such as baseflow contribute to hydrologic inputs each month.

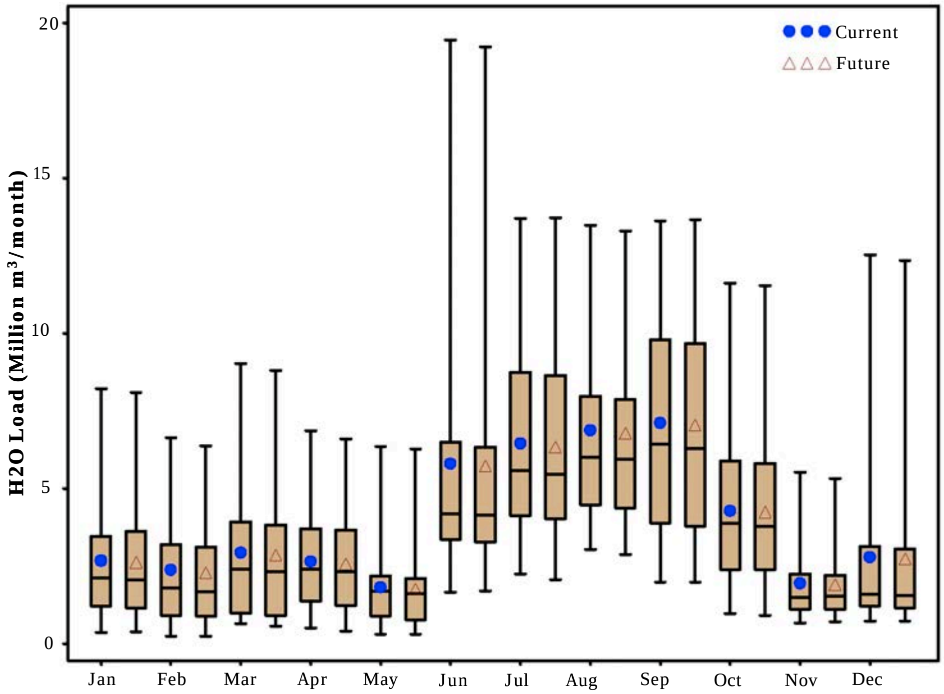


Figure 4-5 Within-Year Variation in Hydrologic Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-6 shows the seasonal variability in TN loads under current and future conditions. Seasonal patterns in TN loads reflect the seasonality in hydrologic inputs shown in Figure 4-6. As with hydrologic inputs, June has the most variable TN loadings, but the highest TN loads are from July through September. Wet season TN loadings are nearly twice as high as those during the dry season. A reduction in TN loads is apparent from the current to the future watershed condition, particularly during the wet months (June–September) as a result of no direct point-source discharge, lowered emissions, and less TN from atmospheric deposition.

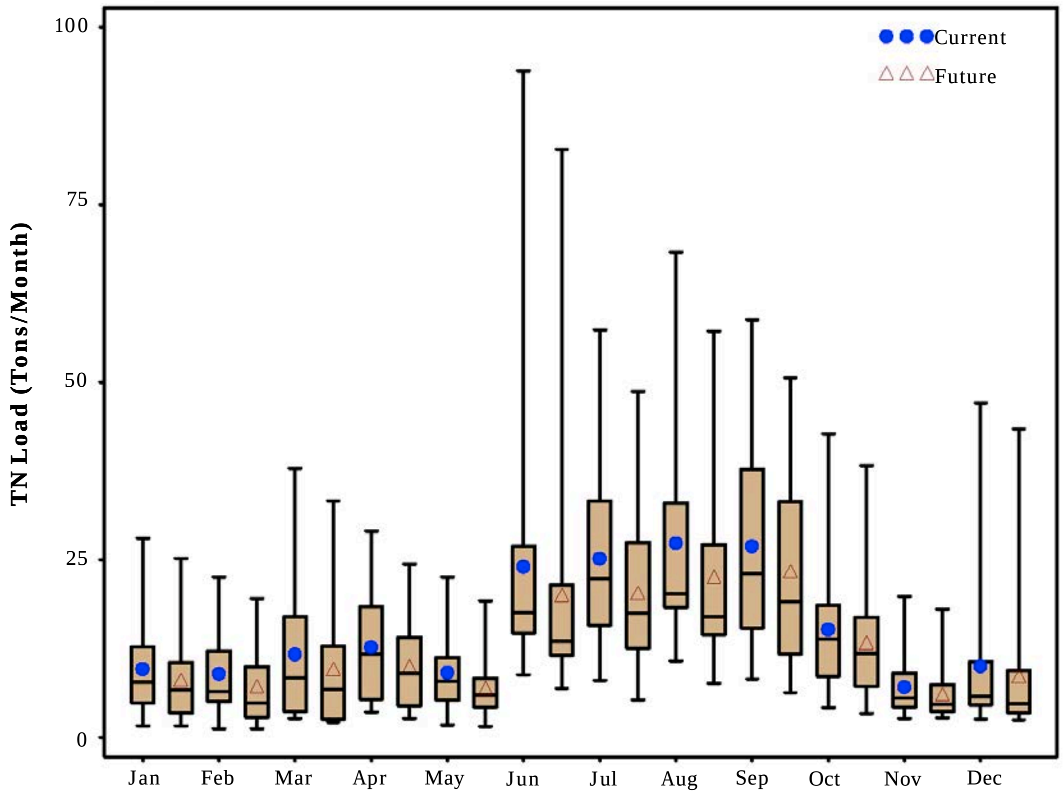


Figure 4-6 Within-Year Variation in TN loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-7 shows seasonal variation in TP loads under current and future conditions. As with TN loads, the monthly variability in TP loads is largely a function of hydrologic inputs. Seasonality is apparent for TP loads, with a nearly two-fold increase in TP load from the dry season to the wet season. TP loadings are nearly identical between the current and future watershed conditions.

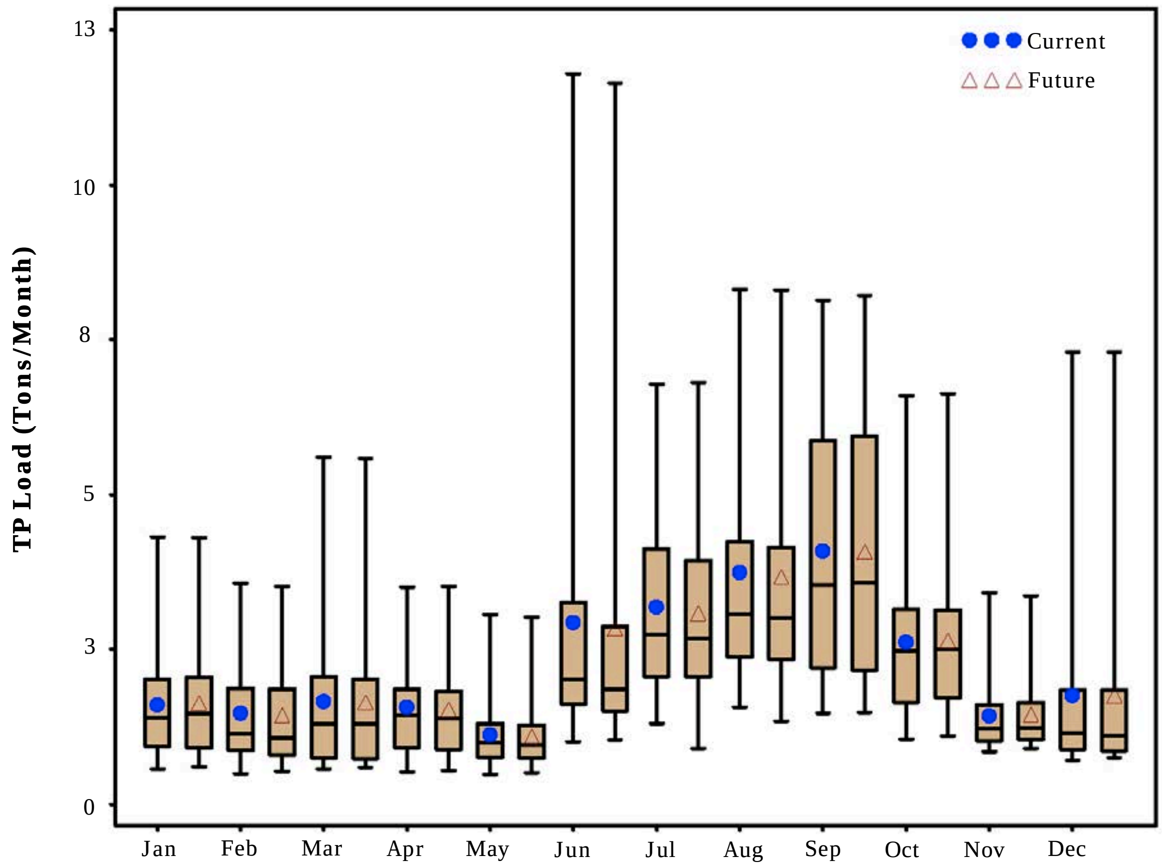


Figure 4-7 Within-Year Variation in TP Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-8 shows seasonal variation in total TSS loads under current and future conditions. Loadings of TSS are higher and more variable during the wet season from June through October under current and future conditions. Very little change in TSS loadings was observed, however, from the current to future watershed condition.

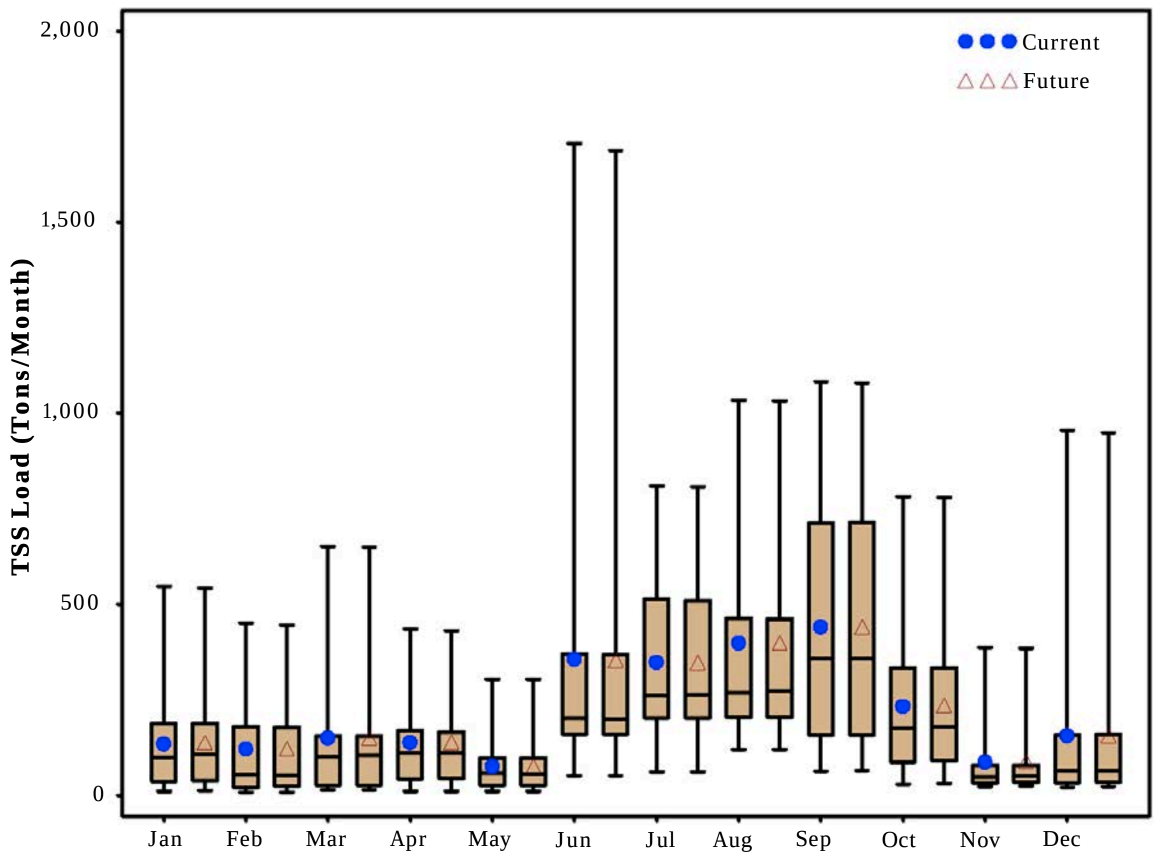
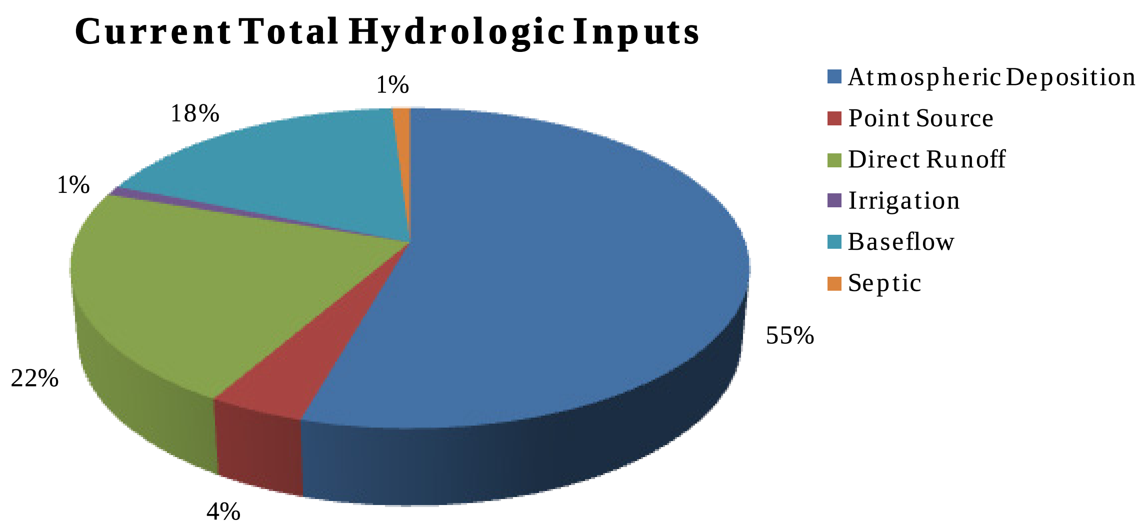


Figure 4-8 Within-Year Variation in TSS Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

4.4.1.3 Source Allocation

A. Overall

Figure 4-9 compares the hydrologic inputs from each of the sources during current and future watershed conditions. The major difference in the relative contribution of each source type between current and future conditions is the lack of direct point-source discharges in the future conditions. Because point-source discharges are in current conditions but not future, the relative percent contribution of the remaining sources appears quite different in some cases, even though the total load may be the same or less. Slight increases in hydrologic load from baseflow, direct runoff, and atmospheric deposition can be observed. In both scenarios, atmospheric deposition is the largest source of hydrologic inputs to the estuary, accounting for greater than half of the total hydrologic load. This is a reflection of the relatively large surface area of the estuary compared to the watershed's land area. Direct rainfall on the bay is a larger source of freshwater loading, even though inland areas average almost 9 more inches of precipitation than the bay annually. Direct runoff and baseflow also contributed significant hydrologic loads at approximately 20% each. Septic tanks and irrigation loads were minor sources.



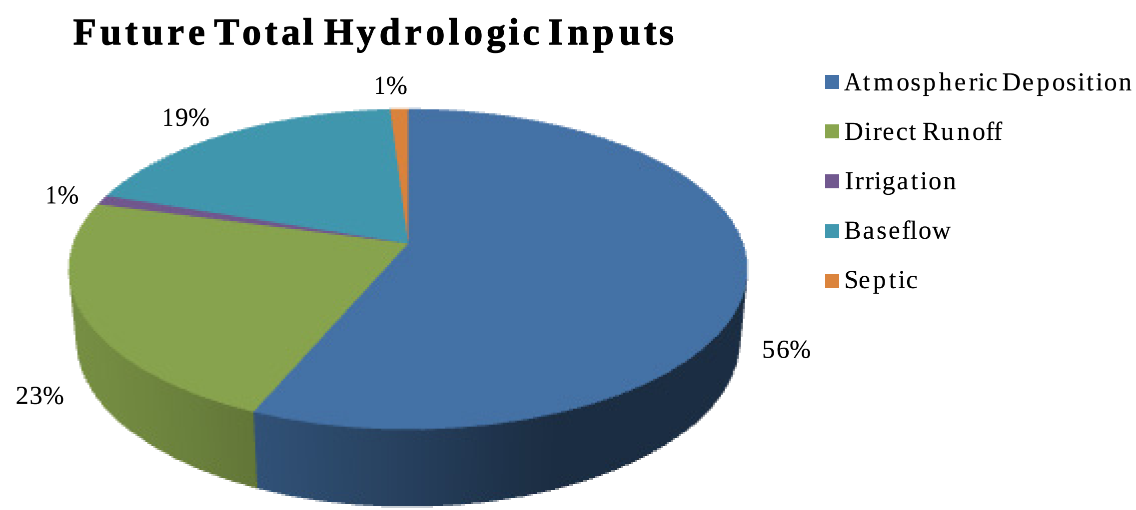


Figure 4-9 Comparison of the Relative Contributions from Various Sources to Hydrologic Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-10 compares TN loads by source for current and future watershed conditions. In both conditions, direct runoff accounted for the largest contribution of estimated current and future TN loads (45% and 48%, respectively). Atmospheric deposition was a significant source of TN, contributing nearly one-third of the total TN load. A reduction in the contribution of TN loads derived from point sources from 7% to 0% can be seen and results in changes to the relative contributions of remaining sources. Baseflow was a significant but smaller source of TN to the estuary. The smallest TN loads originated from septic tank and irrigation sources in future conditions and combined represented 4% of the total TN load.

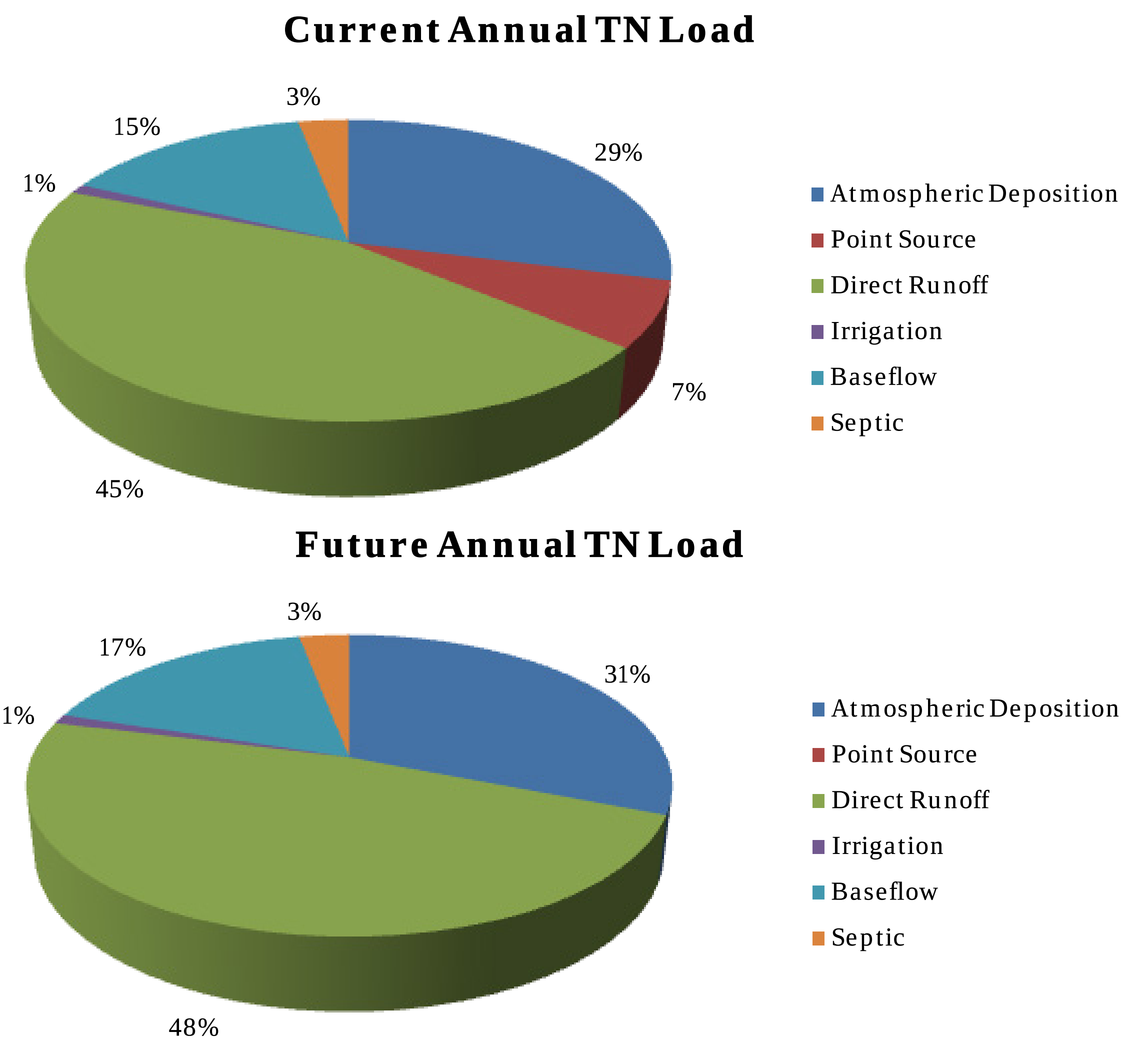


Figure 4-10 Comparison of the Relative Contributions from Various Sources to TN Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-11 compares the TP loads from each source during current and future watershed conditions. Increases in TP loadings from baseflow (2%) and irrigation (1%) can be observed as well as the elimination of point-source TP loads. Direct runoff was by far the largest source of TP loads in both conditions and represented half of the total TP loadings to Sarasota Bay. Considerable TP loads were also contributed via baseflow (almost 30%) with much smaller contributions from irrigation, septic tanks, and atmospheric deposition.

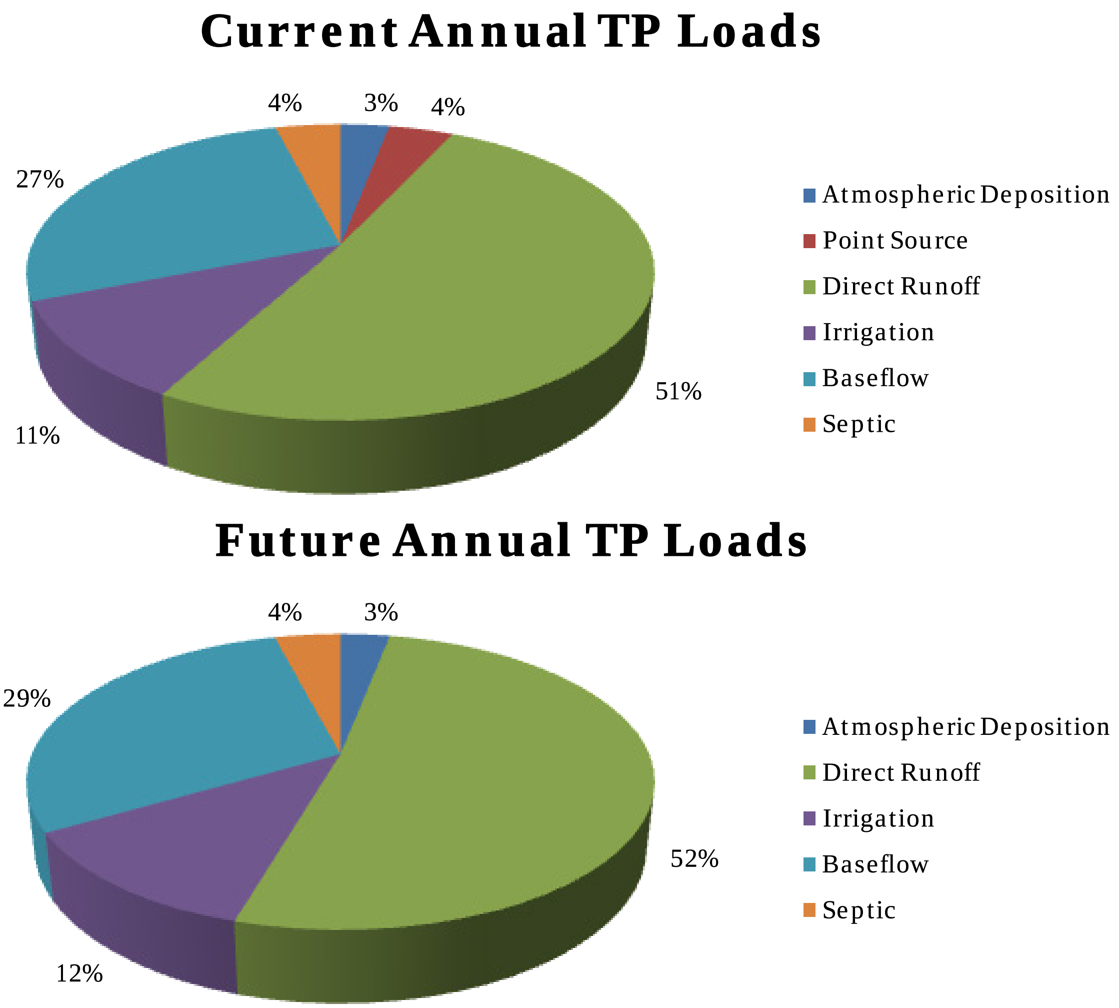
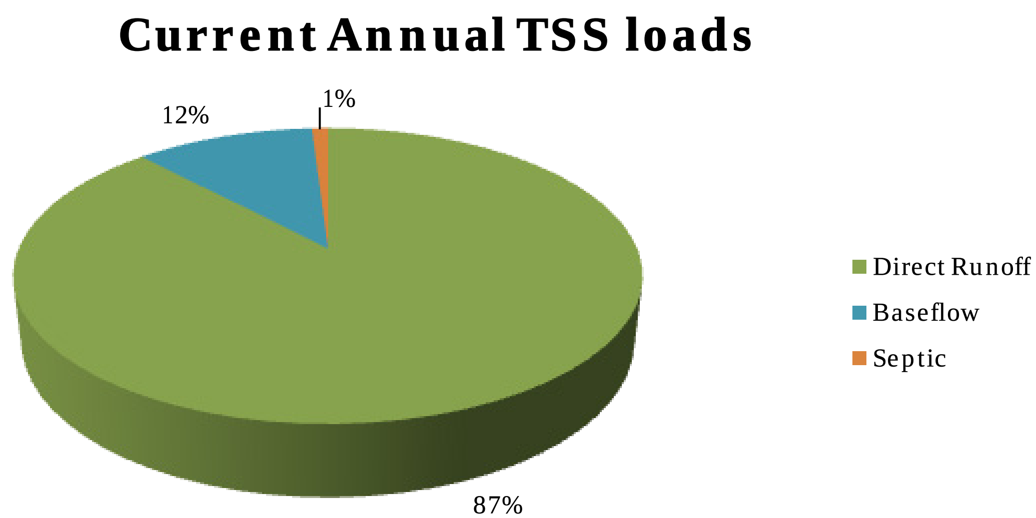


Figure 4-11 Comparison of the Relative Contributions from Various Sources to TP Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

Figure 4-12 compares the TSS loads from each source during current and future watershed conditions. Differences in the relative contribution of TSS loads from each source for current and future conditions are negligible. A slight increase in TSS loads from baseflow is suggested (1%), as well as slight decreases in TSS from direct runoff (1%) and septic sources (<1%). The majority of TSS originated from direct runoff (nearly 90%) with an additional 10% derived from baseflow.



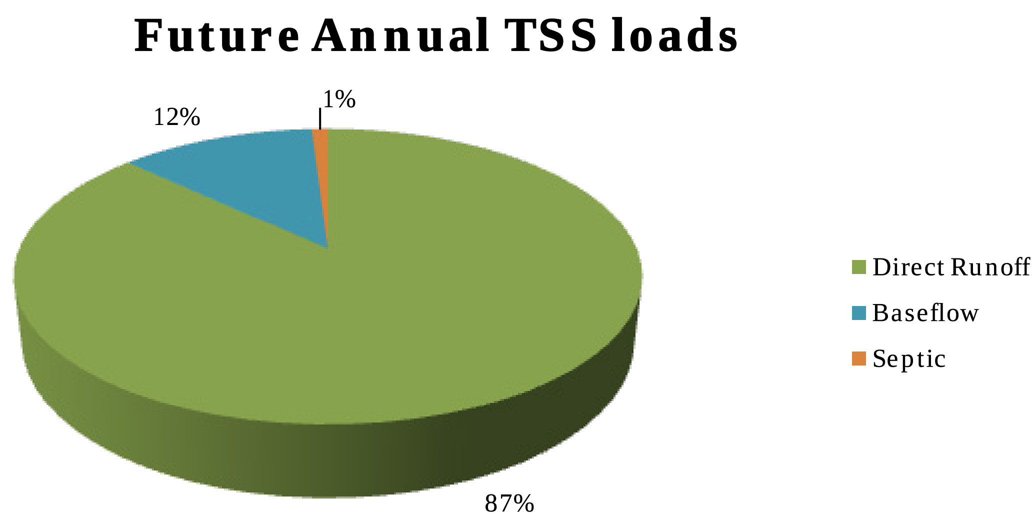


Figure 4-12 Comparison of the Relative Contributions from Various Sources to TSS Loads to Sarasota Bay for Current and Future Watershed Conditions (1989–2008)

B. Annual Variation

Figure 4-13 compares annual hydrologic loads by source for current and future conditions. The relative contribution of annual hydrologic loads by source is very similar for current and future watershed conditions, with the exception of point-source discharges. Very slight increases in baseflow are apparent in the future condition and are consistent across years.

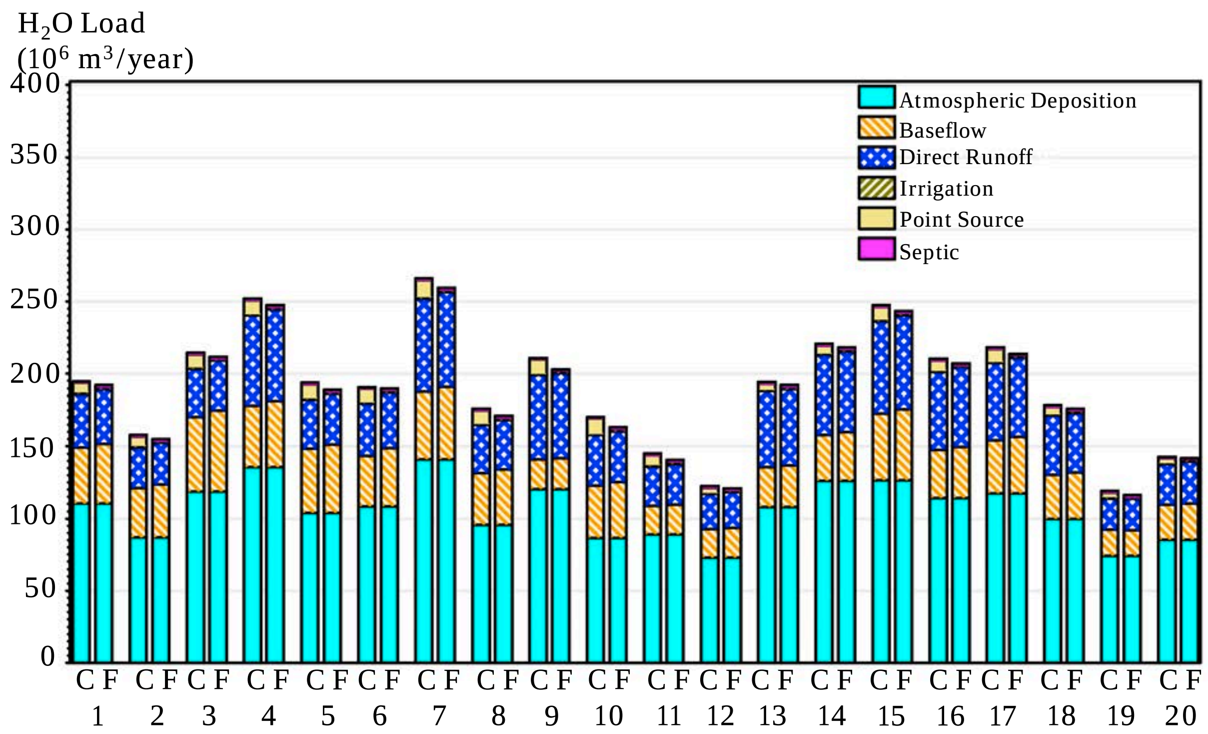


Figure 4-13 Comparison of Annual Hydrologic Loads to Sarasota Bay by Source for Current and Future Watershed Conditions (1989–2008)

Figure 4-14 compares annual TN loads by source for current and future conditions. No point-source loads are in the future conditions, and a small reduction in the relative contribution of TN loads by source occurs between current and future watershed conditions as a result of lower TN loads from atmospheric deposition. Small increases in TN loadings from baseflow and direct runoff sources are also apparent among years under the future condition.

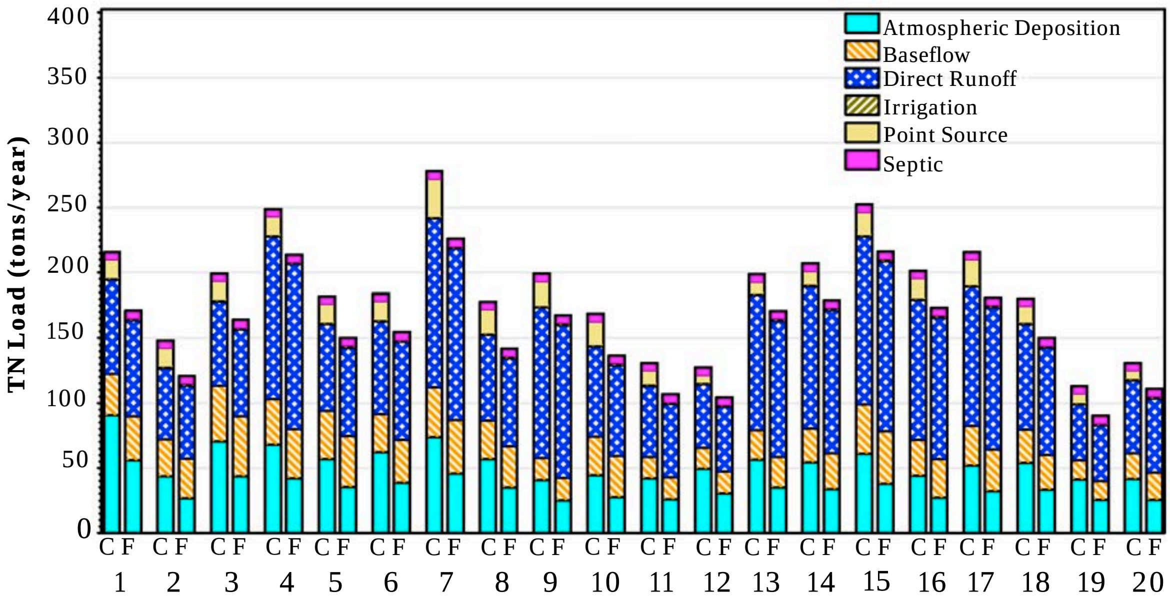


Figure 4-14 Comparison of Annual TN Loads to Sarasota Bay by Source for Current and Future Watershed Conditions (1989–2008)

Figure 4-15 compares annual TP loads by source for current and future conditions. Baseflow and irrigation appear to be responsible for the slight increase in TP loadings during years in which future TP loads are greater than current loading estimates. During several years, a slight reduction in TP loads results from the elimination of point-source loads.

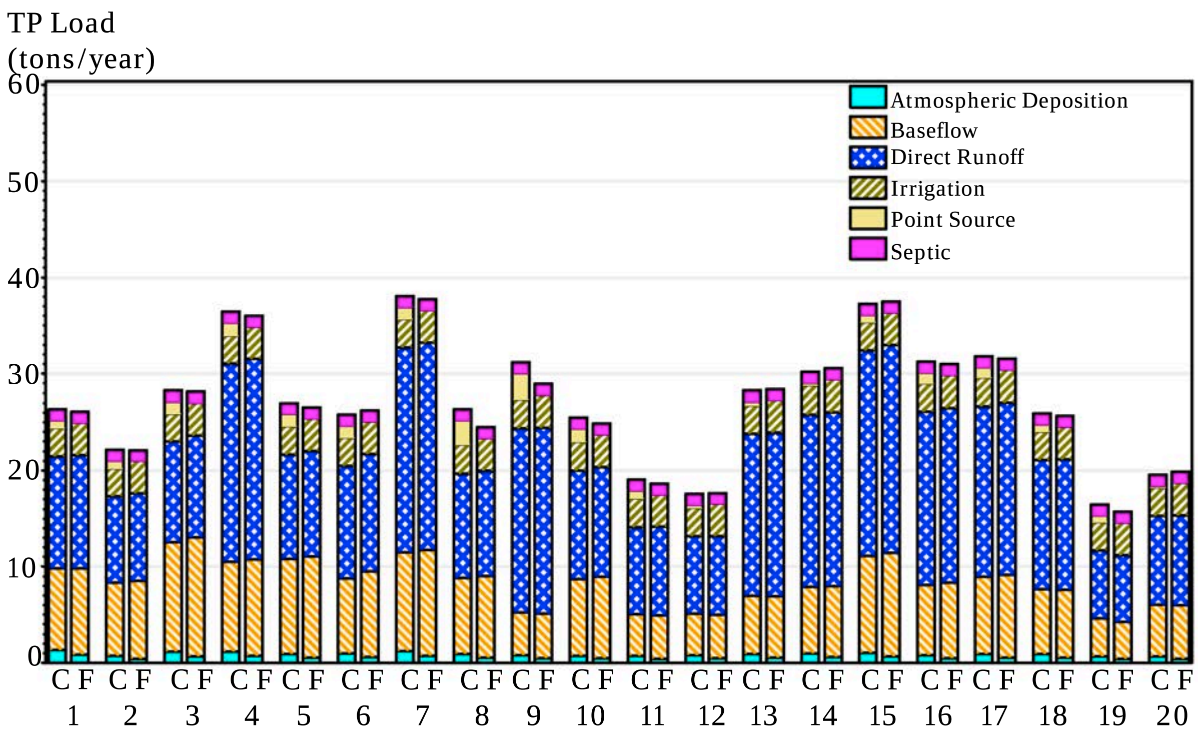


Figure 4-15 Comparison of Annual TP loads to Sarasota Bay by Source for Current and Future Watershed Conditions (1989–2008)

Figure 4-16 compares annual TSS loads by source for current and future conditions. The majority of TSS loads originate from direct runoff in all years with little change in TSS loads from any of the sources between current and future watershed conditions.

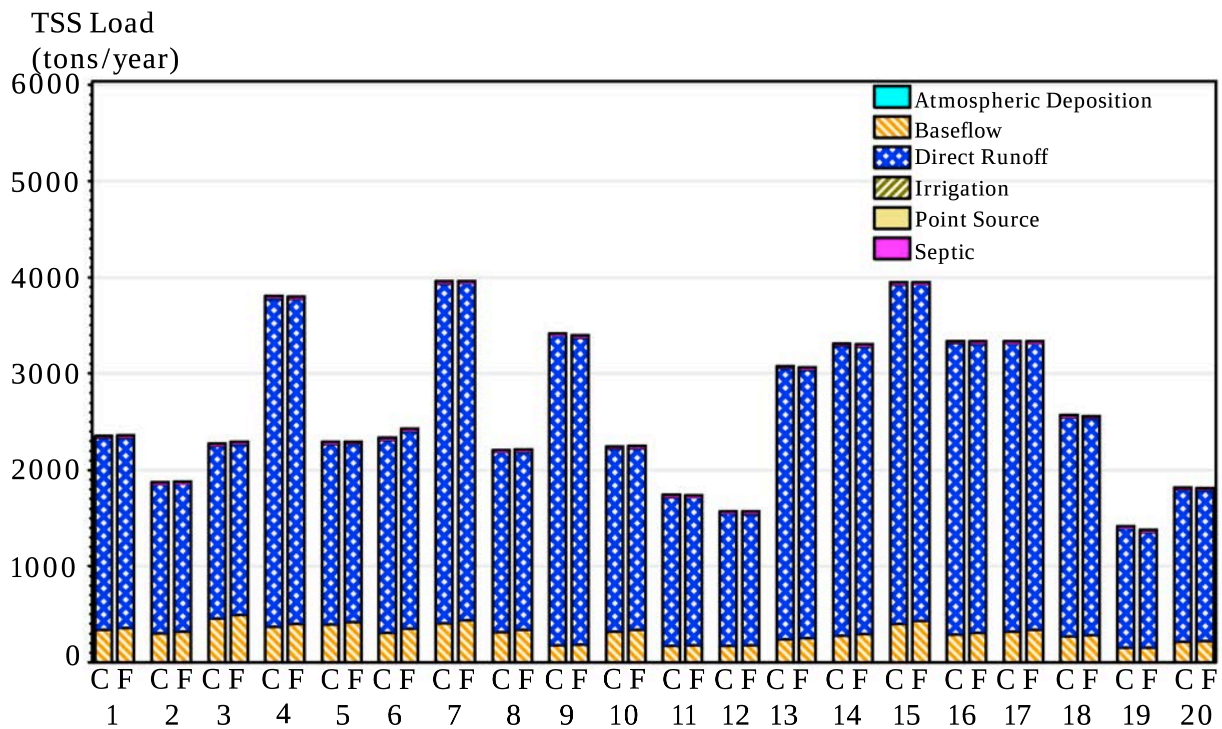


Figure 4-16 Comparison of Annual TSS Loads to Sarasota Bay by Source for Current and Future Watershed Conditions (1989–2008)

C. Spatial

The 10 basins within the Sarasota Bay watershed range in size from 83 to 5,783 acres (Table 4-1). Basin names provided by Sarasota and Manatee Counties were used. Sub-basin identification numbers shown correspond to figures at the end of this Appendix. The largest basins in the watershed—Bowlees Creek, Sarasota Bay Coastal North, and Whitaker Bayou—cover just over half of the watershed (57%), while the Longboat/Lido Key, Cedar Hammock Creek, and Hudson Bayou basins are only half the size of the largest basins and occupy nearly one-third (29%) of the watershed. The Sarasota Bay Coastal South and Cortez Drain basins each drain approximately 5% of the total watershed area. The three smallest basins drained <2% each. One of those basins—the north portion of Siesta Key—drains to Sarasota Bay (83 acres), but the majority of the key drains to Roberts Bay and Little Sarasota Bay to the southeast.

Table 4-1 Acreage of Basins within the Sarasota Bay Watershed		
Basin	Sub-basins	Area (acres)
Canal Road Drain	38,115	378
Sarasota Bay Coastal North	98	4,784
Palma Sola Drain – Bayshore	90	1,397
Cedar Hammock Creek	91,92,95	2,718
Bowlees Creek	93,94,96,97	5,783
Longboat/Lido Key	117	2,816
Sarasota Bay Coastal South	100, 101	1,711
Whitaker Bayou	99,110-114,116	5,219
Hudson Bayou	102-109	2,406
Siesta Key	118	83

Figure 4-17 compares annual average hydrologic loads by source from each Sarasota Bay basin under current and future conditions. In both scenarios, the largest total hydrologic loads are contributed by the largest basins: Whitaker Bayou and Bowlees Creek. The greatest increase from current to future conditions in total hydrologic loads is observed in the Sarasota Bay Coastal North basin as a result of increased contributions from baseflow and direct runoff sources. This increase reflects the conversion of undeveloped areas in the current condition to urban lands in the future. Also notable is the reduction in hydrologic loads from septic tanks in the Longboat/Lido Key and Whitaker Bayou basins following the removal of septic tanks in the future condition.

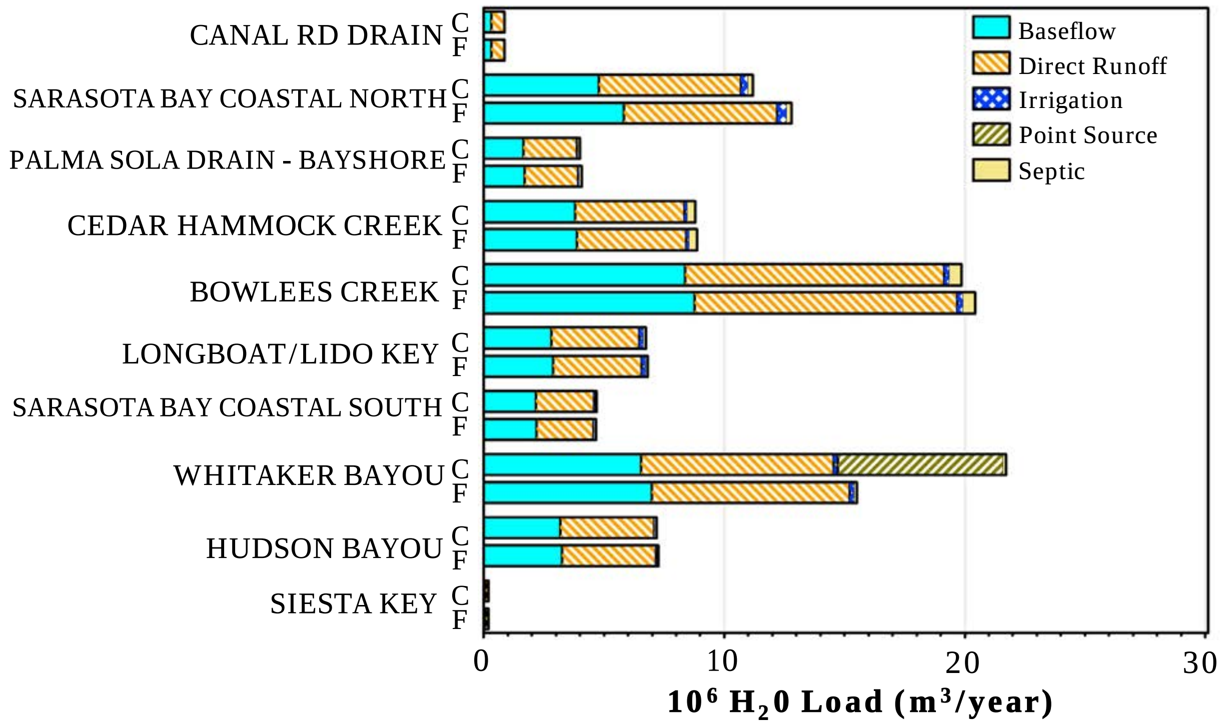


Figure 4-17 Comparison of Annual Hydrologic Loads to Sarasota Bay by Basin and Source for Current and Future Watershed Conditions (1989–2008)

Figure 4-18 compares annual average TN loads by source from each Sarasota Bay basin under current and future conditions. As with hydrologic loads, Whitaker Bayou and Bowlees Creek contributed the greatest TN loads under both conditions. Only small changes in TN loads (1–2 tons) are observed between the current and future conditions. Reductions in septic loads of TN are apparent for Longboat/Lido Key and Whitaker Bayou as a result of septic tank removal. In contrast, increases in septic loads resulted from aging septic tanks in several other basins, including Bowlees Creek. Slight increases in TN loads from baseflow and direct runoff appear to be the result of changes in land use as undeveloped land is converted to urban land uses.

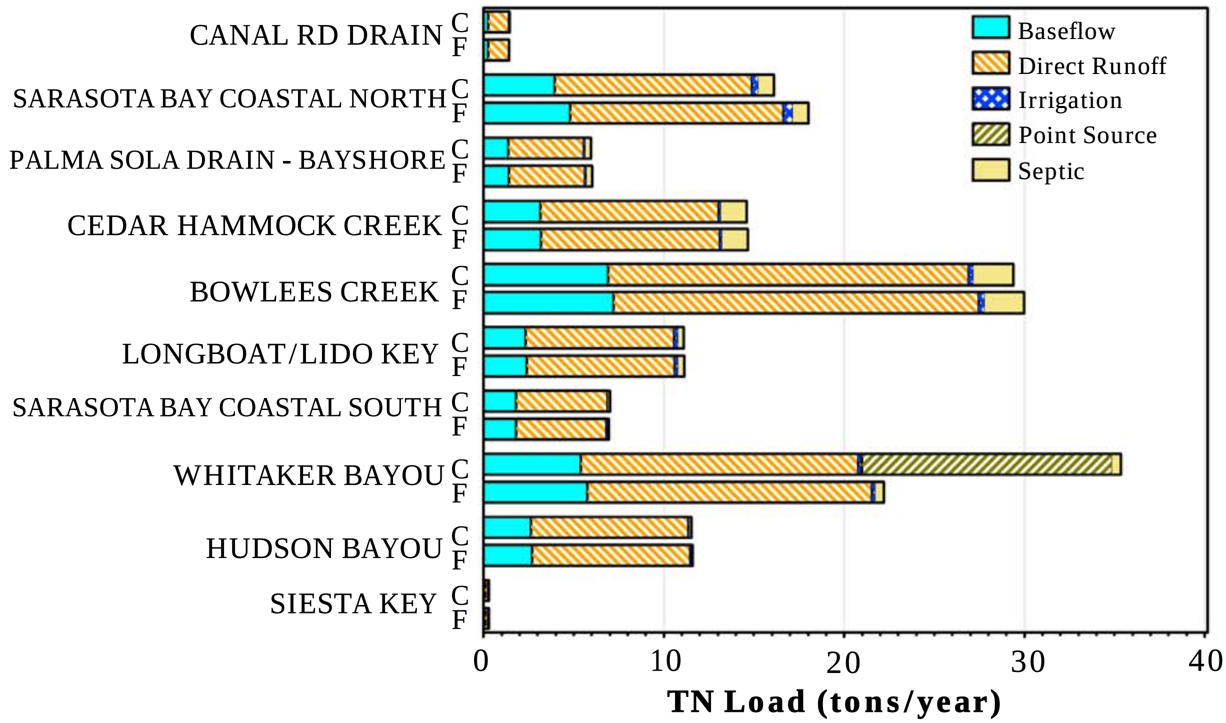


Figure 4-18 Comparison of Annual TN Loads to Sarasota Bay by Basin and Source for Current and Future Watershed Conditions (1989-2008)

Figure 4-19 compares annual average TP loads by source from each Sarasota Bay basin under current and future conditions. The greatest contributions of TP loads are from the largest basins—Whitaker Bayou and Bowlees Creek—though the change in total TP loadings to Sarasota Bay is relatively small from current to future estimates. In general, future TP loadings from a specific source did not change relative to current loading estimates. Slight increases were observed for baseflow and direct runoff, particularly for the Sarasota Bay North, which is presently one of the least developed basins in the watershed. As a result, this basin has the greatest potential to be developed, thus increasing the impervious surface for runoff. Reductions in TP loads from septic tanks are observed for the Longboat/Lido Key and Whitaker Bayou basins as a result of septic tank removal. Increases in TP loads from septic sources are apparent for the Cedar Hammock Creek, Sarasota Bay North, and Bowlees Creek basins as a result of failing septic tanks and potentially from increased baseflows in these basins.

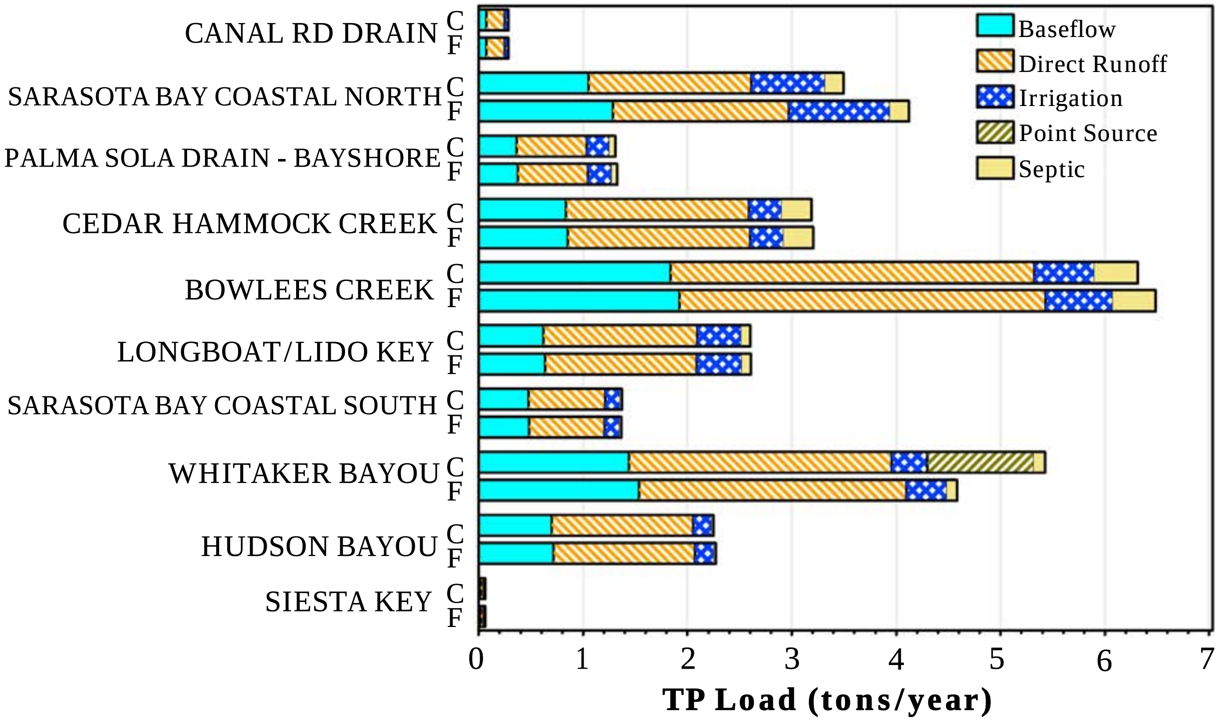


Figure 4-19 Comparison of Annual TP Loads to Sarasota Bay by Basin and Source for Current and Future Watershed Conditions (1989–2008)

Figure 4-20 compares annual average TSS loads by source from each Sarasota Bay basin under current and future conditions. In general, very little change in TSS loads was observed under future watershed conditions, though a slight increase in baseflow-derived TSS is apparent for the Sarasota Bay Coastal North basin and is likely a result of the greater potential for increased urban land uses in this basin.

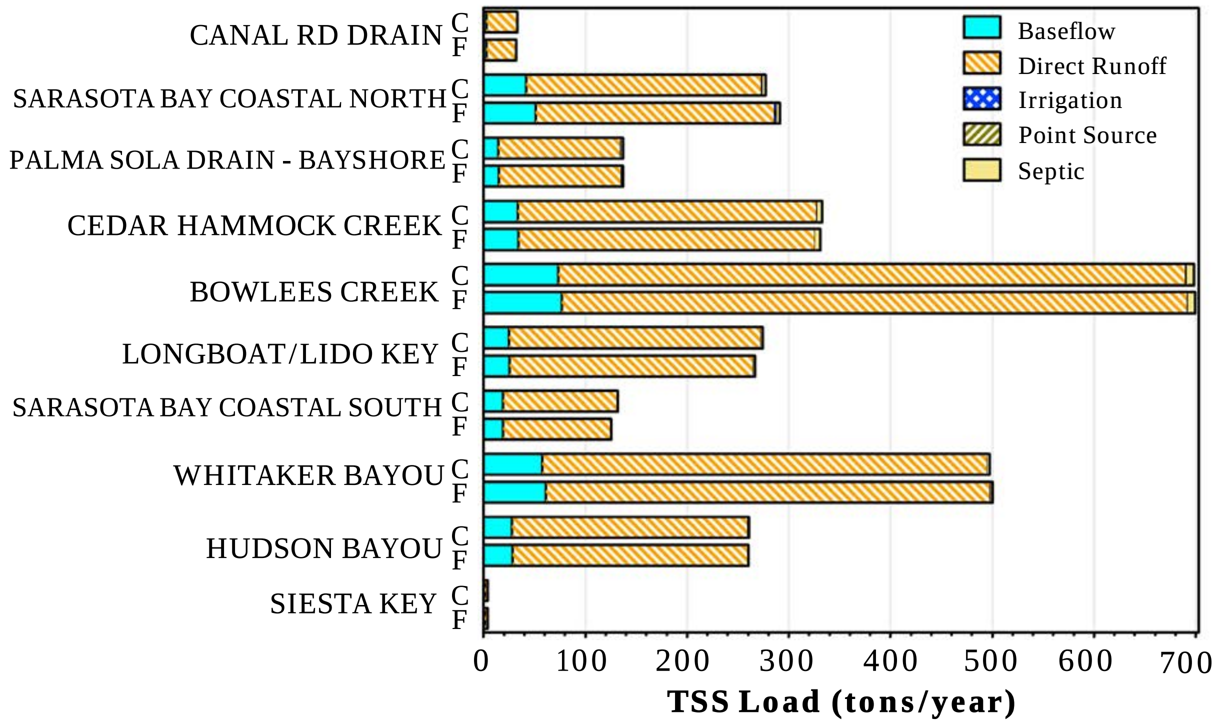


Figure 4-20 Comparison of Annual TSS loads to Sarasota Bay by Basin and Source for Current and Future Watershed Conditions (1989–2008)

Figure 4-21 shows the spatial distribution of unit-area TN loads by sub-basin. Sub-basin numbers correspond to the basin names in Table 4-1. TN loads from the majority of sub-basins remain relatively constant from the current to future conditions. Slight increases are apparent for the Longboat/Lido Key, Sarasota Bay Coastal North, Cedar Hammock Creek, and Bowlees Creek basins. A significant four-fold reduction in TN loads was estimated for Sub-basin 116 in the Whitaker Bayou basin and was the result of a large reduction in septic tank loads in this sub-basin.

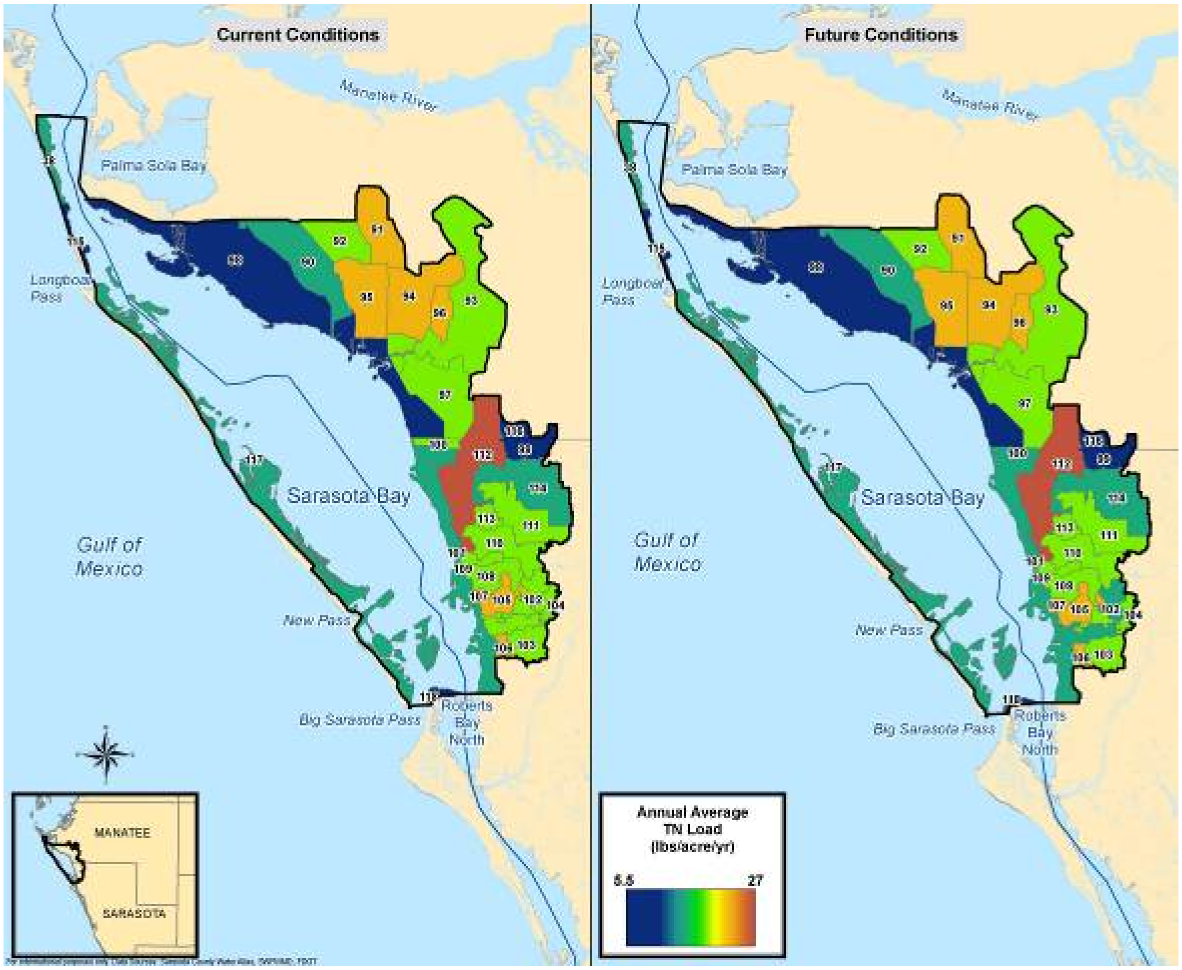


Figure 4-21 Comparison of Current Versus Future Unit-Area Annual TN loads to Sarasota Bay (1989–2008)

Sub-basin numbers correspond to basin names in Table 4-1.

Figure 4-22 depicts the spatial distribution of unit-area TP loads by sub-basin. Sub-basin numbers correspond to the basin names in Table 4-1. As with TN loads, small increases in TP loads were observed in the Longboat/Lido Key, Sarasota Bay Coastal North, Cedar Hammock Creek, and Bowlees Creek basins. TP loads were reduced greatly in Sub-basin 116 of Whitaker Bayou as a result of greatly reduced septic tank loads. Otherwise, TP loadings from most of the Sarasota Bay watershed were relatively consistent from the current to future conditions.

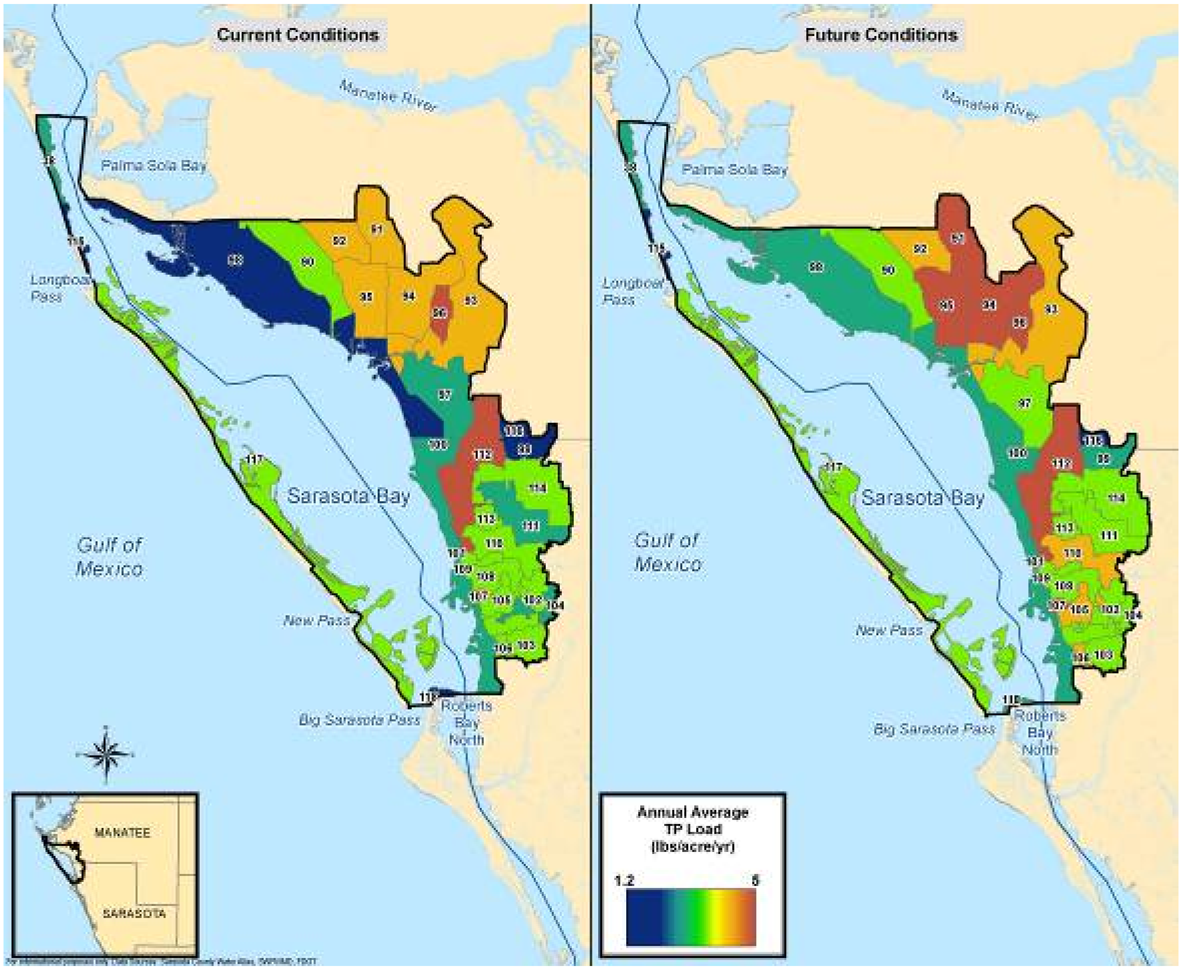


Figure 4-22 Comparison of Current Versus Future Unit-Area Annual TP loads to Sarasota Bay (1989–2008)

Sub-basin numbers correspond to basin names in Table 4-1.

Figure 4-23 shows the spatial distribution of unit-area TSS loads by sub-basin. TSS loads are similar from current to future conditions with little significant change in any of the sub-basins. The largest annual TSS loads per acre are primarily found in the Bowlees Creek, Cedar Hammock Creek, Hudson Bayou, and Whitaker Bayou basins. Reductions in TSS loads are apparent for Sub-basin 116 in Whitaker Bayou as a result of a large decrease in septic tank loads.

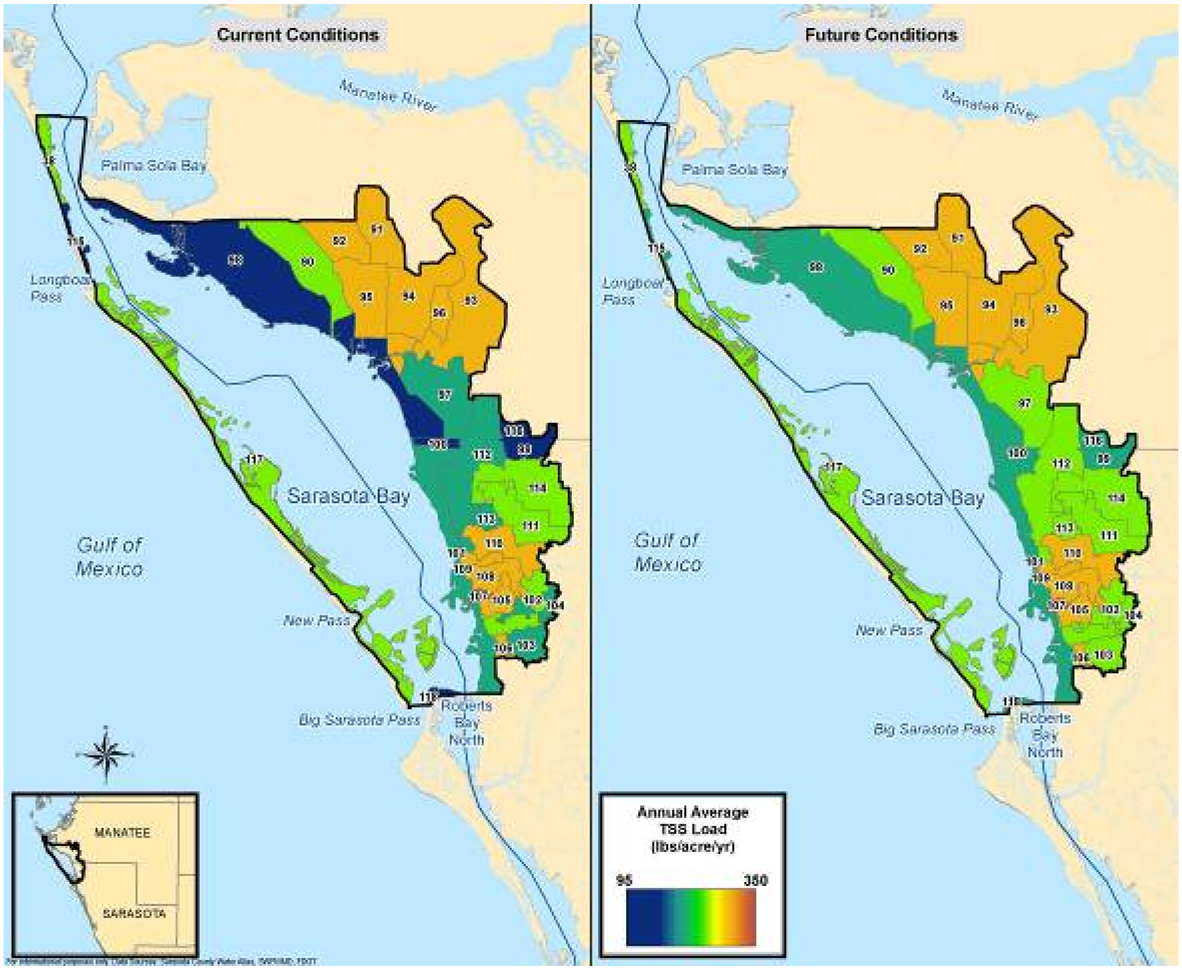


Figure 4-23 Comparison of Current Versus Future Unit-Area Annual TSS Loads to Sarasota Bay (1989–2008)

Sub-basin numbers correspond to basin names in Table 4-1.

5.0 WATER QUALITY LEVELS OF SERVICE

5.1 OBJECTIVE

This section presents the approach, information, and data used for and summarizes the results associated with developing water quality LOS criteria for the Sarasota Bay estuary and associated freshwater tributaries. The information provided in this section will be used to identify potential management actions for the Sarasota Bay WQMP.

5.2 APPROACH

Setting resource protection LOS is one of the most important elements of an effective watershed management plan. An overall approach for protecting Sarasota Bay's resources has recently been established through the work of SBEP, Southwest Florida Water Management District (SWFWMD), Sarasota County, other local governments, FDEP, and other interested parties.

The development of water quality LOS is based on a paradigm that distinguishes targets from thresholds, i.e., that distinguishes water quality management levels from regulatory levels. A **target** is a desired water quality condition and can be used as an "early warning" of undesirable change in water quality. Water quality targets, e.g., chlorophyll *a* concentrations, have been defined by SBEP as the annual mean of the reference period, i.e., the period that was deemed to be protective of desired water quality conditions. There may be years in which water quality targets may be exceeded without causing significant changes in the receiving waterbody. Therefore, some allowable amount of variation should not elicit a significant degradation in water quality and, in the case of Sarasota Bay proper, therefore seagrass coverage. SBEP defined this level of variation as the standard deviation around the mean annual water quality conditions in each segment for the entire period of record. Thresholds have often been set to meet the need for a regulatory level. Where these regulatory levels have not been established, there remains the need for a second water quality management level that elicits significant responses to the target exceedances. Therefore, for the Sarasota Bay WQMP, a **threshold** has been operationally defined as the sum of the annual mean conditions and this standard deviation. A distinction is made between a target, i.e., a desired water quality condition, and a threshold, i.e., a water quality level above which undesirable conditions exist.

The SBEP Management and Policy Boards unanimously approved chlorophyll *a* targets (presented in Section 5.4.2) at their January 15, 2010 meeting. At the June 4, 2010 meeting, both boards delegated authority to the SBEP Technical Advisory Committee for submitting draft NNC using the nutrient targets presented below to FDEP and EPA.

The SBEP approach is based on protecting seagrasses, an extremely important natural resource for Sarasota Bay. The control of loadings on a bay-wide scale is the most effective approach to protect seagrasses and other natural resources. Unless specific localized problems are identified, a bay-wide approach to managing nutrient inputs, as opposed to managing on a basin or catchment scale, is recommended.

The adopted water quality LOS criteria for seagrass, chlorophyll *a*, and nutrients were reviewed and assessed to ensure their appropriateness. The general methodology and the results are described below. A detailed description of the methods is provided in Janicki Environmental, Inc. (2010a, b; 2011a). The relationships between pollutant loading and estuarine water quality, freshwater stream water quality, basin loadings, and freshwater inflow and salinity in the estuary are also discussed below in Section 5.4.3.

DO is another important parameter for assessing the ecological health of aquatic systems. Florida's current standard for DO in Class II and Class III marine waters, which include Sarasota Bay, states that DO "shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L" (Chapter 62-302.530, FAC, Criteria for Surface Water Quality Classifications). This standard was deemed inadequate by FDEP because it did not recognize seasonal and diurnal variability in DO that may cause DO levels to be naturally below the standard.

FDEP proposed a revised methodology for setting DO standards for fresh and marine waters. FDEP's proposed methods, described in FDEP's technical support manual for the derivation of dissolved oxygen criteria (FDEP, 2012a), is under peer review. DO in the estuary and tributaries is compared to existing and proposed criteria in Section 5.4.

NNC have been adopted for freshwater streams by FDEP (2011a). TN NNC for streams were developed based on water quality characteristics of "nutrient watershed regions." Sarasota Bay tributaries are assigned to the West Central region shown in Figure 5-1; this region has a TN nutrient threshold of 1.65 mg/L and a TP threshold of 0.49 mg/L. Ambient nutrient concentrations in Whitaker Bayou and Hudson Bayou were compared to these thresholds.

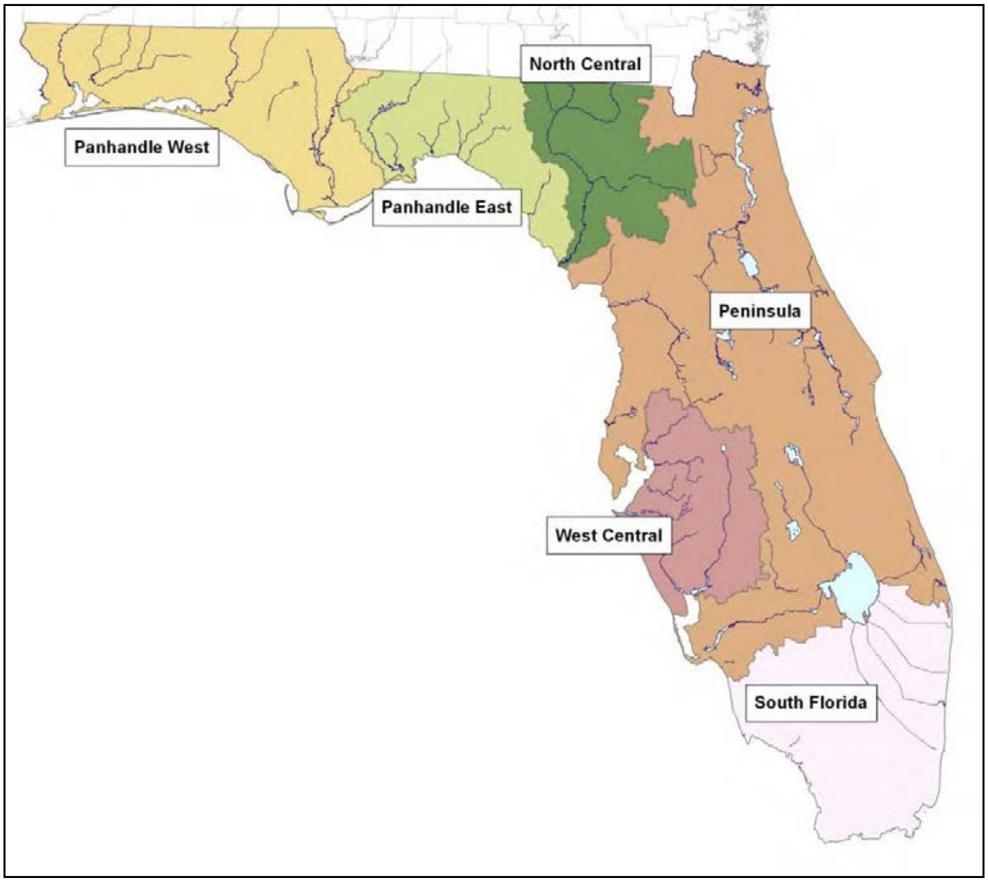


Figure 5-1 Nutrient Watershed Regions of Florida (FDEP, 2012a)

5.3 DATA AND INFORMATION USED

- TN loading and TP concentration and loading criteria as developed for SBEP from *Sarasota Bay Numeric Nutrient Criteria Task 1 – TN and TP Concentration and Loading Based Criteria*, March 17, 2011 (Janicki Environmental, 2011a).
- NNC for TN concentrations for Sarasota Bay as developed for SBEP from *Numeric Nutrient Criteria for Sarasota Bay* (Janicki Environmental, Inc., 2010a).
- Methodologies for developing NNCs [from Empirical Approaches to Establishing Numeric Nutrient Criteria for Southwest Florida Estuaries (Janicki Environmental, Inc., 2010b).
- Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters (EPA, 2010).
- Draft revised Rule Chapter 62-302, FAC, Surface Water Quality Standards. November 1, 2011 (FDEP, 2011a).
- NNC briefing for Environmental Regulatory Commission. November 3, 2011 (FDEP, 2011b).
- Seagrass survey data for Sarasota Bay (1950, 1988, 1994, 1999, 2001, 2004, 2006, 2008, and 2010) provided by SWFWMD (2011).

- ❖ Ambient water quality data provided by Sarasota County (2012) and Manatee County (2012).
- ❖ TN, TP, and TSS loading estimates from the Sarasota SIMPLE-Monthly model (Janicki Environmental, Inc. (2010a).

5.4 RESULTS

5.4.1 Development of Seagrass LOS Targets

Setting water quality targets based on the requirements for the growth and reproduction of seagrasses helps ensure that the entire bay community remains sustainable. Seagrasses serve several important functions including stabilizing the benthic environment by trapping and holding fine-grained particles and sediment in their root systems and removing dissolved nutrients from the water column. Sequestering sediments and nutrients improves water clarity, which is beneficial to the entire system. Seagrasses also provide critical habitat, serving as nurseries for fish, crustaceans, and shellfish, including many commercially and recreationally important species. Seagrasses are also a food source for organisms that live in and on them and for mammals such as manatees.

Human activities can adversely affect seagrasses by physically disturbing them and by introducing excess levels of chemicals that originate in the watershed and enter the bay via stormwater runoff. Excess nutrients in the water can lead to algae blooms that impact water clarity and reduce the magnitude and areal extent of light availability at levels that seagrasses need to survive. If seagrasses are healthy and widespread in a waterbody, then the natural community as a whole is likely healthy.

As stated above, SBEP has set seagrass LOS targets for the entire Sarasota Bay system, including Sarasota Bay proper. The target-setting process was based on comparing historical seagrass coverage that was developed by photo-interpretation of historical (ca. 1950) aerial photographs to recent seagrass surveys conducted by SWFWMD. SBEP defined the seagrass target as the larger areal extent of seagrass coverage under either historical (less areas that have since been filled or dredged) or current conditions. Figure 5-2 presents the seagrass coverage data used to establish the target for Sarasota Bay. The LOS target is 7,269 acres, which represents the 1950 coverage, less areas that have been filled or dredged and are unrestorable. During target-setting, data from 2004 to 2006 were used to represent recent conditions. The 2008 and 2010 surveys indicate that seagrass coverage has been above the LOS target acreage.

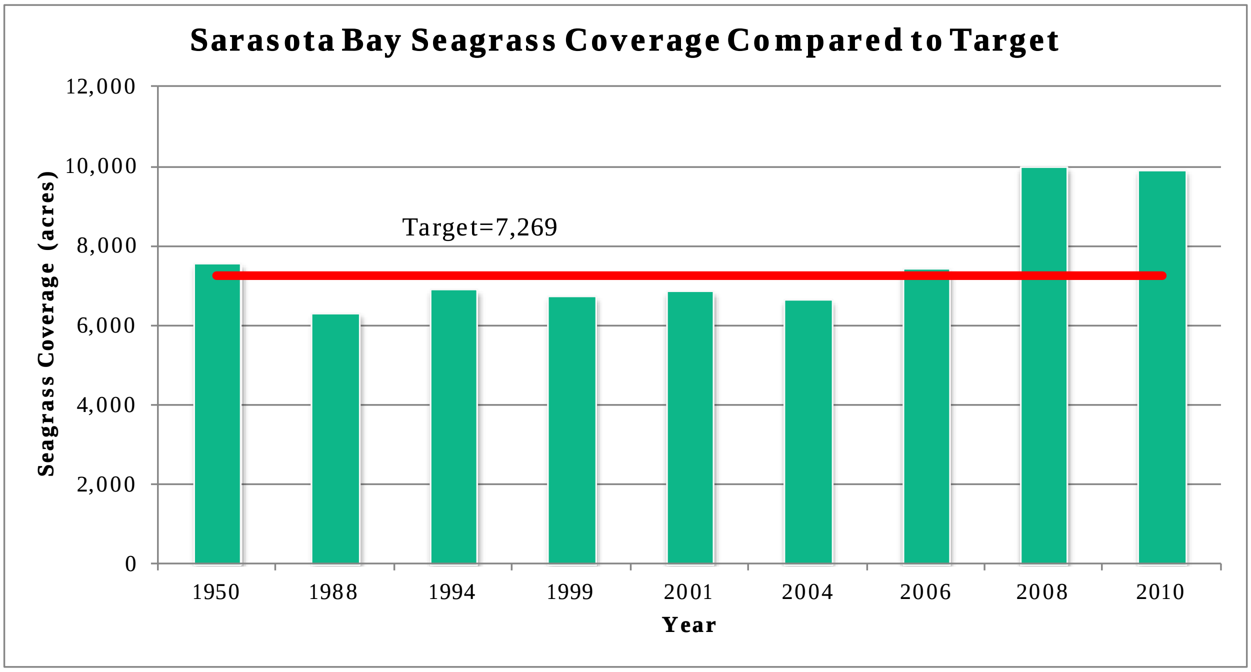


Figure 5-2 Seagrass Coverage (Acres) from Historical and Recent Surveys in Sarasota Bay with Target (7,269 Acres) Shown

5.4.2 Development of Chlorophyll *a* LOS Targets

Improving and maintaining water clarity are fundamental to restoring and protecting seagrass populations. Controlling chlorophyll *a* concentrations in the water column is a primary means of maintaining sufficient water clarity for seagrass restoration and maintenance. Recent data from ambient water quality monitoring programs indicate that chlorophyll *a* concentrations in Sarasota Bay declined from 1998 to 2009. Further analysis of the chlorophyll concentration data using non-parametric trend tests (Kendall-Tau) showed a significant decreasing trend ($p<0.03$) in chlorophyll in the bay (Figure 5-3). This finding, in conjunction with the increased seagrass acreage, provides strong evidence that the current management efforts of Sarasota County, SBEP, and others are successful and resulted in improved water quality and increased seagrass abundance.

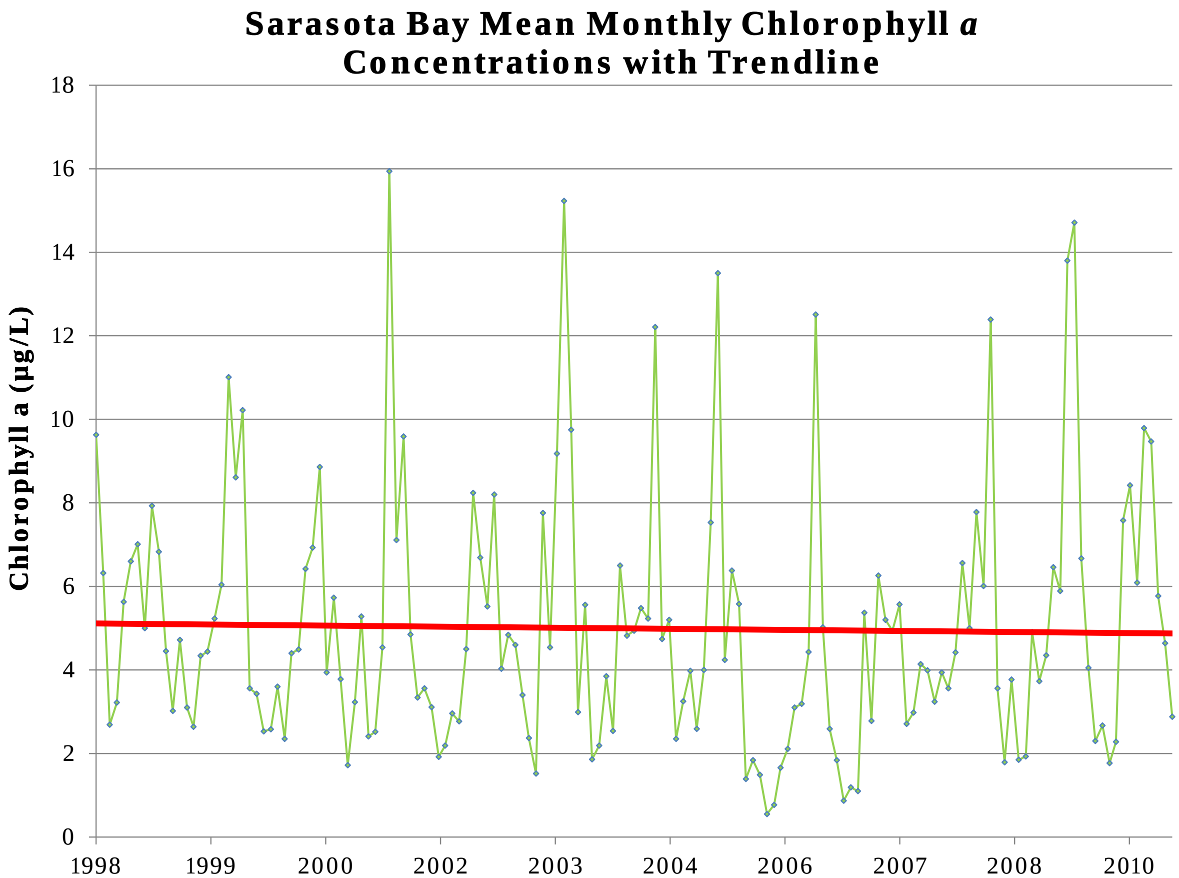


Figure 5-3 Sarasota Bay Mean Monthly Chlorophyll *a* Concentrations with Trend Line (non-parametric Kendall-Tau)

Because the recent extents of seagrass coverages are meeting and exceeding the established LOS targets, SBEP determined that recent chlorophyll *a* concentrations and associated water clarity protect the seagrasses in Sarasota Bay. Data from 2001–2005 were used to establish the LOS target. The resultant mean chlorophyll *a* concentration from this period was established as the LOS target. The LOS target was established with the recognition that there may be years in which the chlorophyll *a* targets are exceeded without resulting in a significant reduction in seagrass cover. This means that some variation in water quality will not result in a significant degradation to environmental quality with subsequent reduced seagrass coverage. The level of acceptable variation was established by SBEP as the standard deviation around the mean annual chlorophyll *a* concentrations in Sarasota Bay for the entire period of record.

A distinction was made between an LOS target (the desired chlorophyll *a* concentration) and a threshold (a chlorophyll *a* concentration above which undesirable conditions are likely to occur). The chlorophyll *a* threshold for the bay is the sum of the target and the standard deviation around the mean annual chlorophyll *a* concentrations in the bay.

Based on these premises, the chlorophyll *a* LOS target for Sarasota Bay was set at 5.2 µg/L and the threshold was set at 6.1 µg/L (equal to the target plus the standard deviation of 0.9 µg/L). The chlorophyll *a* LOS threshold was used to develop the numeric nitrogen LOS target for Sarasota Bay discussed below. As Figure 5-4 shows, annual arithmetic mean chlorophyll *a* concentrations in Sarasota Bay were below the threshold value in all years.

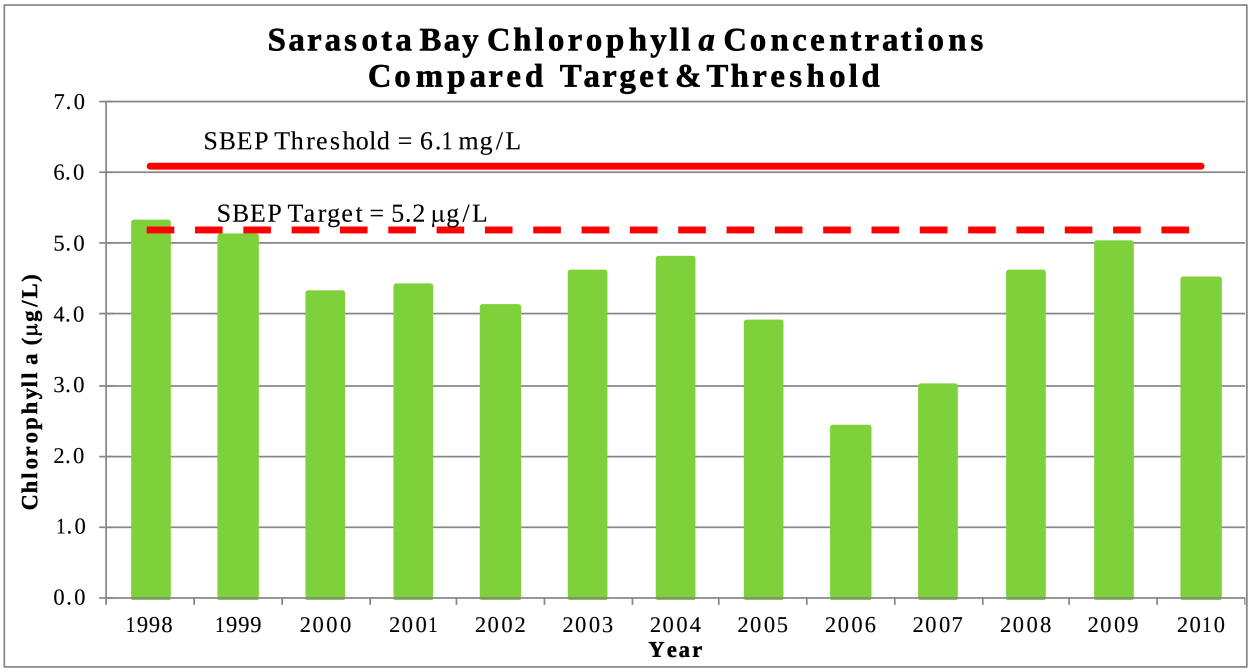


Figure 5-4 Sarasota Bay Chlorophyll *a* Concentrations (Annual Arithmetic Means) with Threshold Line (6.1 µg/L) and Target (5.2 mg/L)

5.4.3 Development of the Nitrogen and Phosphorus LOS

The relationship between nutrients (TN and TP) and eutrophication in the Sarasota Bay estuary system has been investigated by Janicki Environmental (2010a, b; 2011a). Janicki noted that nitrogen is well-documented as the most common growth-limiting nutrient in many estuarine waterbodies. That is, the concentration of nitrogen in the environment determines the growth and productivity of organisms in that environment. Aquatic systems with TN:TP ratios below 10, as is the case with Sarasota Bay, are commonly recognized as nitrogen-limited. Other empirically derived relationships also indicate that nitrogen has a dominant role in the eutrophication process in the Sarasota Bay system (Janicki Environmental, 2010a; 2011a). However, it has also been documented (Janicki Environmental., 2011a) that nitrogen limitation can shift to phosphorus limitation depending on the relative supply of nutrients, the season, or other factors. Thus, the nutrient LOS for Sarasota Bay presented below includes both TN and TP loads and concentrations.

5.4.3.1 Estuarine TN Concentration Target and Threshold

A stressor-response relationship was used to develop the TN concentration NNC as described in Janicki Environmental, Inc. (2010a) and similar to the approach published by EPA (2010). The identification of an empirical relationship (a regression model) between chlorophyll *a* and some measure of nutrient conditions was essential for this approach to be successful.

Figure 5-5 shows monthly average TN concentrations in Sarasota Bay. The decreasing trend line is shown but is not statistically significant. Mean monthly values for 1998 through 2010 ranged over an order of magnitude from under 0.1 mg/L (1998) to over 1.0 mg/L (2004); however, the vast majority of monthly values ranged from 0.2 to 0.5 mg/L. Figure 5-6 is a box-and-whisker plot of calendar month values for TN in Sarasota Bay. A distinct seasonal signal is evident, with higher TN values occurring during the summer months. Monthly means (represented by dots in Figure 5-6) ranged from a high of 0.49 mg/L (September) to a low of 0.29 mg/L (February).

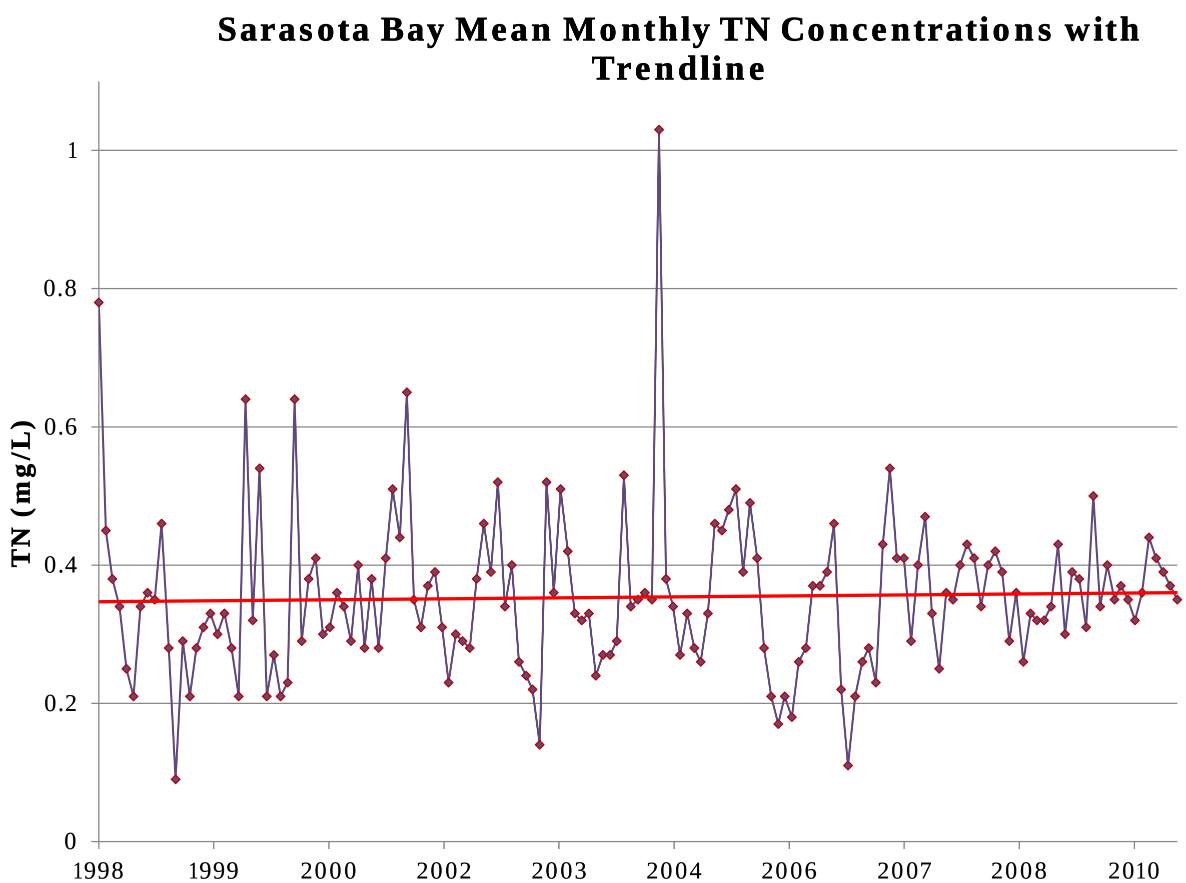


Figure 5-5 Mean Monthly TN Concentrations (mg/L) Observed in Sarasota Bay with Trend Line (non-parametric Kendall-Tau)

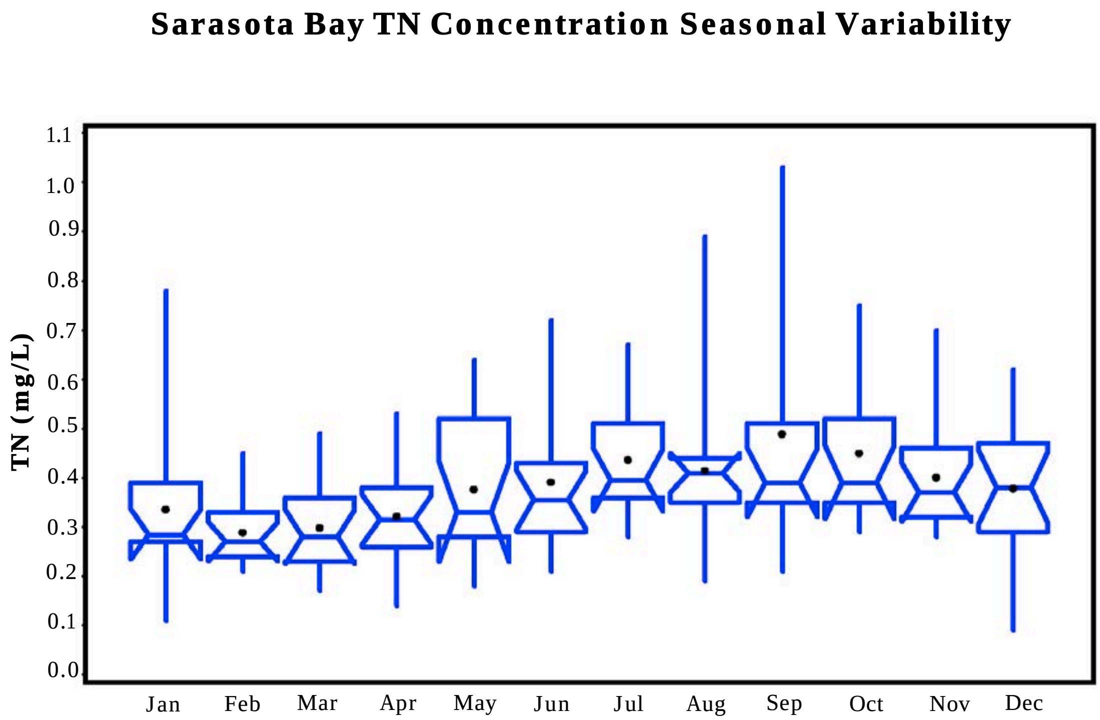


Figure 5-6 Box-and-Whisker Plots of the Monthly TN Concentrations (mg/L) Observed in Sarasota Bay

The independent variables used in the model-building included TN and TP loadings and concentrations, hydrologic loadings, and estimates of residence time of water in the bay. The loadings data investigated included monthly hydrologic, TN, and TP loads as well as cumulative total loads extending from 2 to 6 months (e.g., 2-month cumulative TN load = TN load current month + TN load 1-month prior). The water quality constituents included TN and TP concentrations as well as numerous other constituents. A complete presentation of the process followed to develop the criteria for SBEP can be found in Janicki Environmental (2010a). A general description of the methods and results of the analyses follows.

A regression equation was developed using a multi-step process to quantify the relationship between nutrients and chlorophyll *a* in the bay. The TN concentration was identified as the variable that made the greatest contribution to explaining the variability in chlorophyll *a* concentrations in Sarasota Bay. As expected, a pattern of increasing chlorophyll *a* concentrations with increasing TN concentrations was observed (Figure 5-7).

As in the regressions developed for other Sarasota Bay system segments (including Roberts Bay, Little Sarasota Bay, and Blackburn Bay), initial efforts to identify a quantifiable relationship revealed a seasonal difference in residuals. This indicated that given the same TN concentration, higher chlorophyll *a* concentrations are expected during the summer months. Therefore, a seasonal term was added to the regression equation. The seasonal term is a dummy variable that equals one during the wet season (June–October) and zero during other months.

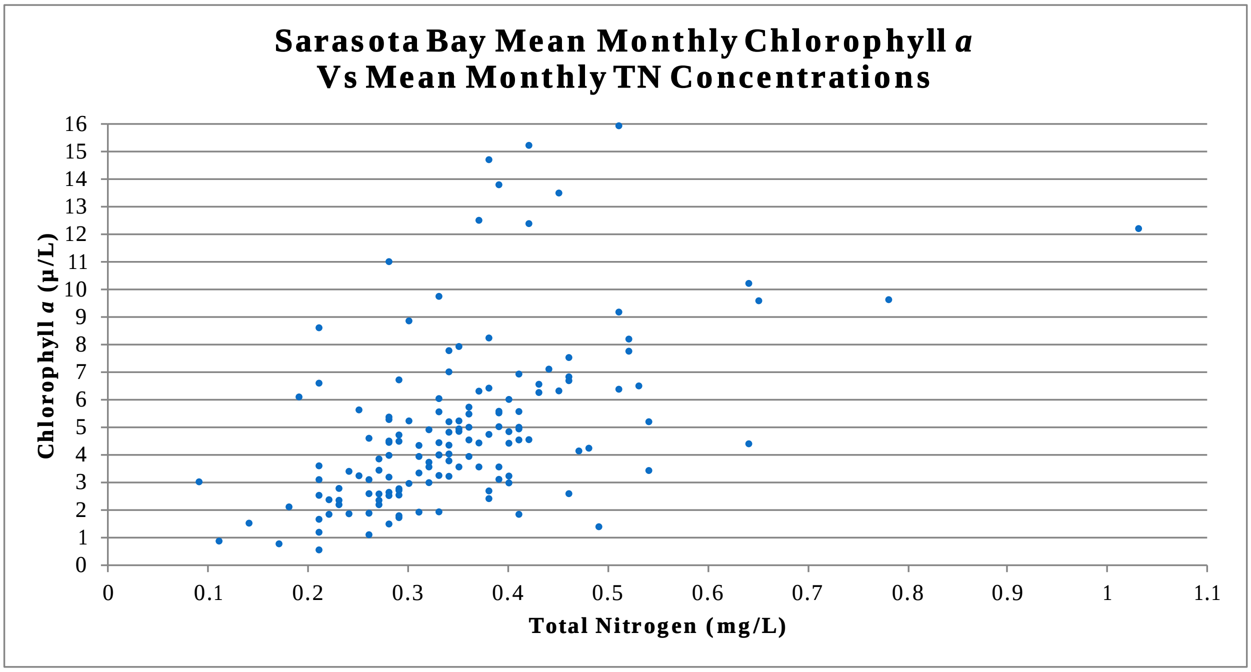


Figure 5-7 Relationship Between Monthly Average Chlorophyll *a* and TN Concentrations in Sarasota Bay

However, Sarasota Bay is a substantially larger estuary with greater spatial variability in TN concentrations than the other Sarasota Bay system segments. Specifically, TN concentrations in the north portion of the bay (the dividing line is shown in Figure 5-8) are greater than those in the south portion (Table 5-1). In contrast, less spatial variability (between sampling sites) occurs in the north chlorophyll *a* concentrations. Therefore, a regional term was added to the regression equation to account for the spatial differences in TN and chlorophyll *a* concentrations in Sarasota Bay.

Figure 5-8 North and South Portions of the Sarasota Bay Segment

Table 5-1 Comparison of Water Quality within North and South Sarasota Bay (Values Represent Medians for 1998–2009)

Variable	North Sarasota Bay	South Sarasota Bay
Chlorophyll *a* (µg/l)	5.2	3.4
TN (mg/L)	0.56	0.28
Color (PtCo units)	20	10

Further analysis of the residuals from the regression model revealed that color also contributed to the variation in chlorophyll *a*, and a color variable was subsequently added to the regression equation. The final regression equation (Equation 1) obtained was:

(Equation 1)

$$[\text{Chlorophyll } a] = -1.06 + (3.58 * [\text{TN}]) + (0.32 * [\text{color}]) + (2.03 * \text{season}) - (4.84 * \text{region})$$

The analyses demonstrate that the relationships between chlorophyll and other parameters is different in the north part of the bay than in the south, so factors were included in the regression equation to improve predictive ability by accounting for what part of the bay is of interest and to recognize that color was shown to play a part in the relationships. The color variable was added only to improve the fit of the regression model. This does not imply that color has a significant direct effect on chlorophyll *a*. Also, the magnitude of the different parameters does not equate to their influence in the relationships. Equation results are calculated by season and then aggregated annually.

The model was fit with 156 observations and resulted in an R2 value of 0.67. The regression was highly significant with a probability of a greater |F| value of <0.0001. The slope and parameter coefficients were also significant. Figure 5-9 is a plot of predicted versus observed chlorophyll *a* concentrations.

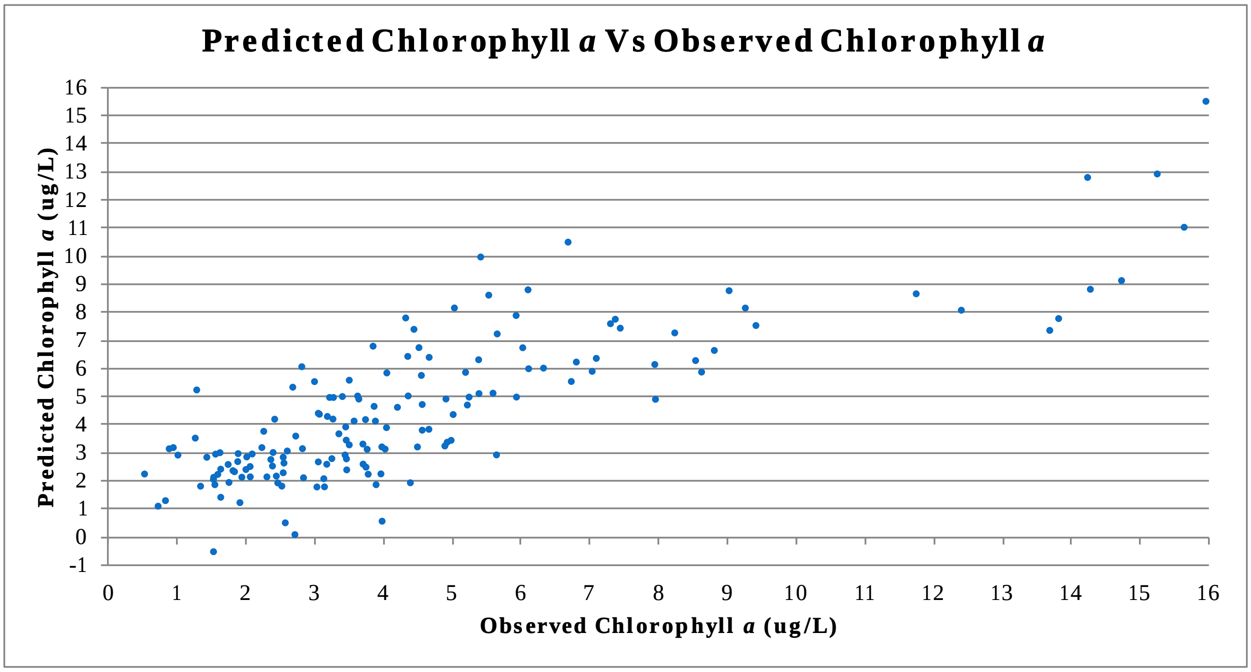


Figure 5-9 Predicted vs Observed Chlorophyll *a* Concentrations in Sarasota Bay ($R^2 = 0.67$)

Therefore, based on these data analysis results, the TN concentration NNC provides the LOS threshold for Sarasota Bay and is defined by Equation 1 and varies according to the observed color in any given year. Ambient TN concentrations in Sarasota Bay for 1998–2010 were compared to the TN NNC that were calculated for each year using Equation 1, as shown in Figure 5-10. Using annual geometric means of the concentrations, ambient TN concentrations were lower than the TN criterion for all years. The ambient concentrations are within a relatively tight range, between 0.2 and 0.4 mg/L. Much of the variability in the TN criterion was due to changes in color (see Equation 1).

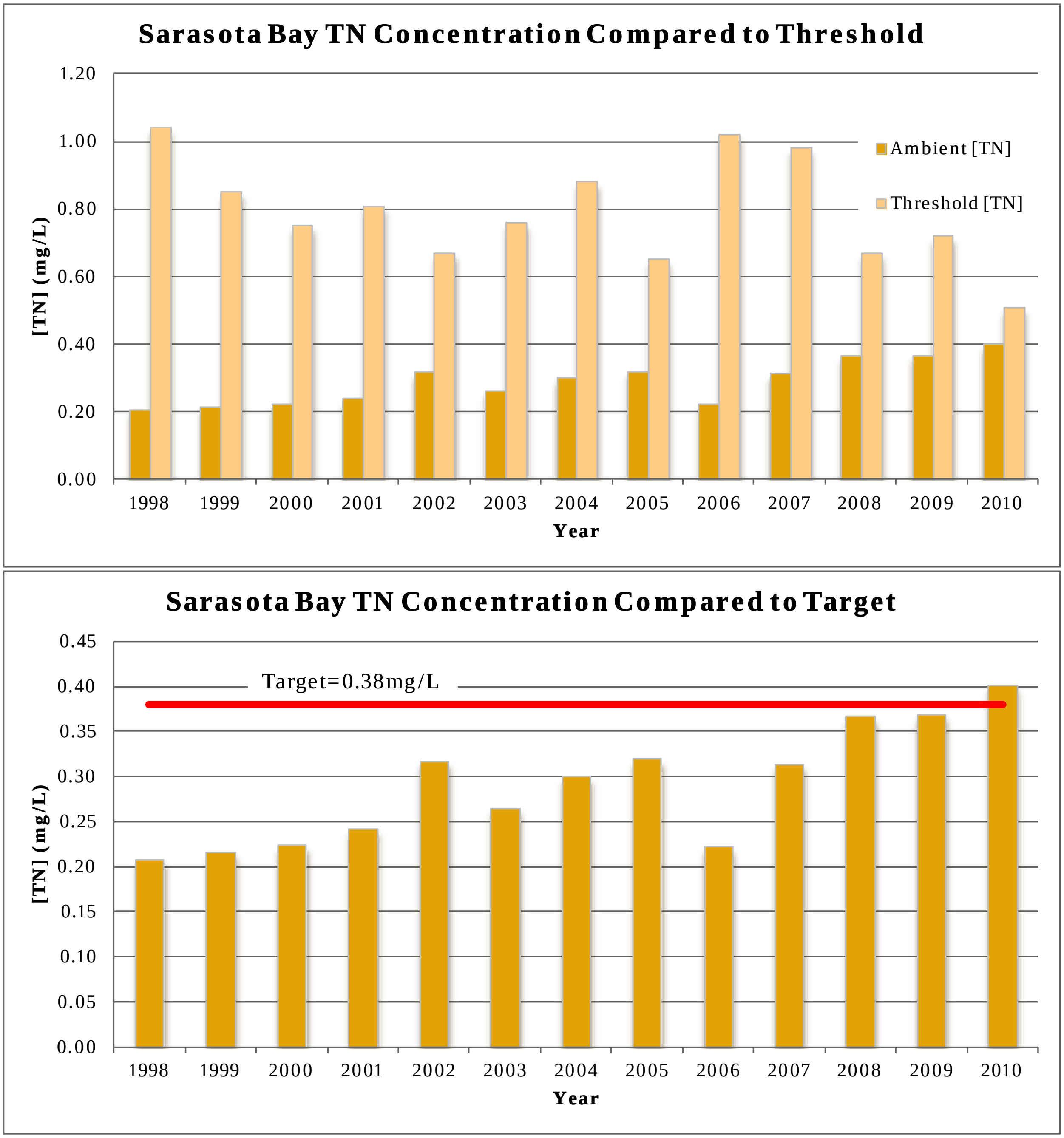


Figure 5-10 Comparison of Observed Annual Geometric Mean TN Concentrations in Sarasota Bay to Year-Specific TN Thresholds (shown in the upper panel) and TN Target (shown in the lower panel)

There remains the need for a TN concentration target for Sarasota Bay. To maintain consistency with the method used to set the chlorophyll *a* target, the TN concentration LOS target for Sarasota Bay is the annual mean for the 2001–2005 reference period. This target is 0.38 mg/L.

5.4.3.2 Estuarine TP Concentration Target and Threshold

The same approach that was used for TN loads above was used to develop LOS TP concentration target and threshold. Therefore, concentration-based NNC for TP were developed using the reference period approach (Janicki Environmental, 2011a). The TP concentration target for Sarasota Bay is the annual mean for the 2001–2005 reference period, which was deemed appropriate due to the seagrass coverage observed during this period (Janicki Environmental, 2010a). As described above, SBEP also considered the year-to-year variability in water quality conditions and arrived at a threshold (concentrations above this level indicate undesirable conditions) as the sum of the TP target and one standard deviation of the long-term TP concentrations.

Following this approach, the TP concentration target, standard deviation, and threshold for Sarasota Bay are 0.15, 0.04, and 0.19 mg/L, respectively. Figure 5-11 compares ambient TP concentrations for 1998–2008 to the target and threshold. TP concentrations were below the threshold in all years. Given that nitrogen is the limiting nutrient in Sarasota Bay, TP would not be expected to have a substantial influence on chlorophyll concentrations and seagrass growth.

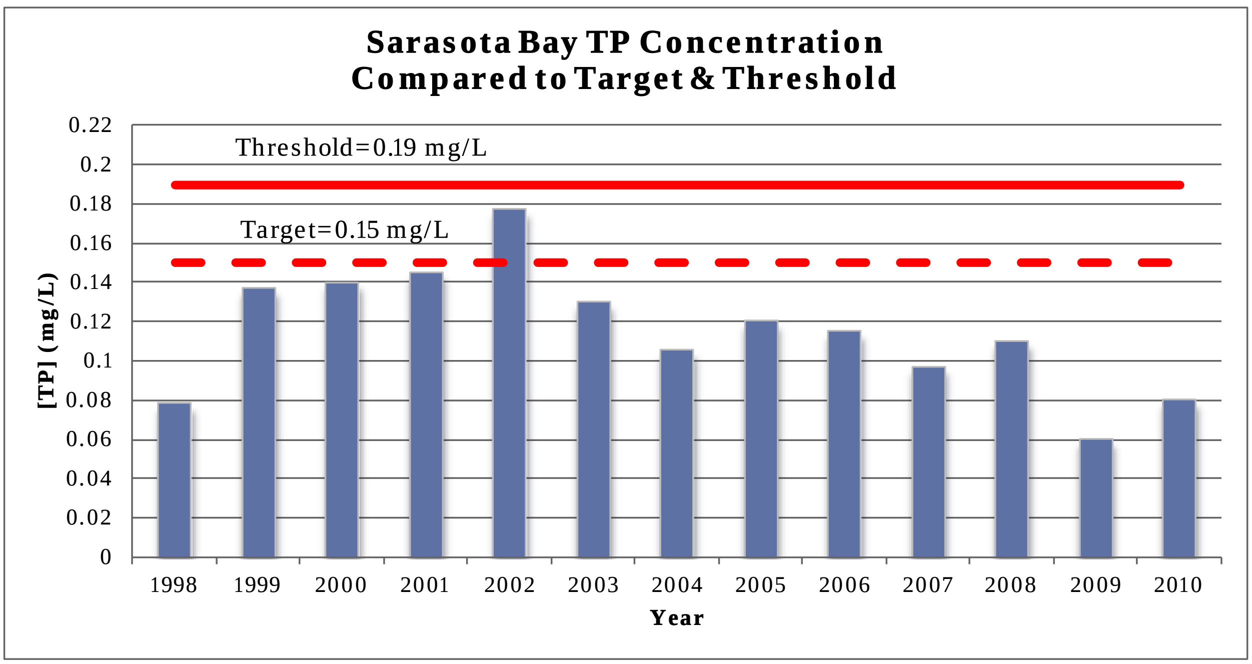


Figure 5-11 Comparison of TP Concentration Threshold (0.19 mg/L) and Target (0.15 mg/L) for Sarasota Bay to the Annual Geometric Mean TP Concentrations from 1998–2008

5.4.3.3 Estuarine TN Loading Target

Concentrations of chemicals including nutrients in a waterbody change in response to internal cycling in the water (e.g., uptake by vegetation), exchange with other waterbodies (e.g., between the bay and the Gulf of Mexico), and inputs (loadings) from the watershed. Of these factors, loadings can be most influenced by management actions. Loading rates normally vary depending on rainfall and land use changes, among other watershed characteristics. However, adverse impacts to a receiving water such as the bay will only occur when the loading rate exceeds the bay's assimilative capacity—that is, the bay's ability to use or disperse the watershed-based inputs.

The relationship between loadings and indicators of ecological health (e.g., chlorophyll *a*, TN, and TP concentrations and the extent of seagrass) has been previously examined by Janicki Environmental 2010a, b; 2011a). Regression modeling was used to identify a technically defensible relationship between TN concentration and TN load and between TN concentration and chlorophyll *a* concentration (Janicki Environmental, 2011a). However, the best-fit regressions indicated that the TN load explained only 16% of the variability in TN concentration and 32% of the variability in chlorophyll *a* (r^2 = 0.16 and 0.32, respectively). Because of these weak relationships, the "reference period" approach was used to set TN loading targets and thresholds, with 2001–2005 used as the reference period. Chlorophyll *a* concentrations and seagrass targets were met during this period, so concurrent TN loads were assumed to protect the resources. The LOS target, standard deviation, and LOS threshold for TN loads were 215.3, 21.9, and 237.2 tons/year, respectively. Figure 5-12 compares the TN load target and threshold to the annual TN loads for Sarasota Bay. TN loads were below the LOS threshold for all years except 1992, 1995, and 2003. The process used to develop the TN load criterion is detailed in Janicki Environmental (2011a).

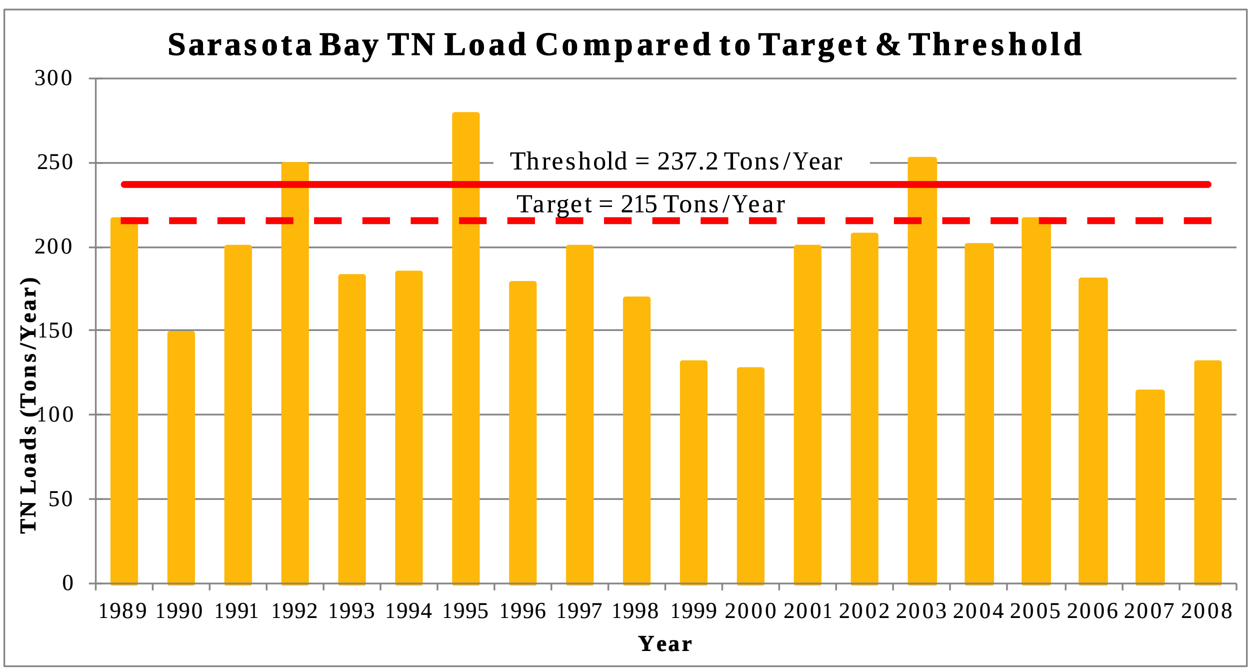


Figure 5-12 Comparison of TN Load Threshold (237.2 tons/year) and Target (215.0 tons/year) for Sarasota Bay to Annual Loads (1998–2008)

5.4.3.4 Estuarine TP Loading Target and Threshold

Regression modeling was used to identify a technically defensible relationship between TP concentration and TP load and between TP concentration and chlorophyll *a* concentration. However, the best-fit regressions indicated that TP load explained only 1% of the variability in TP concentration and 39% of the variability in chlorophyll *a* (r-squared = 0.01 and 0.39, respectively).

Because of the weak relationships, the reference period approach was used to set TP loading target and threshold. 2001–2005 were used as the reference period. The LOS target, standard deviation, and threshold for TP loads were 31.8, 3.4, and 35.2 tons/year. Figure 5-13 compares the TP load target and threshold and annual TP loads for Sarasota Bay. TP loads were below the threshold for all years except 1992, 1995, and 2003 when rainfall was elevated.

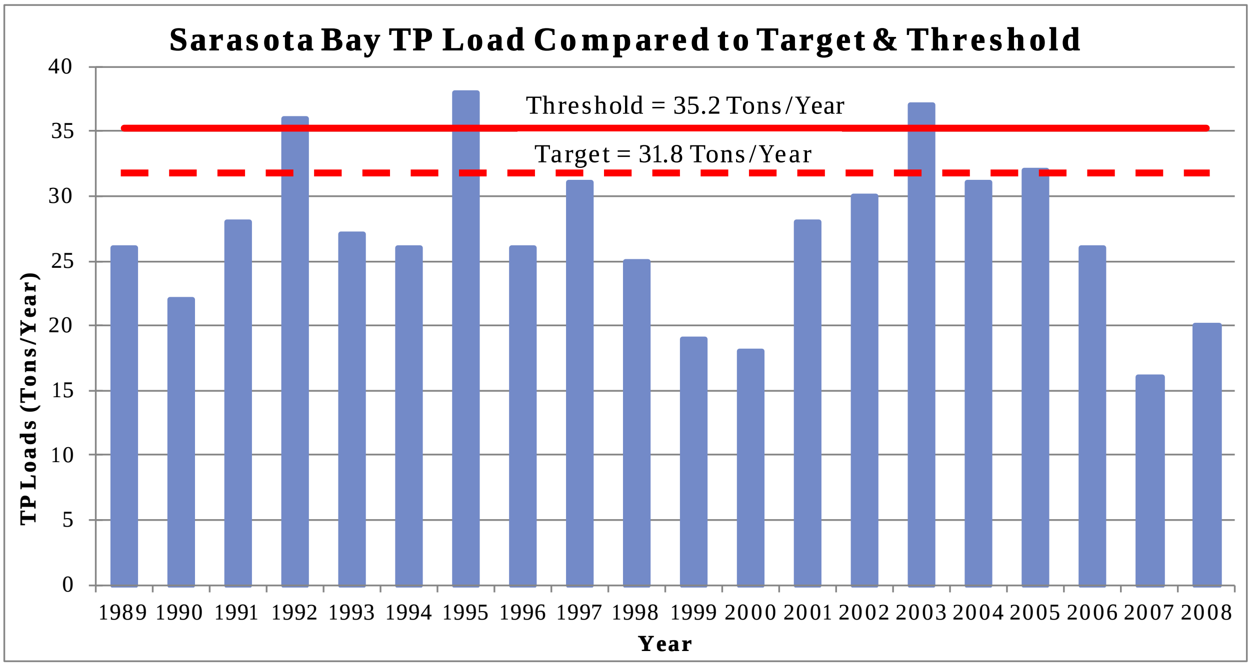
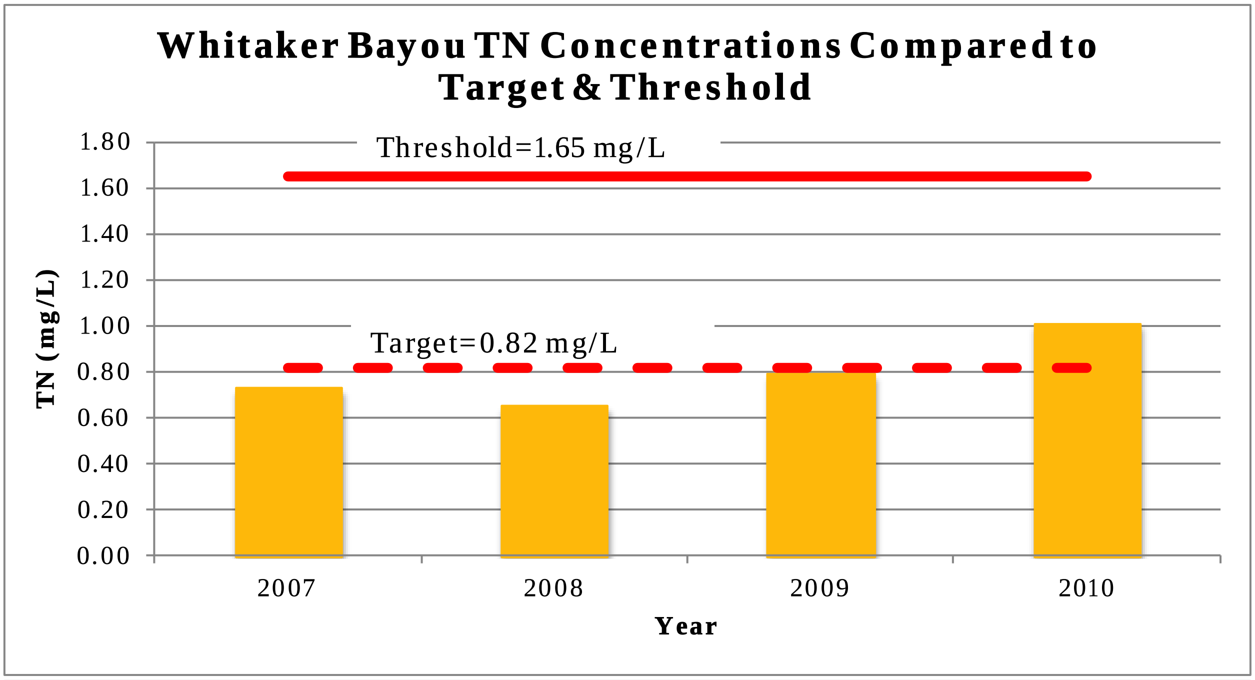


Figure 5-13 Comparison of TP Load Threshold (35.2 tons/year) and Target (32.0 tons/year) for Sarasota Bay to Annual Loads (1998–2008)

5.4.3.5 Development of Freshwater Tributary TN and TP Concentration LOS Thresholds and Targets

Data from the three freshwater sampling sites in Whitaker Bayou and two freshwater sites in Hudson Bayou were used to characterize ambient TN and TP concentrations for the respective tributaries. Data for 2007–2010 were compared to the FDEP NNC for the West Central Nutrient Watershed Region (FDEP, 2012a) as seen in Figure 5-14 and Figure 5-15. The only sampling site in Bowlees Creek is located in the marine reach.



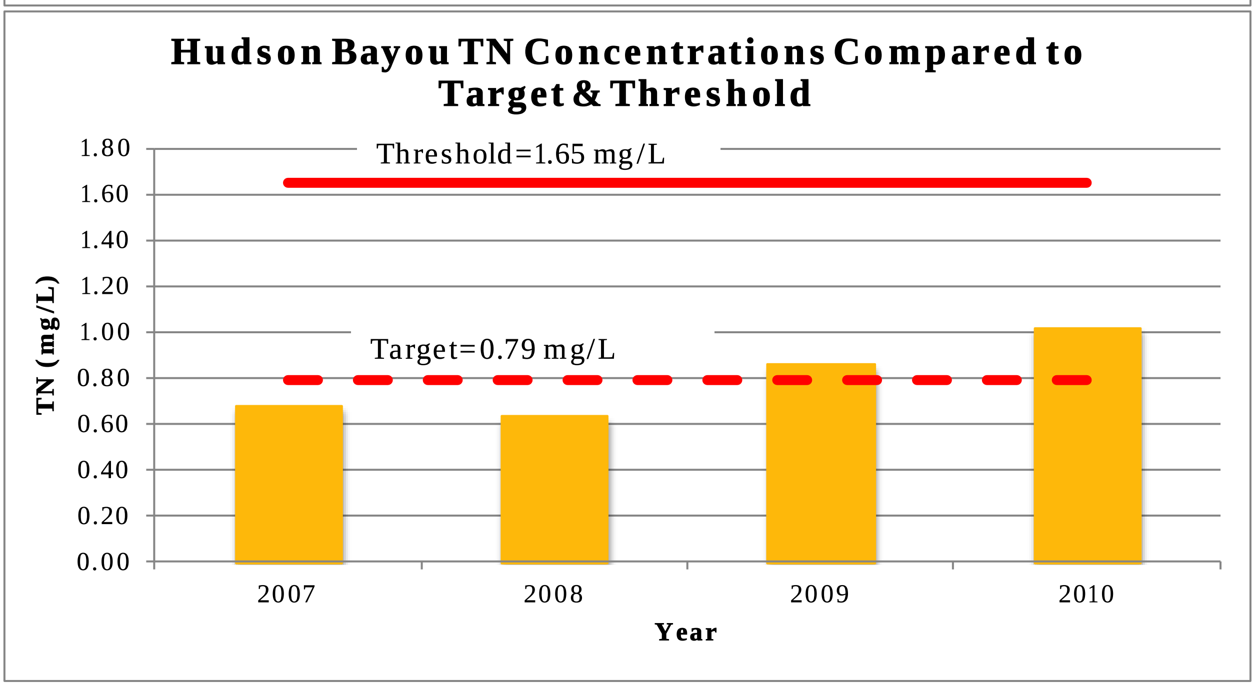
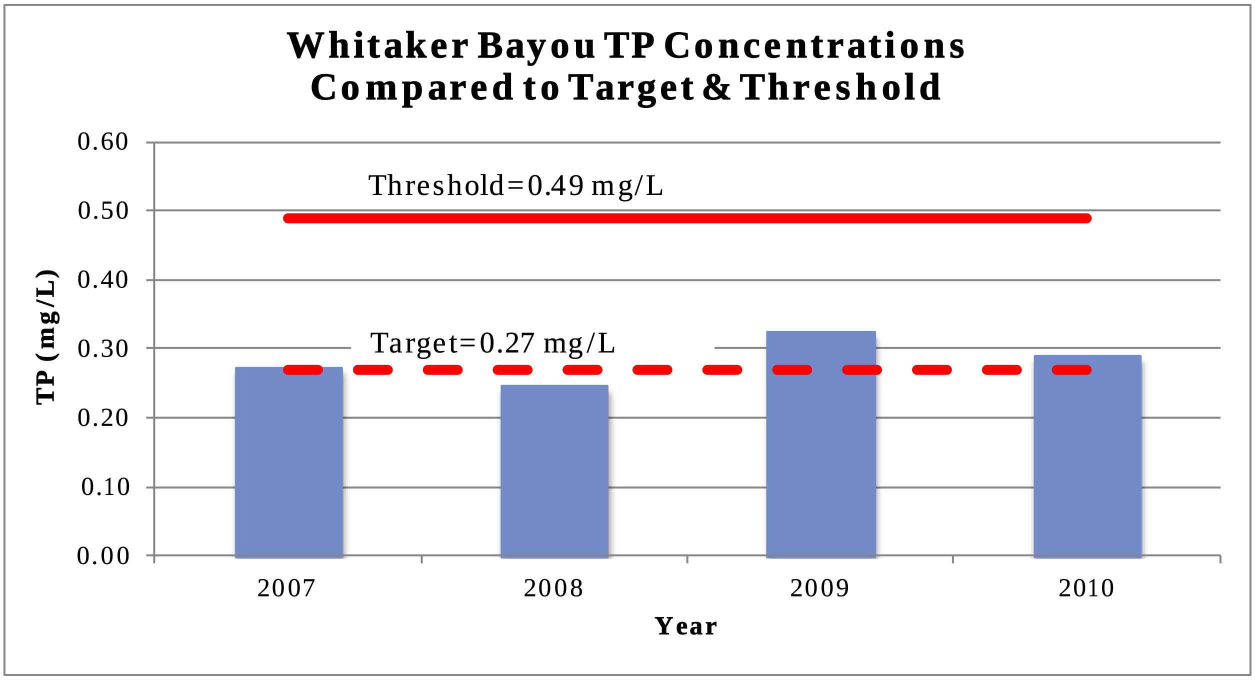


Figure 5-14 Comparison of the Freshwater TN Threshold (1.65 mg/L) and Targets to TN Concentrations in Whitaker Bayou (top) and Hudson Bayou (bottom)



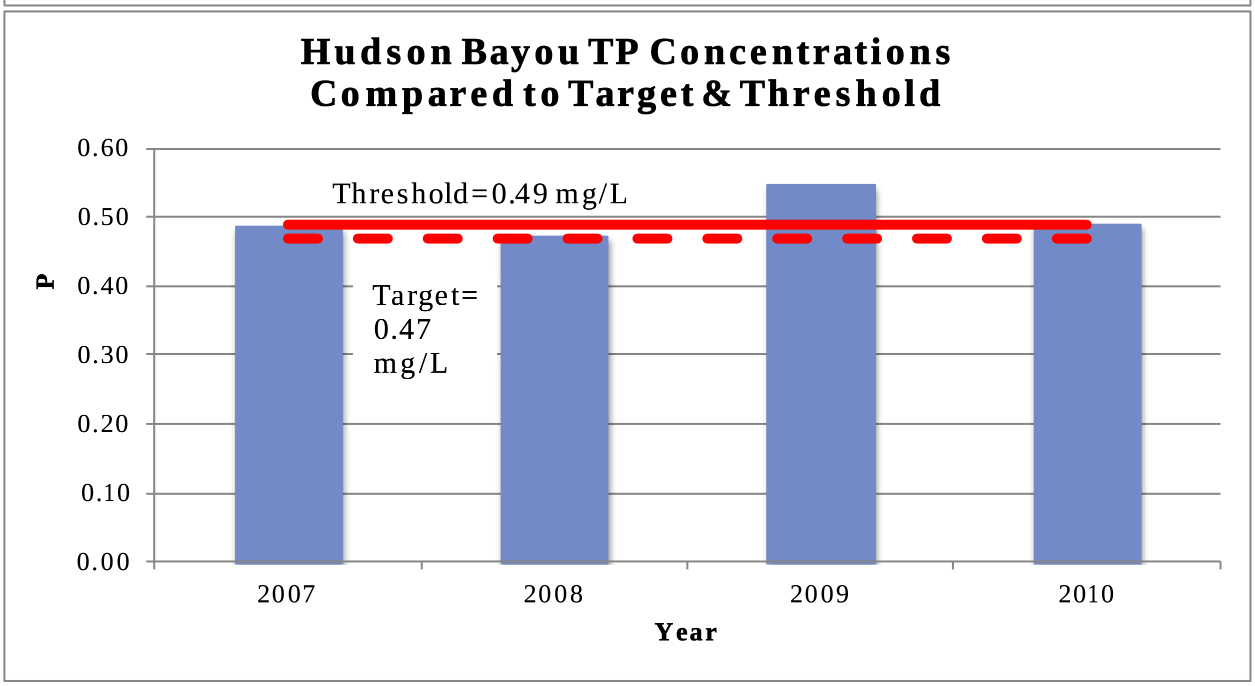


Figure 5-15 Comparison of the Freshwater TP Threshold (0.49 mg/L) and Targets to TP Concentrations in Whitaker Bayou (top) and Hudson Bayou (bottom)

The tributaries were also sampled in 2006 but only for October–December. Calculating an annual geometric mean for TN or TP using the FDEP (2012a) protocol requires at least four temporally independent samples per year with at least one sample taken between May 1 and September 30 and at least one sample taken during the other months of the calendar year. Thus, the geometric mean for the 3-month period in 2006 was not used to determine conformance with the criterion. Using annual geometric means of the concentrations, ambient TN concentrations for freshwater sites in both Whitaker Bayou and Hudson Bayou were much lower than the TN criterion of 1.65 mg/L for all years. However, the ambient concentrations in both tributaries increased substantially (but not statistically significantly) between 2007 and 2010. The ambient TP concentrations for Whitaker Bayou are also well below the threshold of 0.49 mg/L. In contrast, Hudson Bayou TP concentrations were considerably higher than Whitaker Bayou. Hudson Bayou TP was higher than the threshold concentration in 2009 and equaled it in 2007 and 2010. To not meet the threshold, the threshold must be exceeded in any 2 years of a 3-consecutive-year period, thus the streams met the threshold criteria.

There remains the need for a TN and TP concentration target for the Sarasota Bay tributaries. To maintain consistency with the method used to set the estuarine TN concentration target, a reference period approach is recommended. The most recent data available for Sarasota Bay tributaries is 2006–2010. The mean of these recent data (0.39 mg/L) could be used as an initial target, as shown in Figure 5-14 and Figure 5-15 above. As more data become available, subsequent analyses can be applied to develop an appropriate target.

As Figure 5-14 and Figure 5-15 illustrate, both creeks met the TN target in 2007 and 2008, but neither met the target in 2010. Whitaker Bayou met the target in all 4 years, but Hudson Bayou did not meet the target in any year.

5.4.3.6 Development of Watershed Loading LOS

Basin-specific LOS criteria were developed using TN, TP, and TSS loadings from basins within the Sarasota Bay watershed. Evaluating watershed-based loadings can help prioritize watershed management efforts to protect critical estuarine and freshwater resources. The simplest method of setting LOS is to compare the TN, TP, and TSS loads originating from each basin.

The basin LOS are intended to help the County and resource managers identify areas in which nutrient and TSS loads are elevated so that stormwater management activities can be prioritized. Thus, only stormwater-generated surface runoff and base flow were included in the LOS estimates. Irrigation, point sources, septic tanks, and atmospheric deposition to the estuary were not included in the estimated watershed loads. Point source and septic tank loadings are not controlled using the same mechanisms and are managed through independent programs. Irrigation is a beneficial use of highly treated reclaimed water and accounts for only 1% of the TN load to the bay.

Nutrient Loading LOS

Table 5-2 shows TN and TP loading targets for Sarasota Bay basins. To be consistent with the methods used to develop the chlorophyll target, annual loads for 2001 through 2005 were averaged to determine the target. The threshold is the target plus one standard deviation of all years' annual loads. As can be seen, the targets reflect the relative loading levels to each basin, with larger basins in general having higher targets. TN targets ranged from 0.31 (Siesta Key) to 34.0 tons/year (Bowlees Creek). TP targets ranged from 0.06 (Siesta Key) to 6.60 tons/year (Bowlees Creek). TN thresholds ranged from 0.43 (Siesta Key) to 41.24 tons/year (Bowlees Creek). TP thresholds ranged from 0.08 (Siesta Key) to 7.98 tons/year (Bowlees Creek). Basin loadings are compared to TN and TP targets and thresholds in Figure 5-16, Figure 5-17, Figure 5-18, Figure 5-19, Figure 5-20, Figure 5-21, Figure 5-22, Figure 5-23, Figure 5-24, and Figure 5-25.

Table 5-2 TN and TP Loading Targets and Thresholds for Sarasota Bay Basins

Basin	TN (tons/year)		TP (tons/year)	
	Target	Threshold	Target	Threshold
Canal Road Drain	1.76	2.26	0.31	0.40
Sarasota Bay Coastal North	18.5	23.3	3.14	3.89
Palma Sola Drain – Bayshore	7.03	8.68	1.28	1.57
Cedar Hammock Creek	16.6	20.3	3.25	3.97
Bowlees Creek	34.0	41.2	6.60	7.98
Longboat/Lido Keys	13.3	17.0	2.60	3.31
Sarasota Bay Coastal South	8.37	10.5	1.44	1.81
Whitaker Bayou	26.4	32.7	2.57	4.91
Hudson Bayou	13.9	17.6	2.46	3.10
Siesta Key	0.31	0.43	0.06	0.08

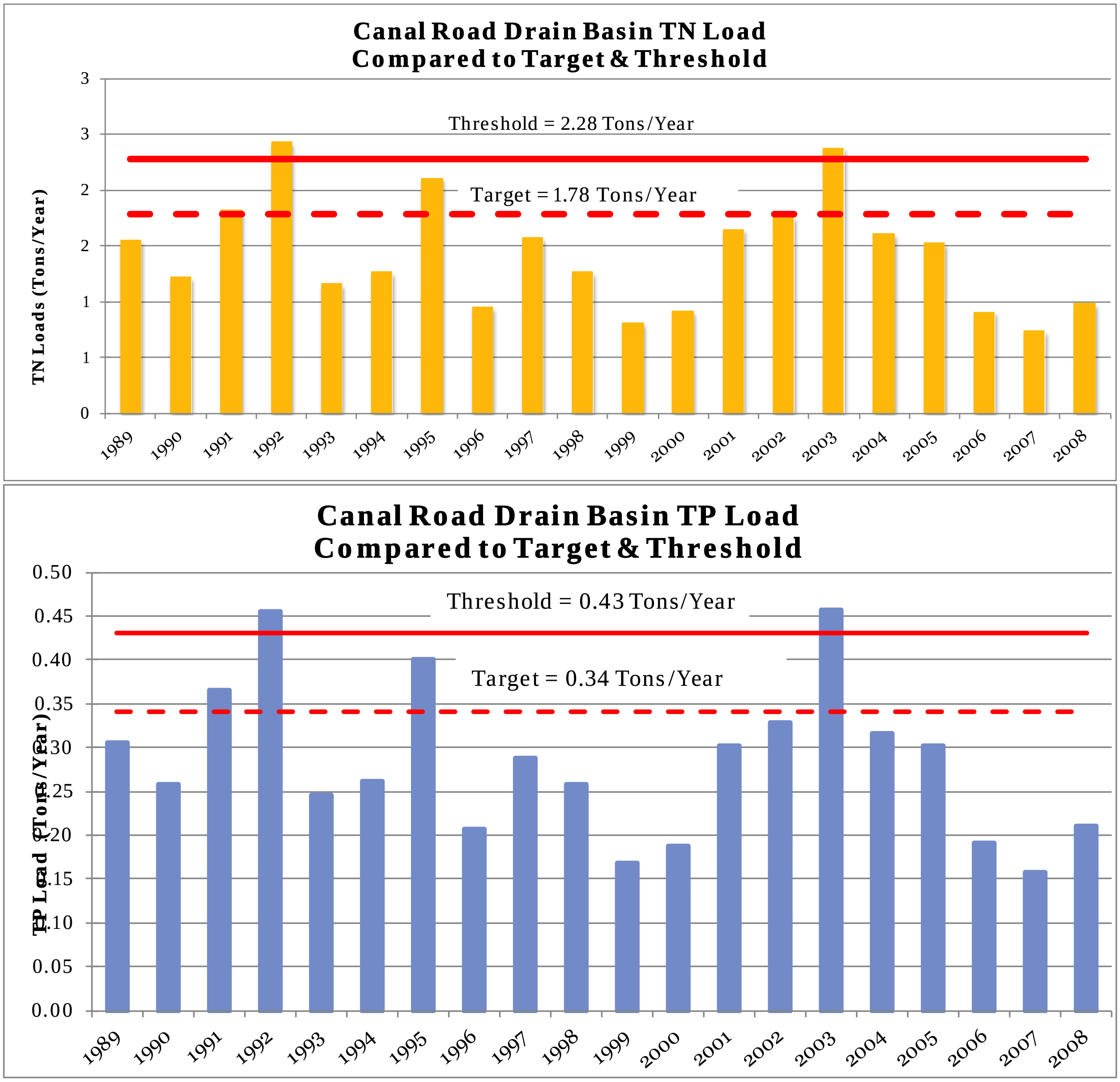
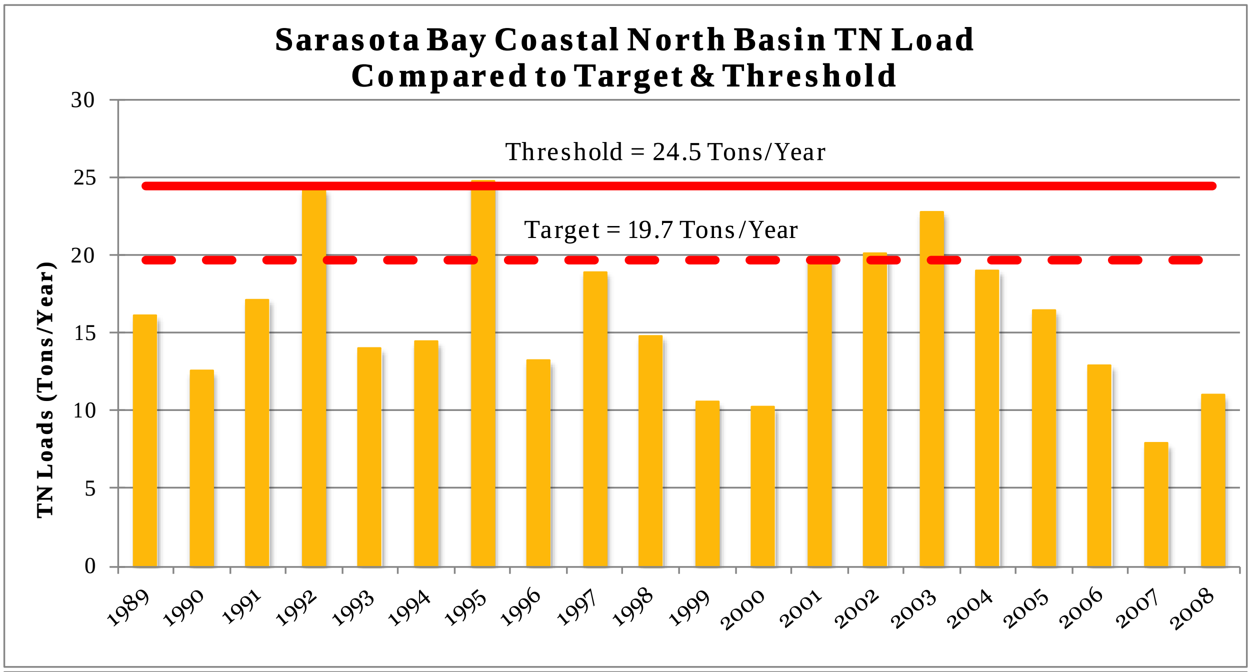


Figure 5-16 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Canal Road Drain



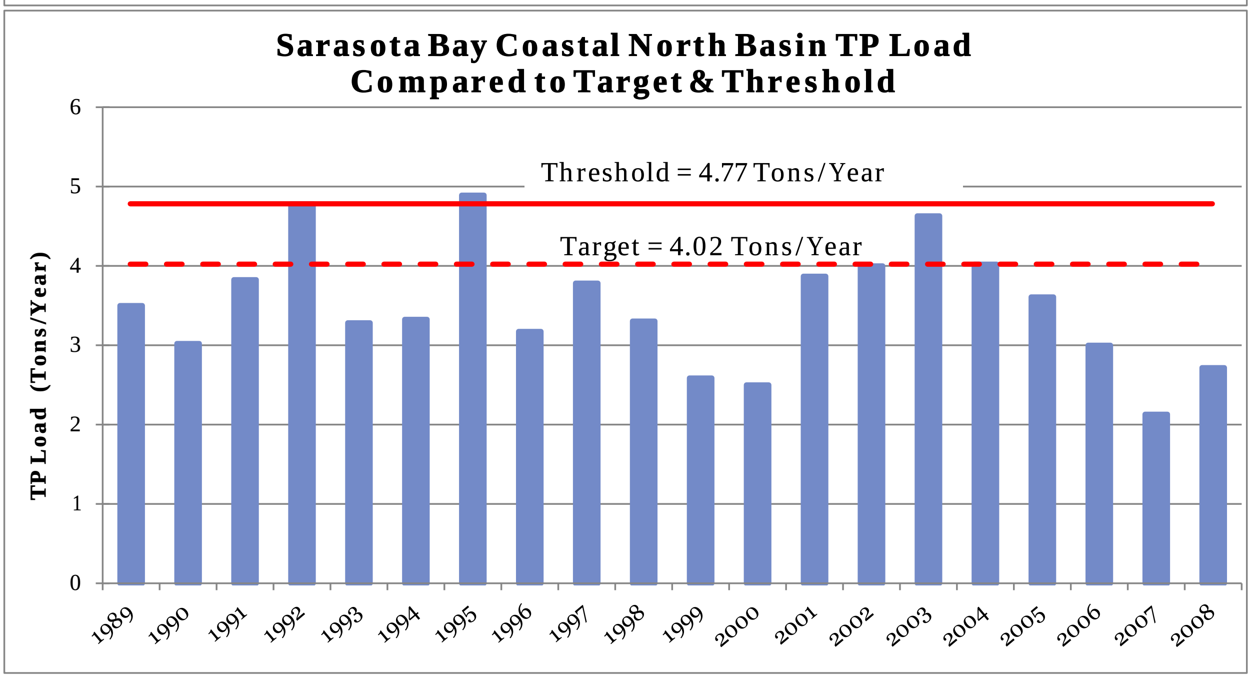
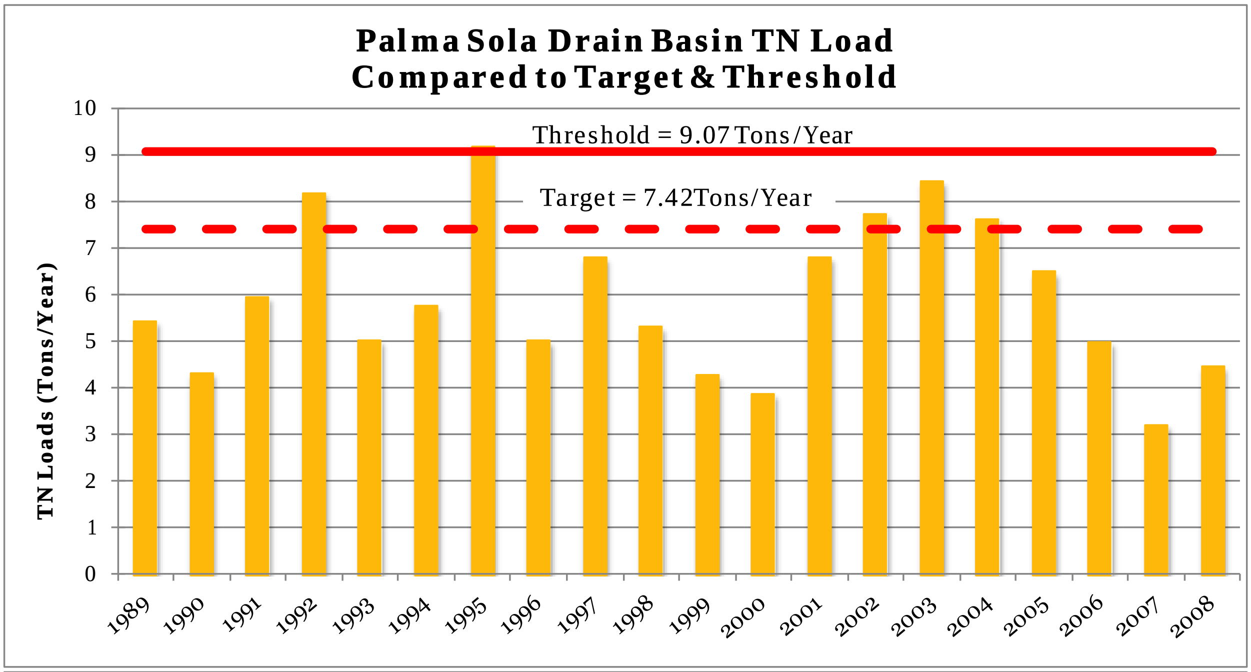


Figure 5-17 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Sarasota Bay Coastal North



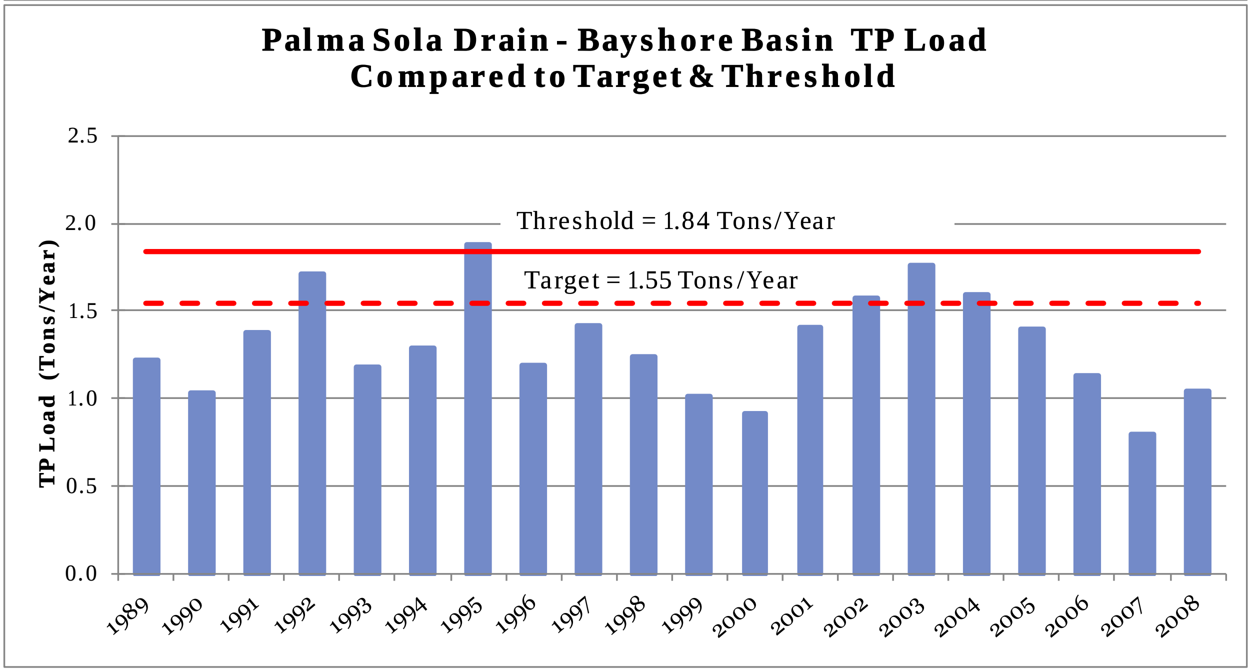


Figure 5-18 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Palma Sola Drain—Bayshore

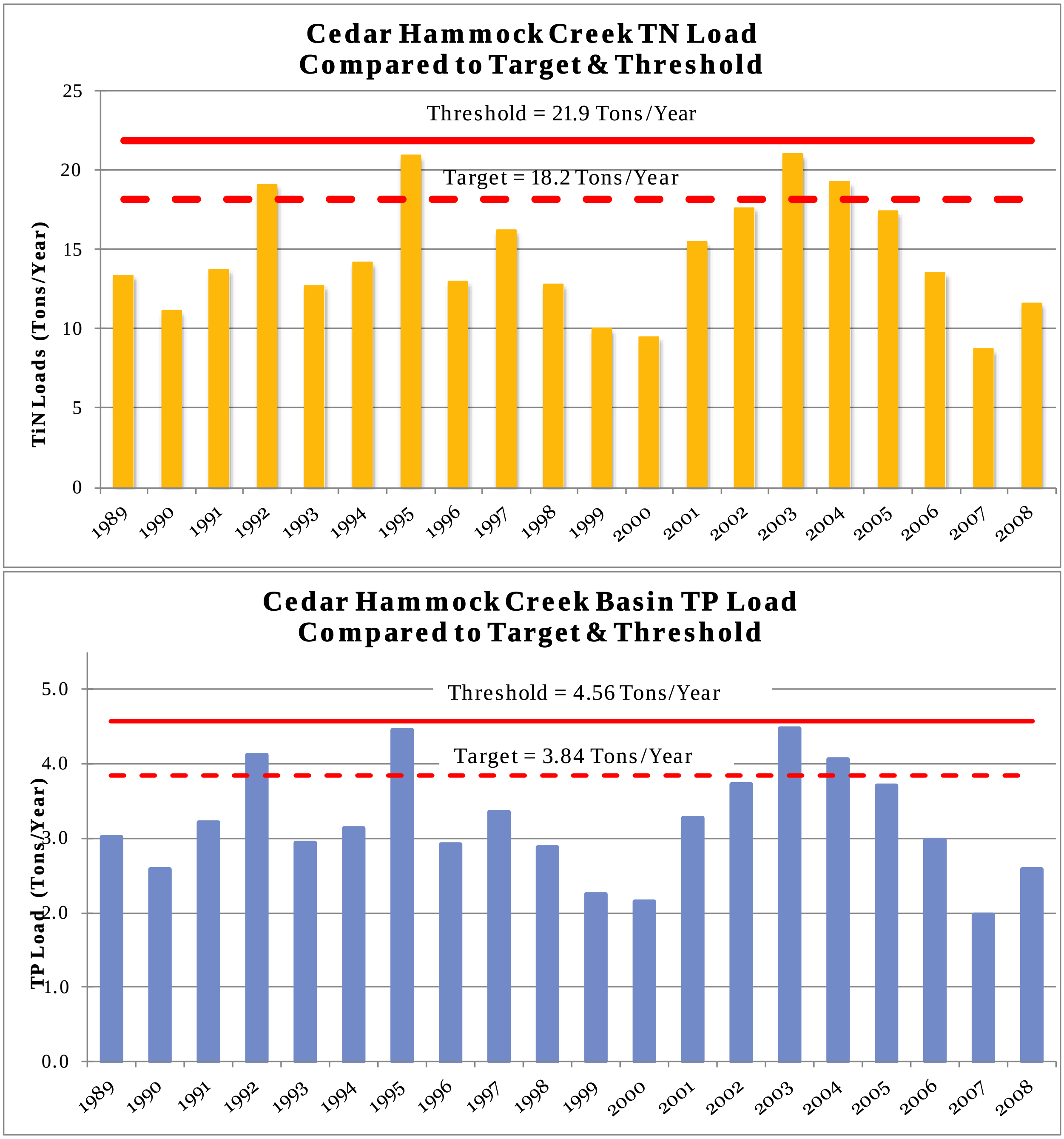
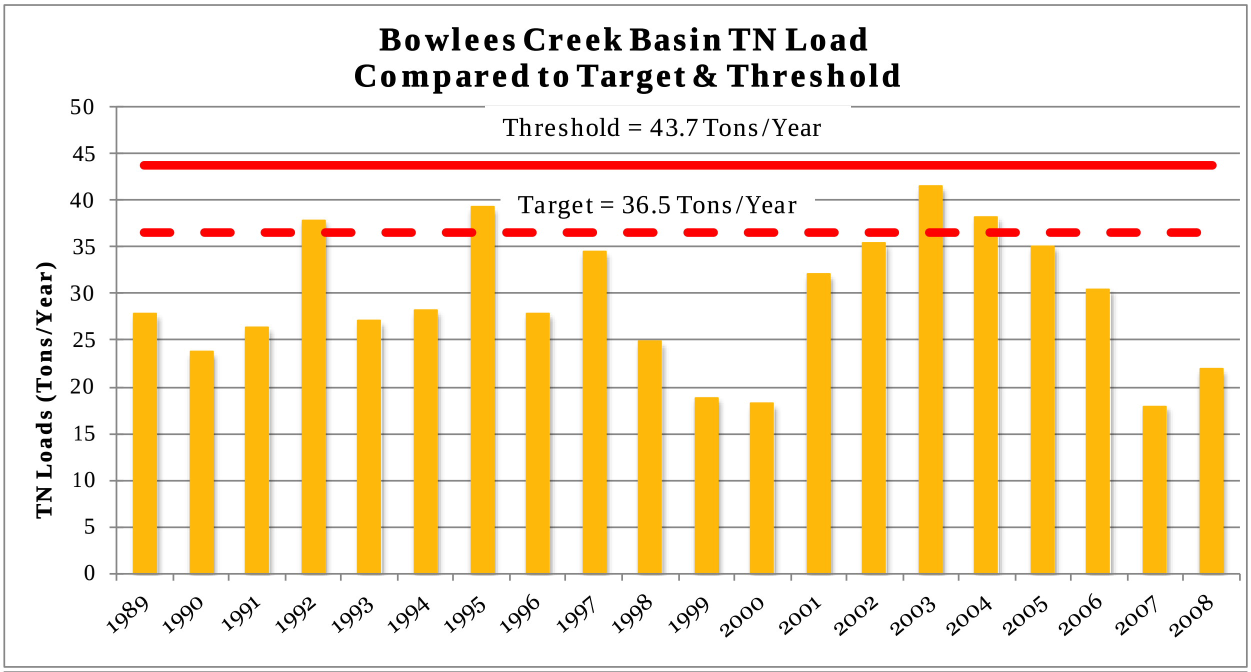


Figure 5-19 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Cedar Hammock Creek



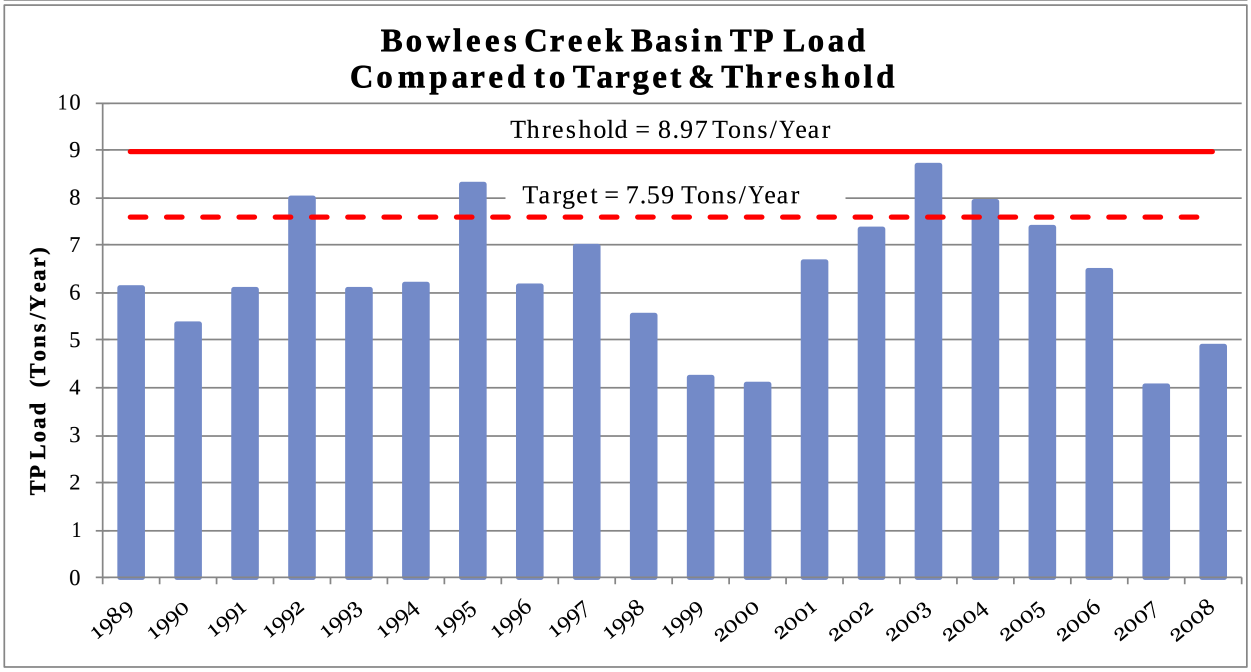
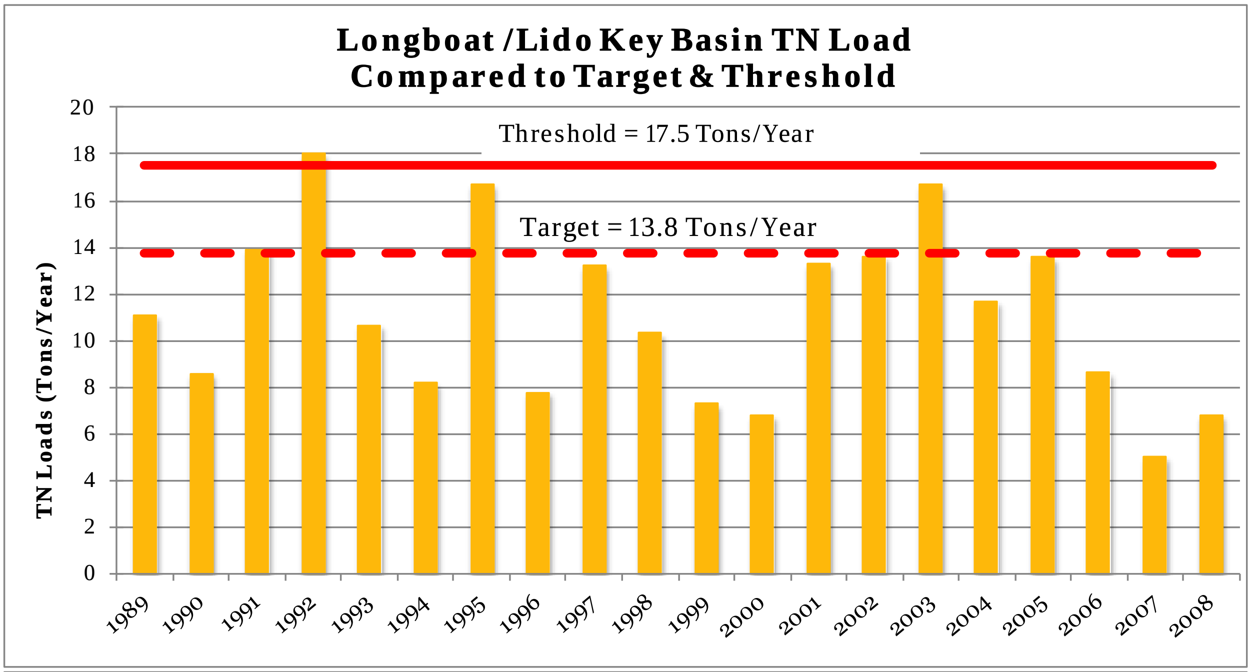


Figure 5-20 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Bowlees Creek



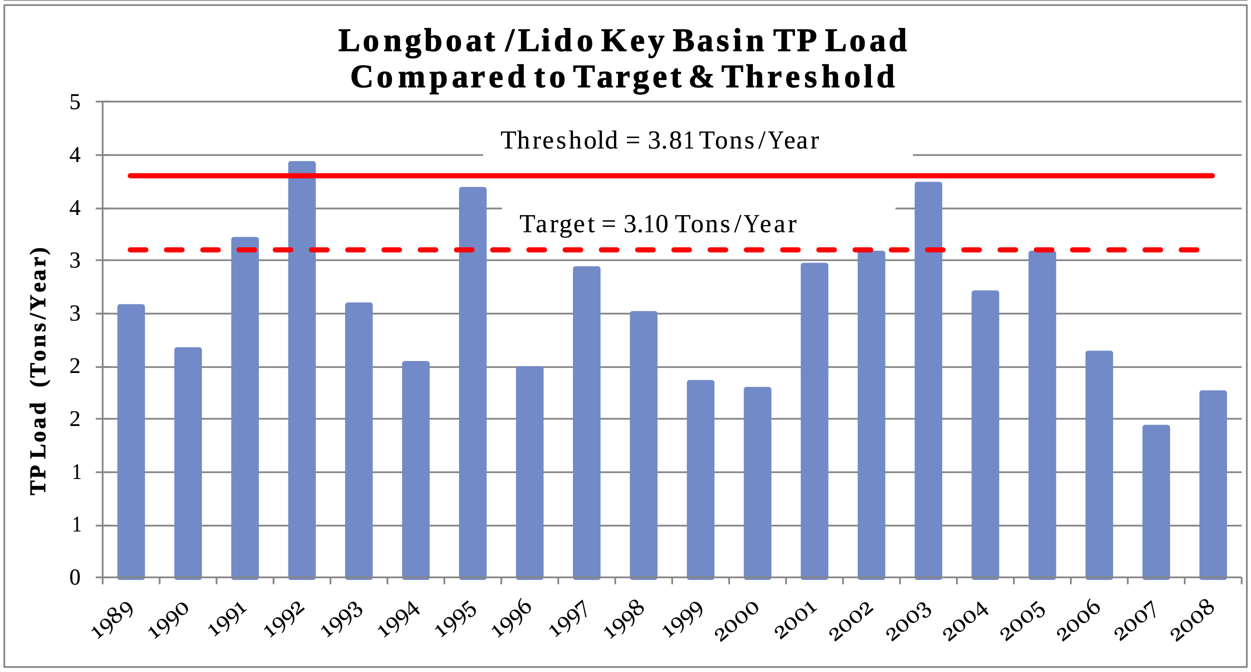
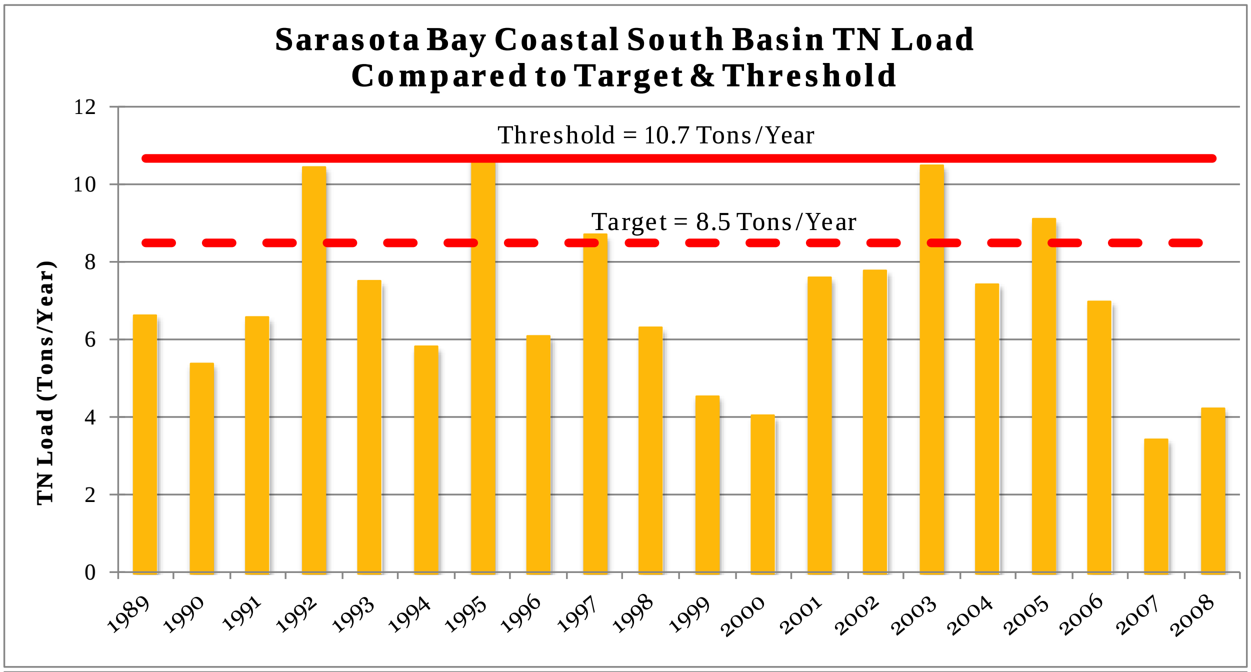


Figure 5-21 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Longboat/Lido Keys



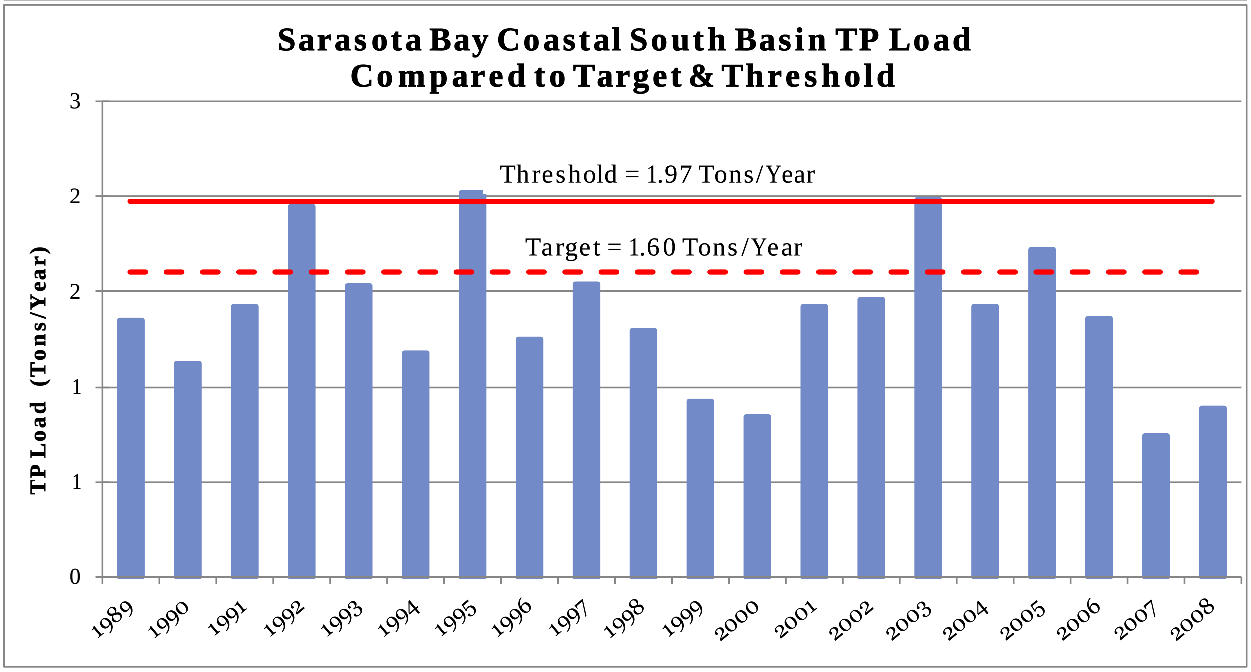
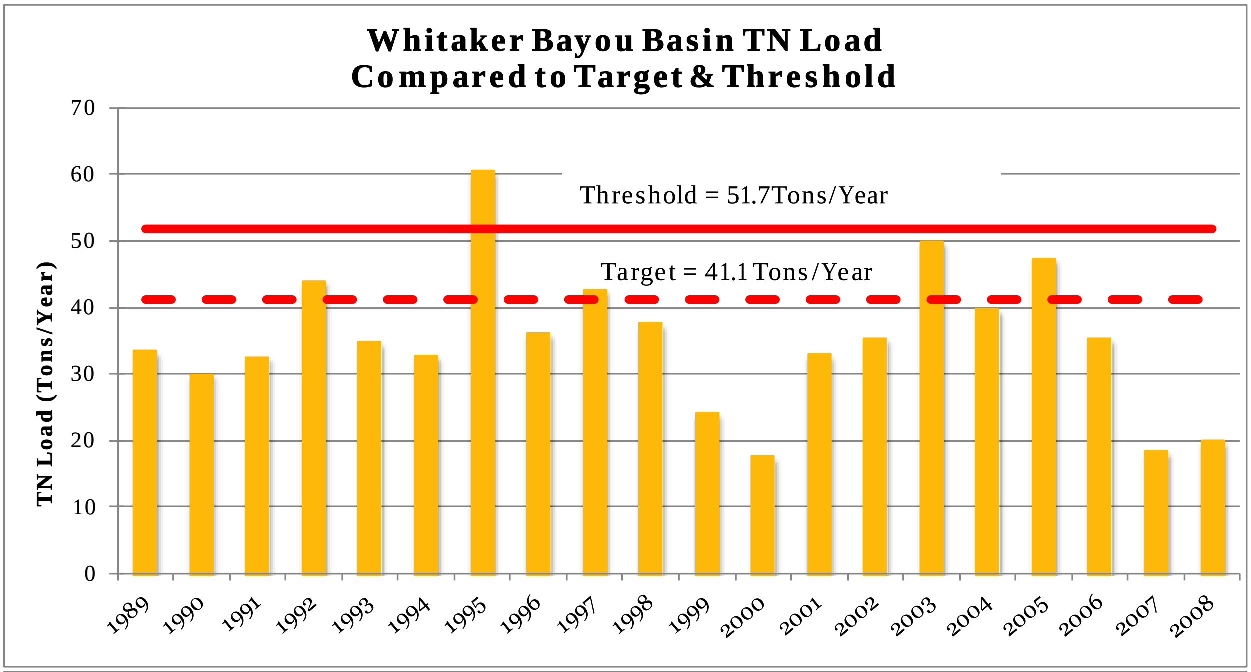


Figure 5-22 Comparison of Mean Annual TN (Top) and TP (bottom) Loads to Basin Targets and Thresholds—Sarasota Bay Coastal South



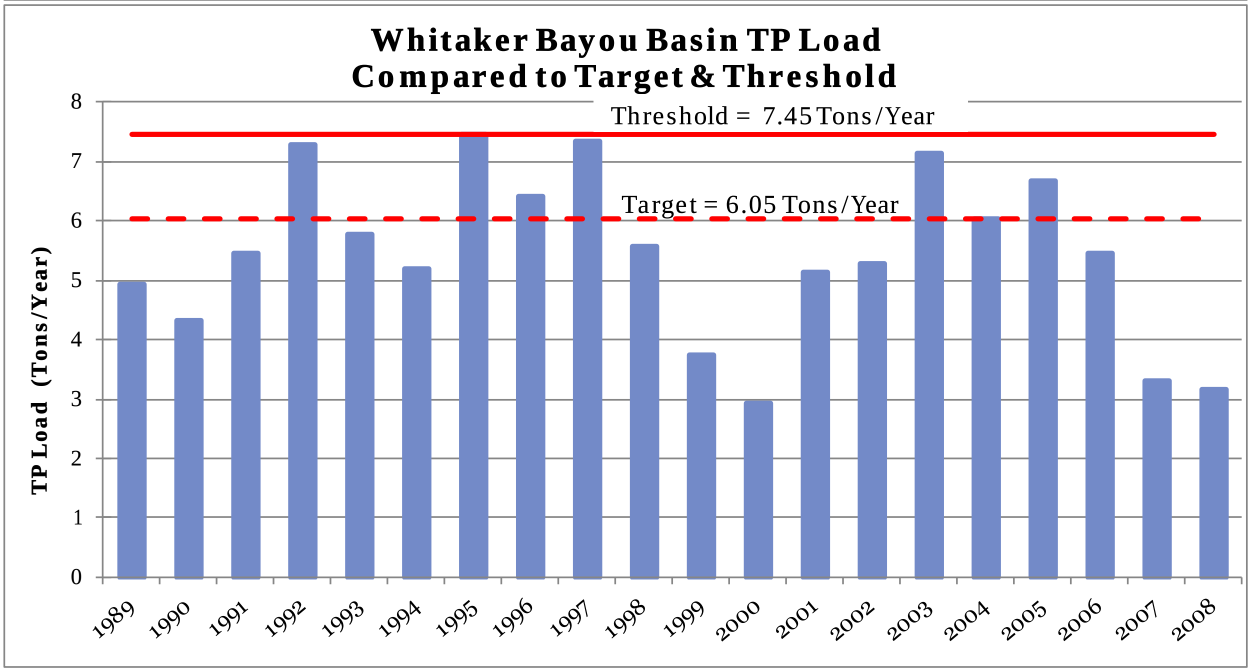
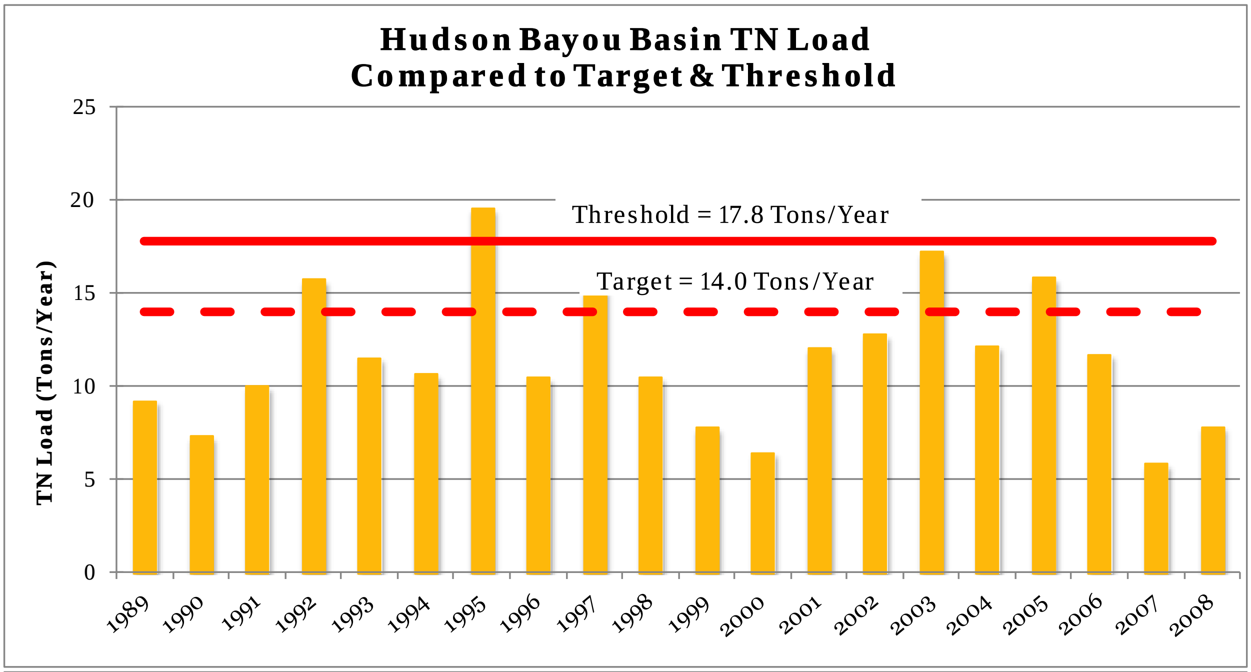


Figure 5-23 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Whitaker Bayou



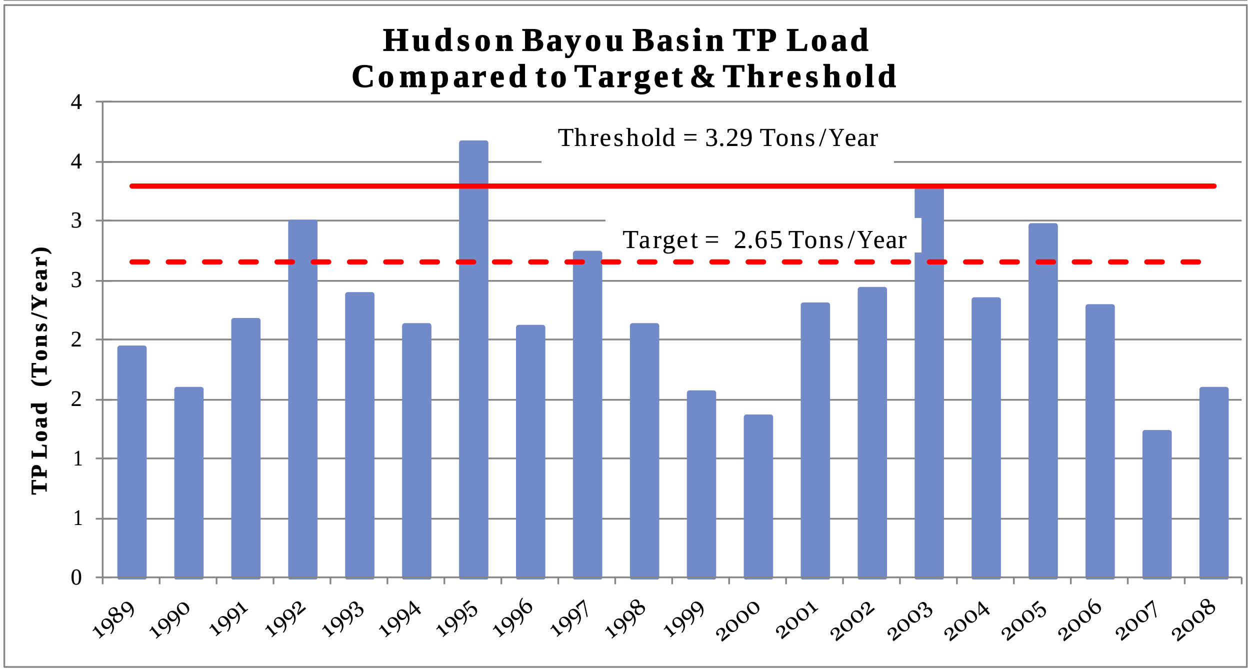
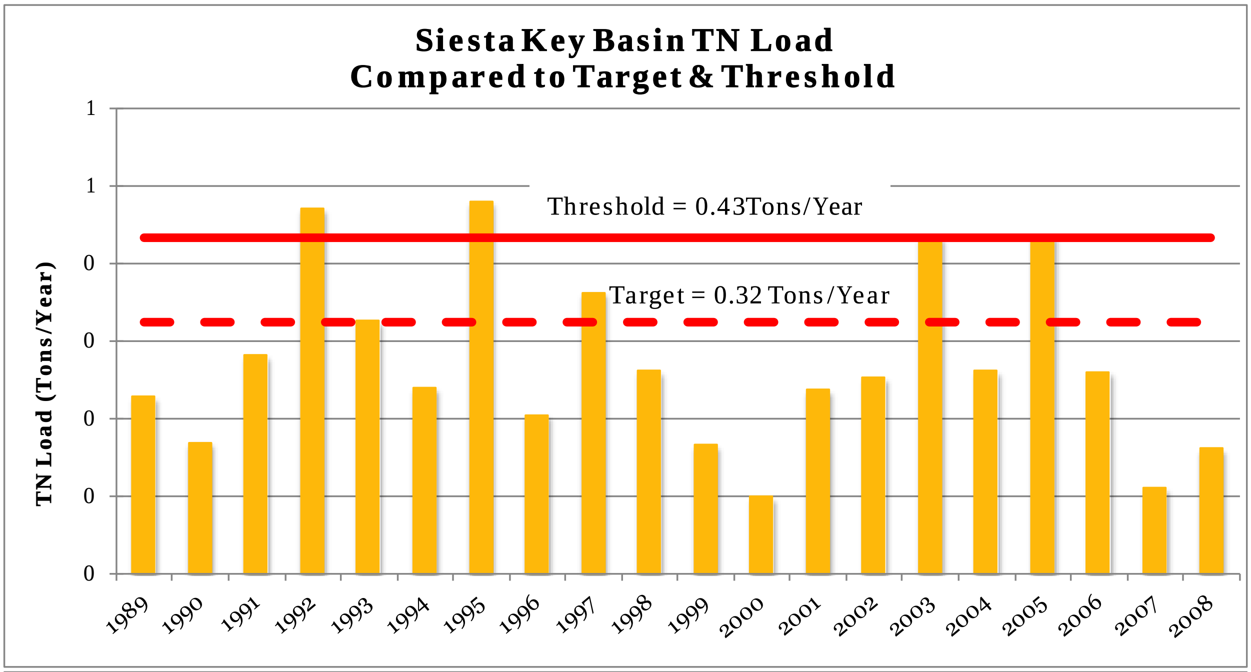


Figure 5-24 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Hudson Bayou



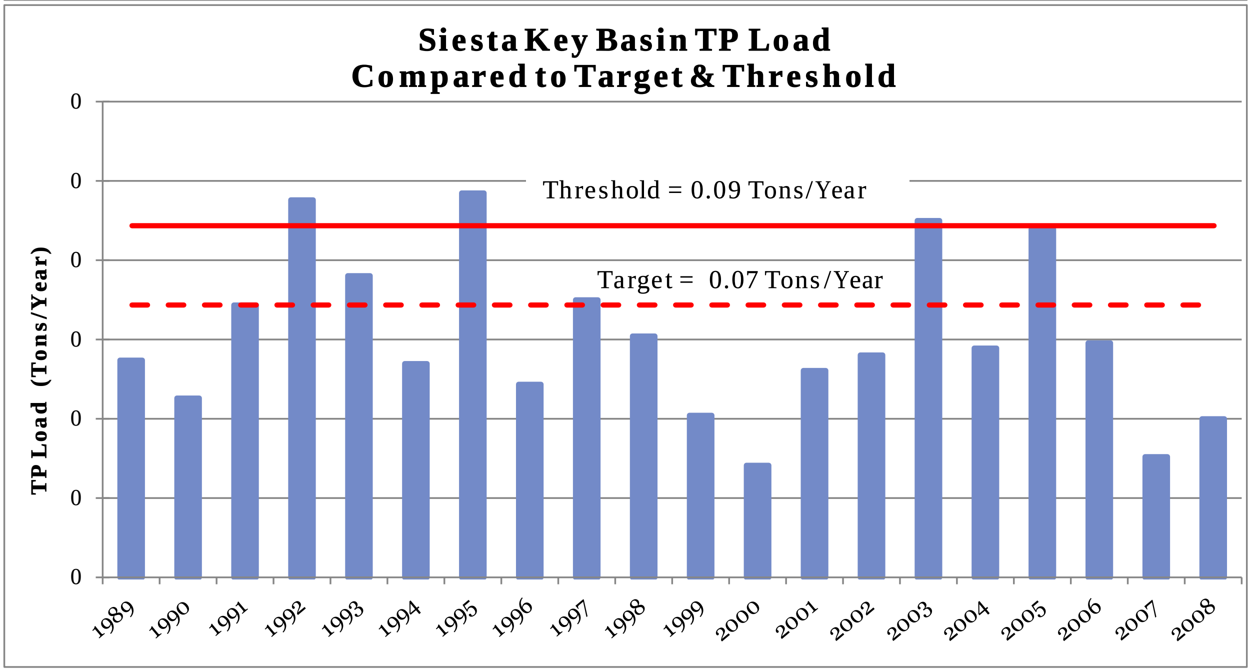


Figure 5-25 Comparison of Mean Annual TN (top) and TP (bottom) Loads to Basin Targets and Thresholds—Siesta Key

TSS Loading LOS

Table 5-3 shows TSS loading targets for Sarasota Bay basins. To be consistent with the methods used to develop the chlorophyll target, annual loads for 2001–2005 were averaged to determine the target. The threshold is the target plus one standard deviation of all years' annual loads. As can be seen, the targets reflect the relative loading levels to each basin, with larger basins in general having higher targets. TSS targets ranged from 0.31 (Siesta Key) to 34.0 tons/year

(Bowlees Creek). TSS thresholds ranged from 0.43 (Siesta Key) to 41.24 tons/year (Bowlees Creek). Basin loadings are compared to TSS targets and thresholds in Figure 5-26, Figure 5-27, Figure 5-28, Figure 5-29, Figure 5-30, Figure 5-31, Figure 5-32, Figure 5-33, Figure 5-34, and Figure 5-35.

Table 5-3 TN and TP Loading Targets and Thresholds for Sarasota Bay Basins

Basin	TSS (tons/year)	
	Target	Threshold
Canal Road Drain	1.76	2.26
Sarasota Bay Coastal North	18.5	23.3
Palma Sola Drain - Bayshore	7.03	8.68
Cedar Hammock Creek	16.6	20.3
Bowlees Creek	34.0	41.2
Longboat/Lido Keys	13.3	17.0
Sarasota Bay Coastal South	8.37	10.5
Whitaker Bayou	26.4	32.7
Hudson Bayou	13.9	17.6
Siesta Key	0.31	0.43

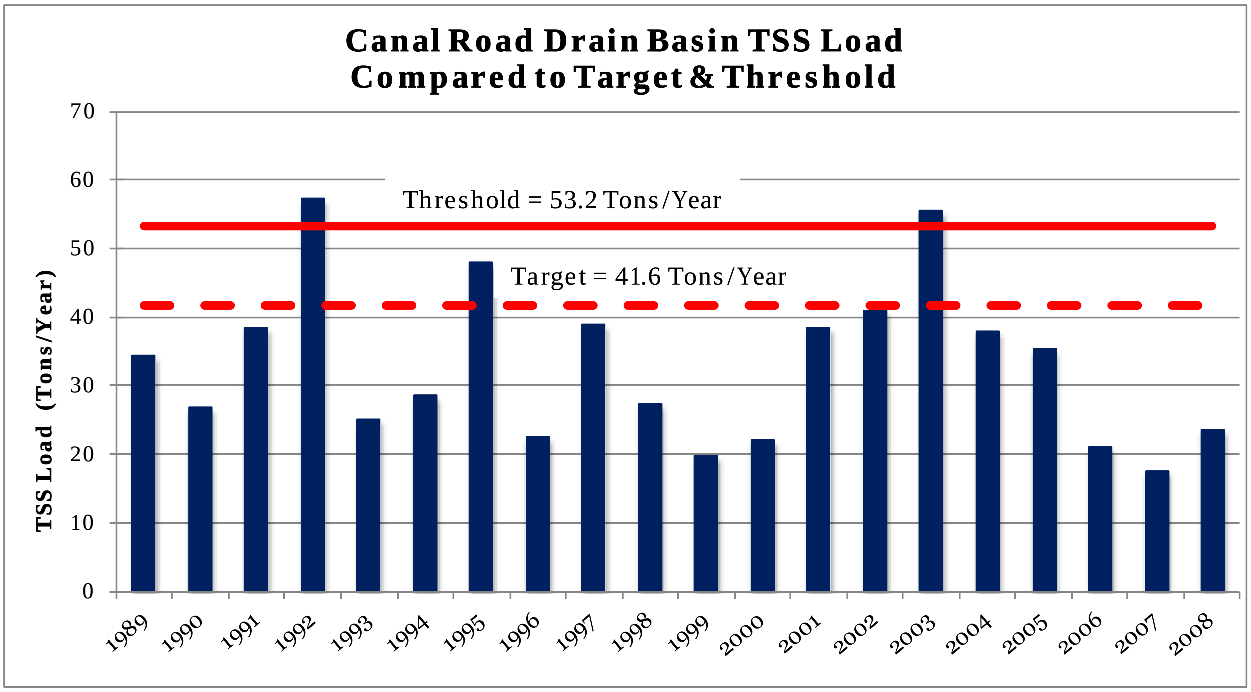


Figure 5-26 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Canal Road Drain

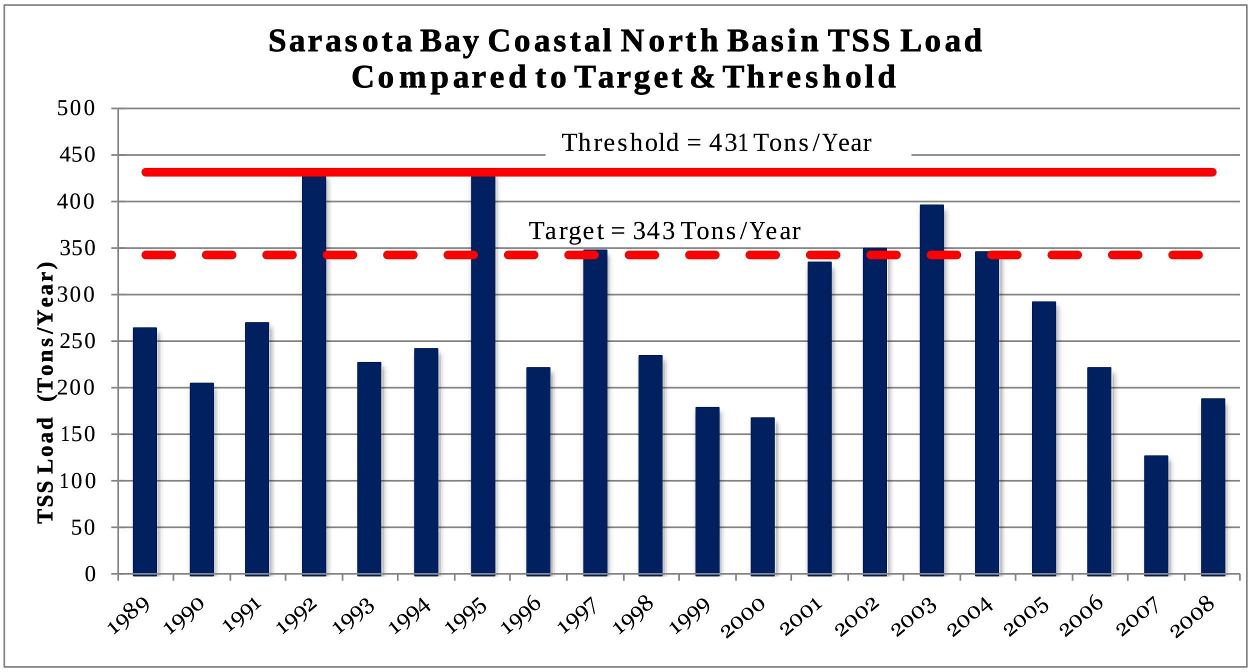


Figure 5-27 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Sarasota Bay Coastal North

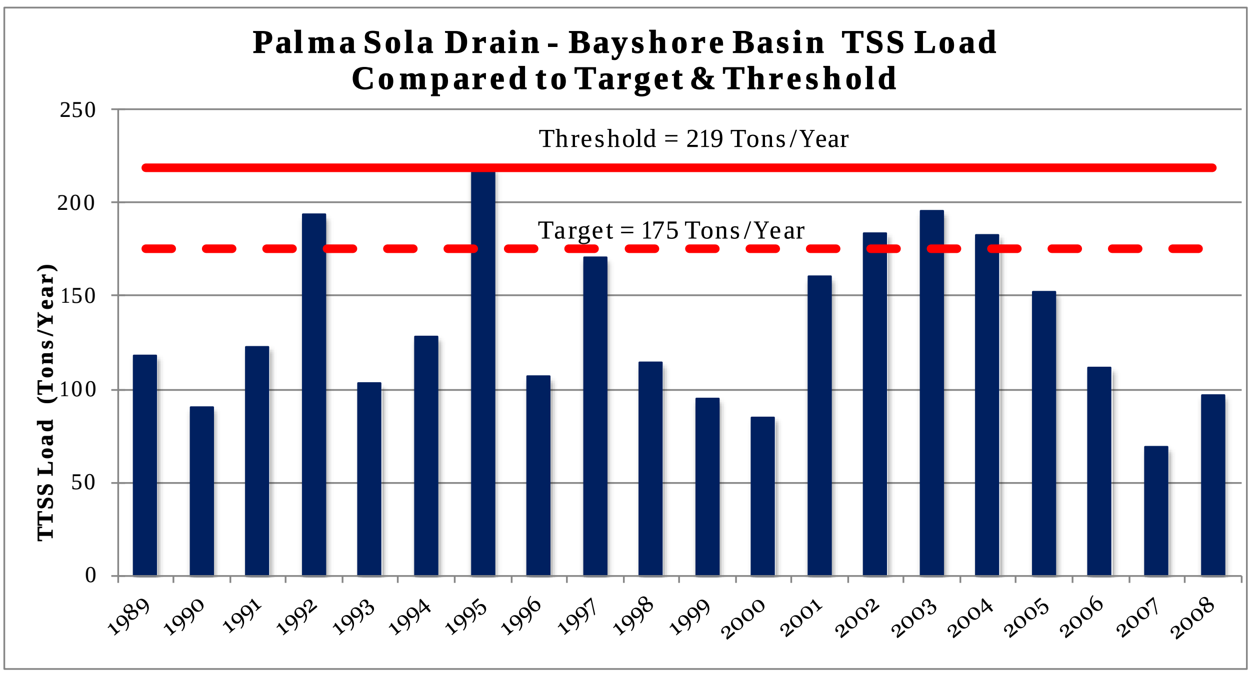


Figure 5-28 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Palma Sola Drain—Bayshore

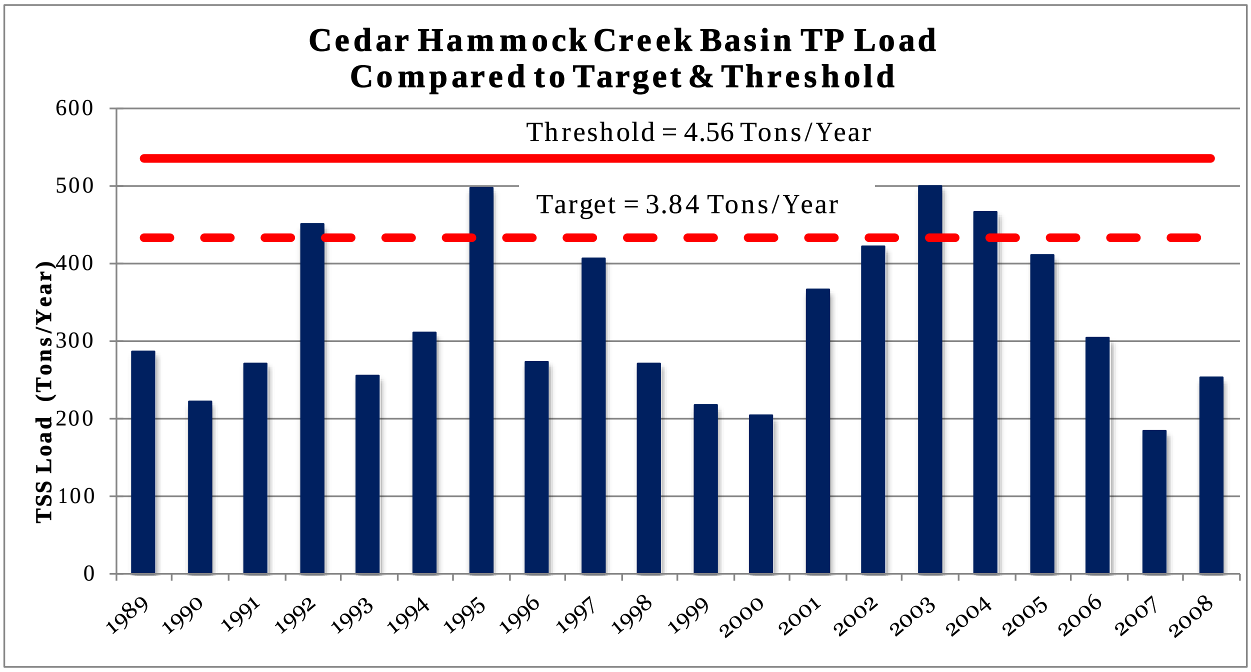


Figure 5-29 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Cedar Hammock Creek

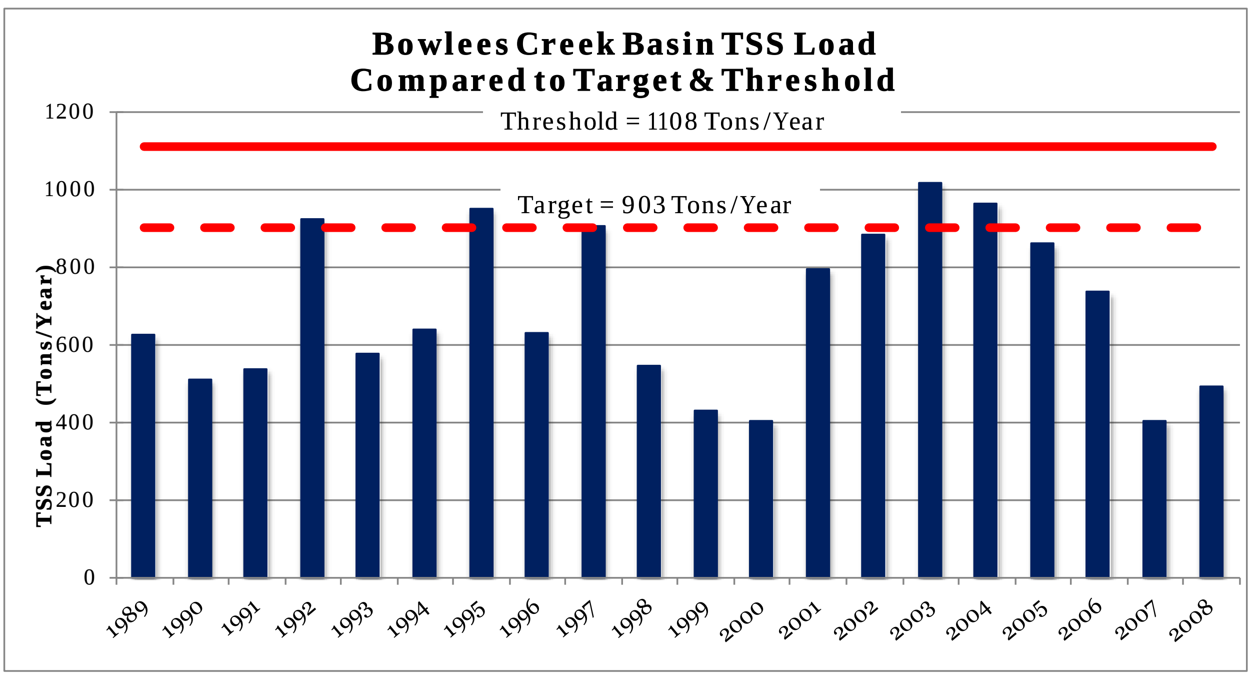


Figure 5-30 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Bowlees Creek

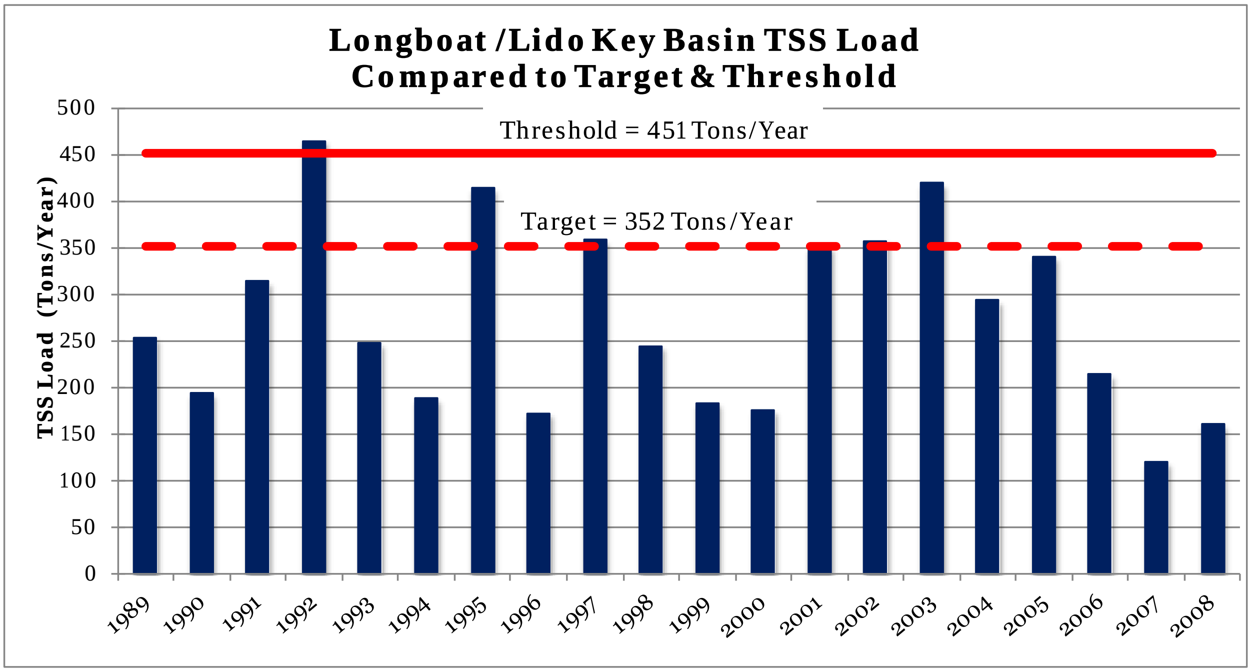


Figure 5-31 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Longboat/Lido Keys

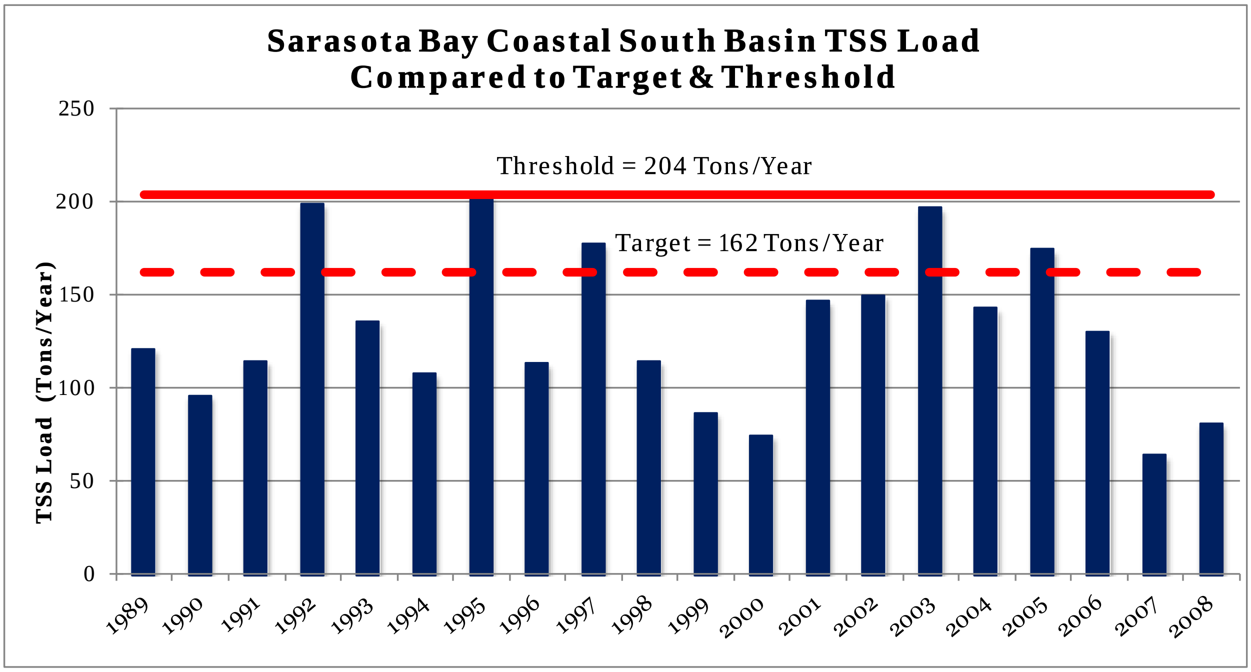


Figure 5-32 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Sarasota Bay Coastal South

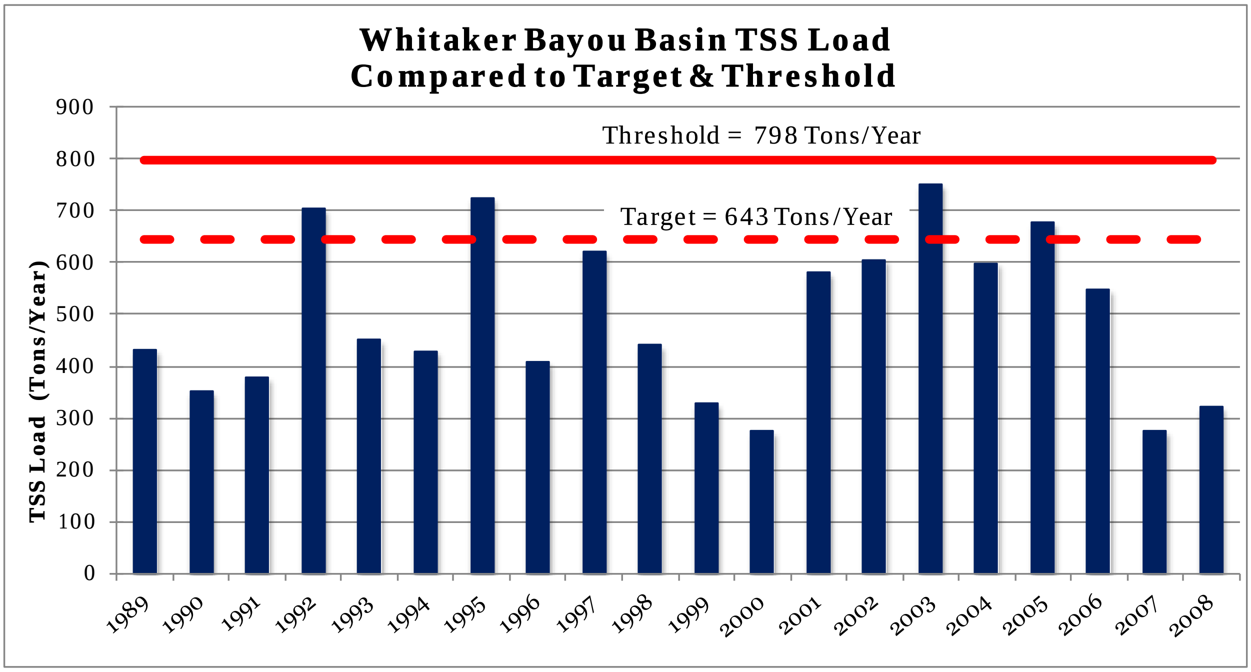


Figure 5-33 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Whitaker Bayou

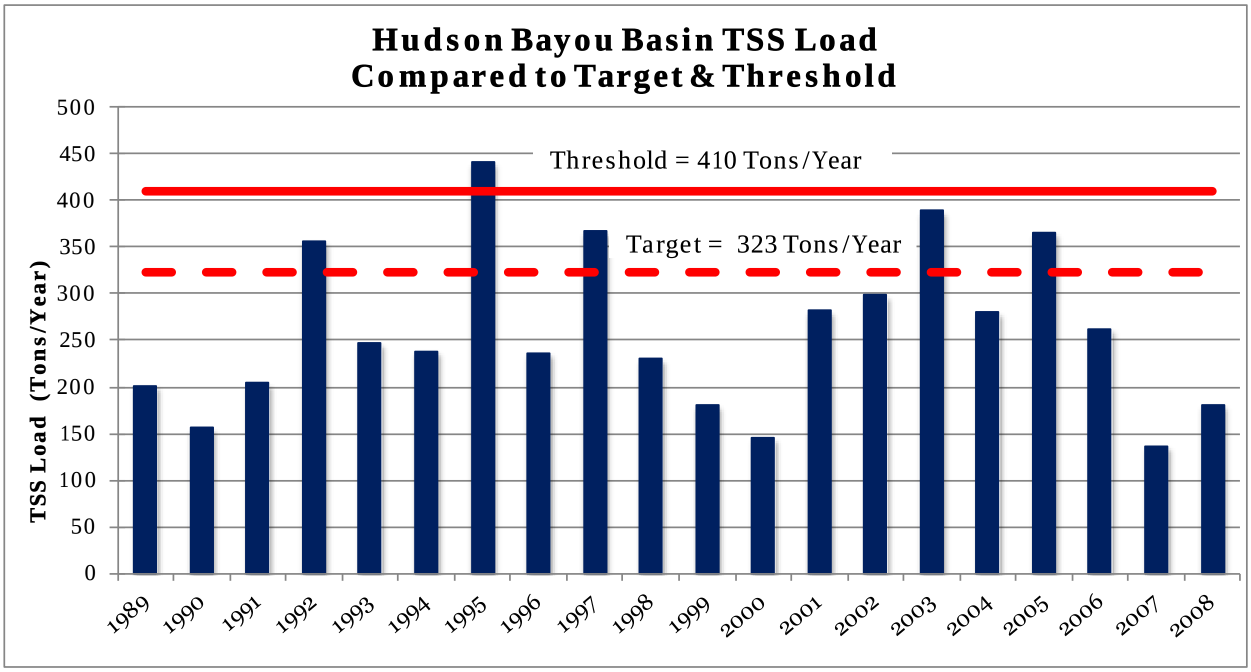


Figure 5-34 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Hudson Bayou

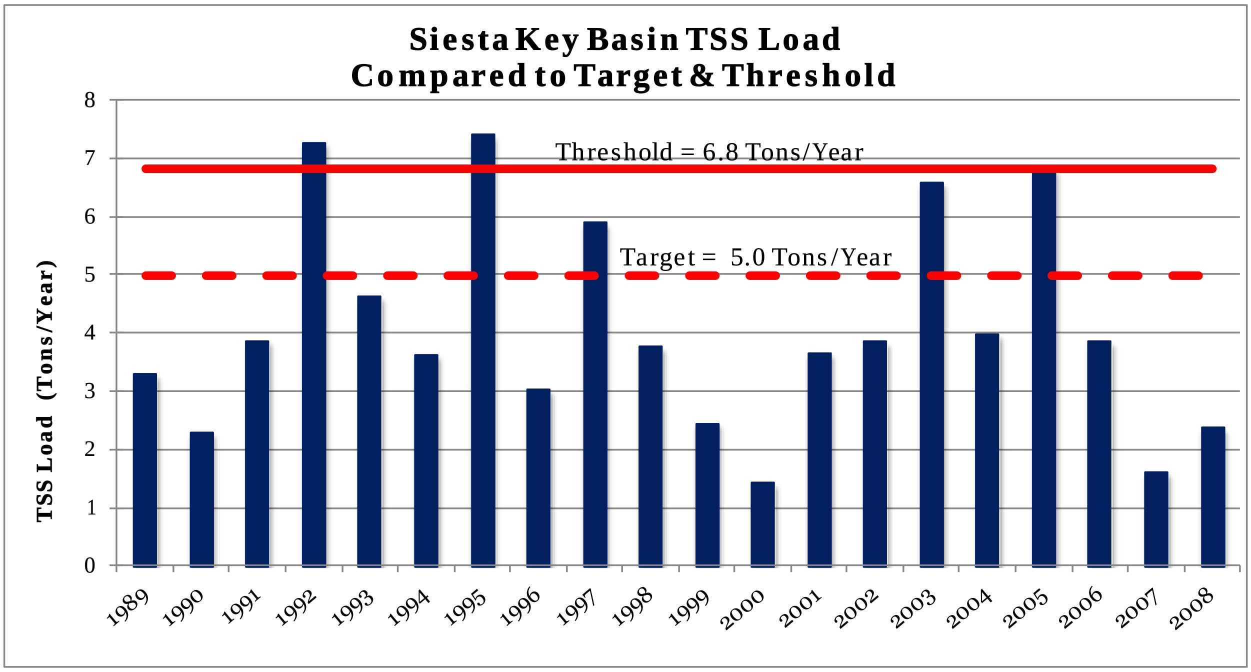


Figure 5-35 Comparison of Mean Annual TSS Concentrations to Target and Threshold—Siesta Key

5.4.3.7 Development of Freshwater Inflow LOS for Maintenance of Salinity Distributions

An additional water quality parameter that is important to the aquatic health of the estuary is salinity. Most estuarine flora and fauna have a preferred range of salinity for both juveniles and adults of the species. The study of the life histories of many estuarine species has revealed that most organisms that live in coastal waters tolerate a wide range of salinities, as shown in Table 5-4. This trait has been developed to allow biota to adapt to the natural variability in salt concentrations resulting from varying rates of freshwater inflows.

Table 5-4 Salinity Preferences for Selected Species (ppt)

Species	Lower Limit	Upper Limit
Oyster Adult	11	33
Oyster Larval	11	31
Bay Scallop Juvenile and Adult	14	36
Bay Scallop Larval stage	22	36
Blue Crab, Megalopae	16	38
Blue Crab, Spawning Female	21	38
Sea Trout	15	34
Turtle Grass	7	48
Bay Anchovy	10	20
Pinfish	20	25
Pink Shrimp	10	15
Black Mangrove	15	30
White Mangrove	17	25

The results of this work indicate that tidal exchange of bay water with the Gulf of Mexico is the predominant factor affecting salinity in the bay because of two factors. One factor is the relatively small watershed area in comparison to the bay surface area. The Sarasota Bay watershed is less than 20% larger than the bay itself. In contrast, the Tampa Bay and Charlotte Harbor watersheds are six and 16 times the size of their respective estuaries. The second factor is the conveyance capacity of the coastal inlets including Anna Maria Pass, New Pass, and Big Sarasota Pass. The mean ratio of freshwater inflow to tidal prism volume (the volume of water exchanged between the bay and gulf during a tide cycle) is approximately 0.15, which means that the tidal exchange volume is more than five times the freshwater inflow on average.

Figure 5-36 shows that current freshwater inputs are somewhat higher than historical at moderate and higher flow rates (above the 30th percentile). Figure 5-37 shows that the range of salinity was narrower under historical conditions, from approximately 33.0 to 37.3 ppt. Current salinities range from 30.2 up to 38.5 ppt, which is still well within the typical range of tolerance for most estuarine organisms. Although extreme salinities are outside the juvenile scallop preference zone, these organisms generally inhabit open waters of the estuary and are less vulnerable to high salinities. In contrast, oysters that colonize near the mouths of freshwater streams are much more tolerant of wide swings in salinity.

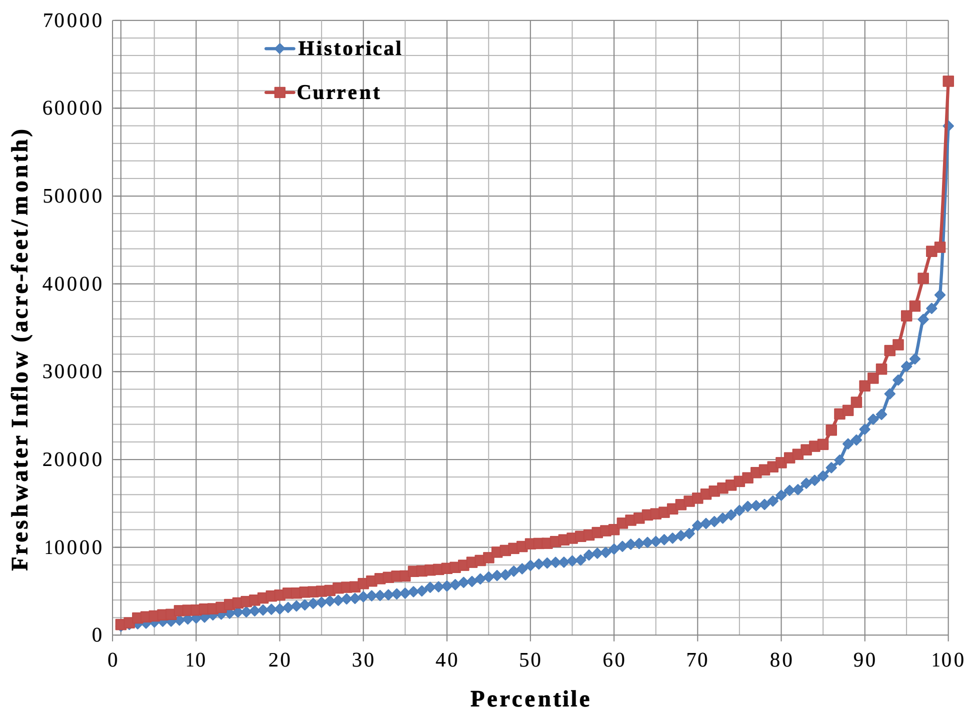


Figure 5-36 Comparison of Current and Historical Freshwater Inputs to Sarasota Bay

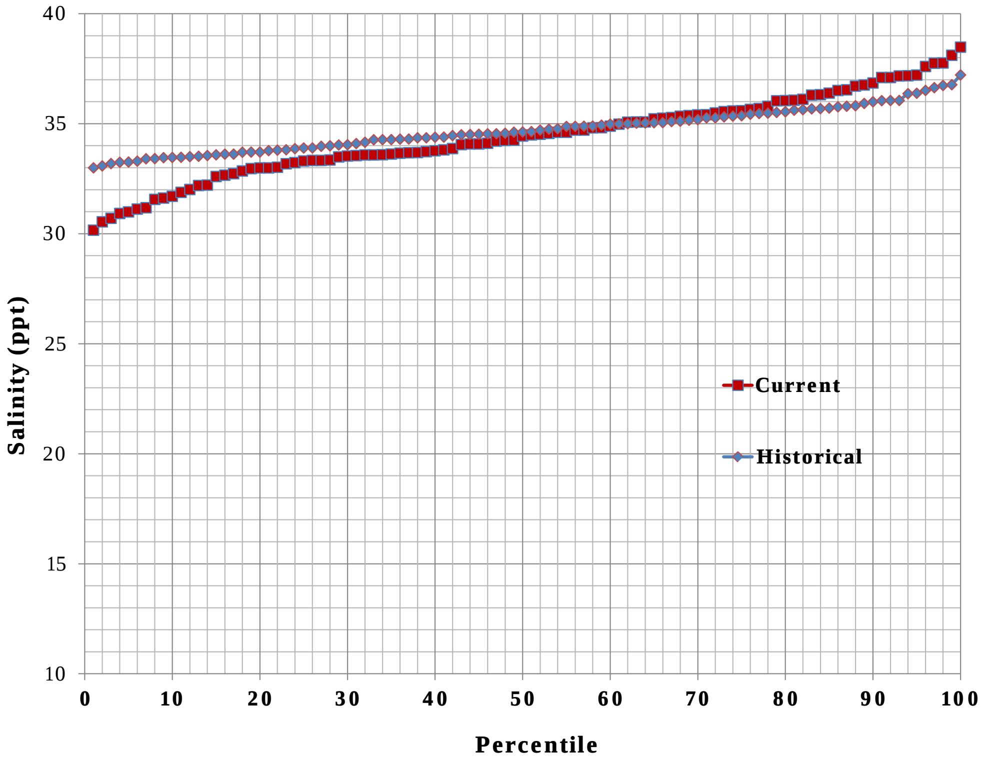


Figure 5-37 Comparison of Current and Historical Salinity Distributions in Sarasota Bay

Although the range of salinity has widened, the mean of the distribution has not shifted. The mean salinity of seawater is typically between 33 and 37 ppt, so freshwater inputs evidently have a limited effect on salinity in the bay. However, to ensure that the historical salinity regime is protected, the LOS target for freshwater inflows for salinity management should be the historical flow distribution. Although the historical inflows are lower than current inflows and would result in less freshwater entering the estuary and potentially increase residence time, the lower flows would also reduce pollutant loadings to the estuary.

5.4.3.8 LOS Conclusion

The previously-developed estuarine water quality LOS targets and thresholds for seagrasses, chlorophyll *a*, TN and TP concentrations and loads, and freshwater inputs are recommended to be included in the Sarasota Bay WQMP. The targets are focused on meeting water quality conditions that are conducive to maintaining seagrass coverage at or above the seagrass LOS target. Table 5-5 summarizes the water quality LOS targets for seagrasses, chlorophyll *a*, TN and TP concentrations and loads, and freshwater inputs.

Table 5-5 Summary of Water Quality LOS Targets and Thresholds for Sarasota Bay

Variable	Targets	Thresholds
Seagrass (acres)	7,269	NA
Chlorophyll *a* (µg/L)	5.2	6.1
TN Concentration (mg/L)	0.38	Varies per Equation.
TN Load (tons/year)	215	237
TP Concentration (mg/L)	0.15	0.19
TP Load (tons/year)	31.8	35.2
Freshwater Tributary TN Concentration (mg/L)	1.65	Varies by tributary
Freshwater Tributary TP Concentration (mg/L)	0.49	Varies by tributary
Basin-specific TN and TP loads	Varies by basin	Varies by basin
Freshwater Inflows	Historical inflow distribution	NA

6.0 DISSOLVED OXYGEN

6.1 INTRODUCTION

This section discusses the importance of DO in marine and freshwater systems, examines the relationship between DO and other water chemistry parameters, and compares ambient DO in the Sarasota Bay estuary and tributary system with proposed DO standards developed by FDEP. Additionally, the feasibility of identifying relationships between DO levels and aquatic biota is assessed. This section compiles information described in Tasks II-6.5 and II-6.6 of the Sarasota Bay WQMP Scope of Work.

6.2 THE RESOURCE AND ITS FUNCTIONS

DO is the amount of oxygen gas contained in water. All aquatic biota in the Sarasota Bay system and its tributaries depend on DO for respiration, and DO determines the types and abundance of organisms that can survive and thrive in the bay and its tributaries. Organisms have a variety of response mechanism to avoid harm when DO levels are reduced below physiological requirements in very low concentrations or moderately low concentrations for an extended period. Fish and other pelagic biota that have high mobility can swim to areas with more favorable conditions. Other species such as shrimp have limited ability to move to avoid low DO effects. Many benthic organisms such as oysters are sessile and cannot move to avoid low DO or are so small that they cannot move far or fast enough to reach higher DO concentrations. Therefore, if adverse conditions cannot be avoided, then the organisms must develop a tolerance to low DO to survive.

If DO levels outside an organism’s range of tolerance cannot be avoided, then harm or death may occur. As a result, DO levels affect the temporal and spatial distribution of all organisms in estuaries and freshwater. Thus, establishing LOS criteria for DO in the estuary and tributaries is crucial to protecting aquatic life. In this document, the water quality criteria and standards are the LOS.

Florida’s current DO standards were adopted about 40 years ago and were based on limited scientific data documenting the low DO conditions that are common in warmer waters and the response of southern warm water species to low DO conditions. Because of natural conditions, DO concentrations frequently fall below the existing DO criteria in many of Florida’s minimally disturbed and healthy fresh and marine waterbodies; therefore, FDEP is revising the existing DO criteria to better reflect State-wide conditions. The current State DO standards (Chapter 62-302.530, FAC) are:

- ❖ For predominantly freshwaters (Class I and III):
  - Shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained.

- ❖ For predominantly marine waters (Class II and III):
  - Shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained.

These standards are based on DO concentration. A concentration-based standard does not account for natural variability in DO levels resulting from changes in environmental conditions. Another measure of DO in water is percent saturation, which is the expected amount of DO in aquatic environments given ambient conditions. Percent saturation depends on ambient water temperature and salinity. The DO concentration at 100% saturation decreases as water temperature and salinity increase. The empirical relationship between DO saturation and temperature for water is well documented (Benson and Krause, 1984). FDEP has proposed DO standards expressed as DO percent saturation that account for the seasonal variability that affects water temperature and salinity. The proposed standards also allow for regional conditions within the State. The proposed State DO standards are:

- ❖ For predominantly fresh waters (Class I and III):
  - The daily average percent DO saturation shall not be below 67% in the Panhandle West bioregion or 34% in the Big Bend, Northeast, and Peninsula SCI bioregions. (The entire Sarasota Bay system is within the Peninsula SCI bioregion.)

- ❖ For predominantly marine waters (Class II and III):
  - The daily average percent DO saturation shall not be below 41.7%.

    and
  - The 7- and 30-day average percent DO saturations shall not be below 51.0 and 56.5%, respectively.

The freshwater criteria were developed based on a State-wide examination of regional stream conditions. FDEP used its Stream Condition Index (SCI), which was developed based on the EPA's "rapid bioassessment" concept. The SCI uses a series of 10 metrics that indicates the levels of ecological integrity and anthropogenic disturbance to a site scored on a scale of 0 to 100. The metrics are measures of the composition and abundance of the in-stream macroinvertebrate community. Macroinvertebrates generally include all insects and other invertebrates (animals without backbones such as clams, snails, flatworms, and arthropods) that are large enough to be seen without the aid of a microscope. Because these organisms have limited or no mobility, they tend to reflect surrounding conditions and as such are good indicators of the environmental health of a site.

FDEP determined that a SCI score below 40 points indicated that the freshwater site was biologically impaired. A regionally based linear regression analysis was conducted to determine the percent DO saturation necessary to support a healthy macroinvertebrate community (SCI score of 40 or above). Multiple lines of evidence indicated that a DO percent saturation of 34 adequately ensures that a site in the SCI Peninsula bioregion, which includes the Sarasota Bay system, is not impaired. Because of regional conditions, the proposed standard is different for the West Panhandle bioregion.

In addition to DO, other factors have a significant influence on the SCI score in streams. Important environmental characteristics that affect SCI scores include stream morphometry, riparian buffer vegetation and width, water velocity, and substrate.

The proposed standards for tidal waters are based on the EPA Virginian Province protocol for setting DO standards, as applied to data available for Florida-specific species. The Virginian Province methodology incorporates assessments of organisms' biological responses to hypoxic stressors in aquatic ecosystems. The approach considers the response to continuous and cyclic exposures to low DO levels to derive criteria that are protective of aquatic life. Using this approach, a minimum daily average DO percent saturation of 41.7 and minimum 7- and 30-day average DO percent saturation of 51.0 and 56.5, respectively, were determined to be protective of marine life.

Both the existing and proposed DO standards are intended to characterize surface waters on a waterbody-wide and long-term basis. Aquatic species can be affected by localized, short-term DO excursions that are not addressed by the standards. If localized or short-term DO problems are identified, then a site-specific investigation should be completed.

Commonalities in the environmental processes affect DO in tidal and freshwater systems. However, unique features also influence DO levels in each waterbody. Characteristics of both systems are discussed below.

6.2.1 Estuary

Oxygen enters tidal waters through two natural processes: diffusion from the atmosphere and photosynthesis by aquatic plants. Mixing of surface water by wind, waves, tides, and currents increases the rate at which oxygen from the air can be dissolved into the water. The magnitude and timing of freshwater inputs to the estuary also affect DO levels. Oxygen solubility in water decreases as water temperature and salinity increase. Many processes influence the amount and distribution of oxygen in the marine environment. Plants and algae produce oxygen during the day as a byproduct of photosynthesis and take oxygen up at night during respiration. Microbes reduce DO levels in estuaries through uptake while decomposing organic matter. Fish and other fauna use oxygen during respiration.

Because of the shifting balance of physical, chemical, and biological processes, DO levels in estuaries vary seasonally, diurnally (daily), and spatially. DO may remain high enough for extended periods to support animals such as highly active fish and at other times decline below a critical threshold. Periods with elevated water temperature or high biological activity during summer can lead to naturally low DO levels in estuaries. Highly productive areas are more likely to become oxygen-depleted at night during the summer when temperature and respiration rates are high. Long residence time in an estuary can also lead to DO depletion. Another cause of reduced DO in water is stratification, which can occur in deeper waters or where waters of different densities meet. Deeper parts of the bay may develop persistent hypoxia (low oxygen) or anoxia (no oxygen) during the late spring and summer, and DO levels may remain below critical thresholds for extended periods.

6.2.2 Tributaries

Tributaries possess a gradient of water quality characteristics that depends on the relative level of influence resulting from watershed-based freshwater inflows and from the open water estuary. Coastal tributaries are generally classified as freshwater (upstream of the influence of saline tidal water) or marine/tidal (mean specific conductance of at least 1,275 µmhos/cm, the State definition of "marine waters" in Chapter 62-302.530, FAC).

Oxygen exerts the same influence on the composition and abundance of aquatic organisms in tributaries as in estuaries. Aquatic organisms in tributaries must be able to avoid areas with low DO levels or adapt to changing DO conditions just as organisms in estuarine waters adapt to changing DO and salinity levels.

DO and biochemical oxygen demand in tributaries are tightly coupled to nutrient inputs via algal biomass, which responds quickly to increased nutrients, often consuming oxygen in the process (Mallin et al., 2004). Linkages among these factors are consistent across aquatic systems, though the nature of the relationships varies as a result of multiple factors. Typically, information on freshwater inflows, nutrient supplies, the associated phytoplankton response, and the biotic integrity of the system are more readily available than the supply rate of organic carbon, re-aeration rates, and sediment oxygen demand, all of which influence DO levels. Uncertainties related to the effects of these less-defined impacts adds to the complexity of developing relationships between nutrients, phytoplankton responses, and DO.

6.2.2.1 Freshwater Tributaries

Freshwater tributaries are upstream of the zone of saltwater mixing in the channel. However, stream hydraulic characteristics may be affected by backwater from tidal action during high tides. Freshwater coastal tributaries are more similar to inland streams in terms of vegetation cover and fish and benthic communities. Some biota have salinity tolerances that confine them to the freshwater portions of a tributary. Anadromous fish species, however, spend different life stages in either fresh or tidal waters, usually spending their adult lives in open tidal waters and returning to freshwater tributaries to spawn. Juveniles often spend their early life in the tidal areas of the tributary before traveling to the open waters. Examples of this behavior include the American shad and Gulf sturgeon. Other fish, such as the bull shark, exhibit a wide range of salinity tolerance and may be found in freshwater or tidal waters as adults.

As in estuaries, tributaries receive oxygen from the atmosphere and through photosynthesis by aquatic plants. Mixing from streamflow turbulence increases the rate at which oxygen from the air can be dissolved into the water. Unlike tidal tributaries, DO saturation levels in freshwater are not influenced by salinity but are still affected by temperature variations.

As a result of the freshwater tributaries' direct connection and proximity to watershed-based sources of nutrient inputs and their smaller volumes relative to the open estuary, these water bodies are likely to have relatively higher nutrient and chlorophyll concentrations and lower DO levels than downstream waters where nutrient loads are rapidly diluted by the greater water volumes (Holland et al., 2004; Sherwood, 2008).

Tributaries with low flushing rates or high nutrient inputs are especially vulnerable to becoming hypoxic as organic carbon is metabolized in the system and oxygen is consumed. Low flow rates or stagnant conditions in tributaries also allow water temperature to rise, further decreasing aeration capabilities. Lack of a tree canopy to provide shade to open water also results in increased water temperature and subsequently lower DO.

6.2.2.2 Tidal Tributaries

The downstream portions of coastal tributaries are subject to chemical and physical influences from the adjoining estuary and freshwater inflows. Salinity and temperature affect DO saturation levels, and tidal mixing provides more circulation than upstream freshwater areas. Although salinity levels in tidal waters may approach zero during periods of high freshwater discharge, salinity can be close to or equal that of the estuary during dry periods.

The vegetation, fish, and benthic communities of tidal tributaries more closely resemble the estuary than freshwater tributaries; however, stationary plant and animal species must be adaptable to large, rapid changes in salinity. Salt content in the tributary can fall from levels near those of the estuary to close to freshwater within hours if heavy rainfall occurs in the watershed. Low salinity can be sustained for prolonged periods, especially in larger watersheds where stormwater runoff takes longer to reach peak levels. DO levels often fall near the outfalls of tributaries, as the less dense freshwater forms a confining layer over the saltwater, effectively separating the bottom water layer from the atmosphere.

The interaction of tides and freshwater inflows results in a longer residence time in tidal tributaries than in upstream freshwater streams. This contributes to high productivity in tidal tributaries, which makes them suited to be nurseries and refuge for many fish and benthic species. The high productivity provides abundant food sources for juvenile fish, and the juveniles of many fish species have greater tolerance for low DO levels than adults.

6.3 OBJECTIVE

This section presents the approach, information and data used, and results associated with DO LOS criteria for the Sarasota Bay estuaries and associated freshwater tributaries. The information provided in this section will be used to identify potential management actions for the Sarasota Bay WQMP. The objectives of this section are to:

- ❖ Identify appropriate DO LOS for the estuary and tributaries that will be protective of tidal and other resources.
- ❖ Identify and discuss factors that affect DO in the estuary and tributaries.
- ❖ Compare reported DO levels in the Sarasota Bay estuarine system and tributaries with the proposed FDEP DO standards.
- ❖ Assess the potential for developing relationships between ambient DO levels and biota in tributaries.

6.4 MONITORING PROGRAMS AND OTHER DATA SOURCE(S)

- ❖ DO and conductivity data for 1996 through 2011 obtained from the State's STORET database and Sarasota County.
- ❖ Technical Support Document: Derivation of Dissolved Oxygen Criteria to Protect Aquatic Life in Florida's Fresh and Marine Waters (Draft) (FDEP, 2012a).
- ❖ Sarasota Bay Numeric Nutrient Criteria: Task 3 – Dissolved Oxygen (Janicki Environmental, Inc. 2011c).
- ❖ Sarasota County Tidal Creek Condition Index Data for 2008–2011 (Sarasota County, 2011).
- ❖ FDEP Stream Condition Index (SCI) Data for Sarasota Bay Waterbodies (2012b).

6.5 APPROACH

6.5.1 DO Relationships with Other Water Quality Parameters

To identify empirical relationships between DO and potential explanatory variables, linear regression techniques were employed. Linear regression is a parametric statistical technique used to explore the relationship between two or more variables. In ordinary linear regression, the relationship between the dependent variable (y-axis) and independent variable (x-axis) is developed. In linear regression, the data are assumed to be independent samples from the population being sampled. For example, if one is developing relationships between DO and explanatory variables in a stream, the data should come from samples that represent the spatial and temporal variability of the stream. Another important assumption of linear regression is that the error term of the model is normally distributed, with constant variance. Often, one or more of the variables exhibits a non-linear relationship with the other variables. While non-linear regression techniques can be employed, one should try transforming the data. Ordinary linear regressions can be developed using transformed data, and these models will satisfy the assumptions of linear regression.

Diagnostic statistics and plots are commonly used to determine if the regression model meets the assumptions of linear regression. The most commonly used statistics are the statistical significance of the model coefficients and the coefficient of determination (r^2). The statistical significance of the model coefficients tests whether the slope and intercept of the model are significantly different from zero. The coefficient of determination is a measure of the variance in the dependent variable that is explained by the model. A plot of the residuals versus the independent variable(s) can be used to judge if the assumption of constant variance is met. Additional plots of residuals versus other variables can also be instructive. For example, a time-series plot of the residuals can be used to assess whether the residuals vary seasonally. Additional diagnostics can be run to identify outliers and test for leverage or influential points. Data points identified by these additional diagnostics should be further investigated to determine if they are the result of a data entry error or other problem that merits removing them from the analysis.

6.5.2 Comparison of Ambient DO Levels in Sarasota Bay and its Tributaries to Current and Proposed FDEP DO Standards

6.5.2.1 Estuary

DO levels in Sarasota Bay were compared with the current and proposed FDEP standards. In this document the LOS is the proposed FDEP standard. The analysis consisted of determining the frequency of occurrences of DO that failed to meet the current standard of 4.0 mg/L. The FDEP IWR requires that no less than 90% of samples meet water quality criteria (i.e., a maximum 10% exceedance) (Chapter 62-303, FAC). Therefore, years with more than 10% of the samples failing to meet the proposed standards were considered to fail. Figure 6-1 summarizes the results in a graphical format.

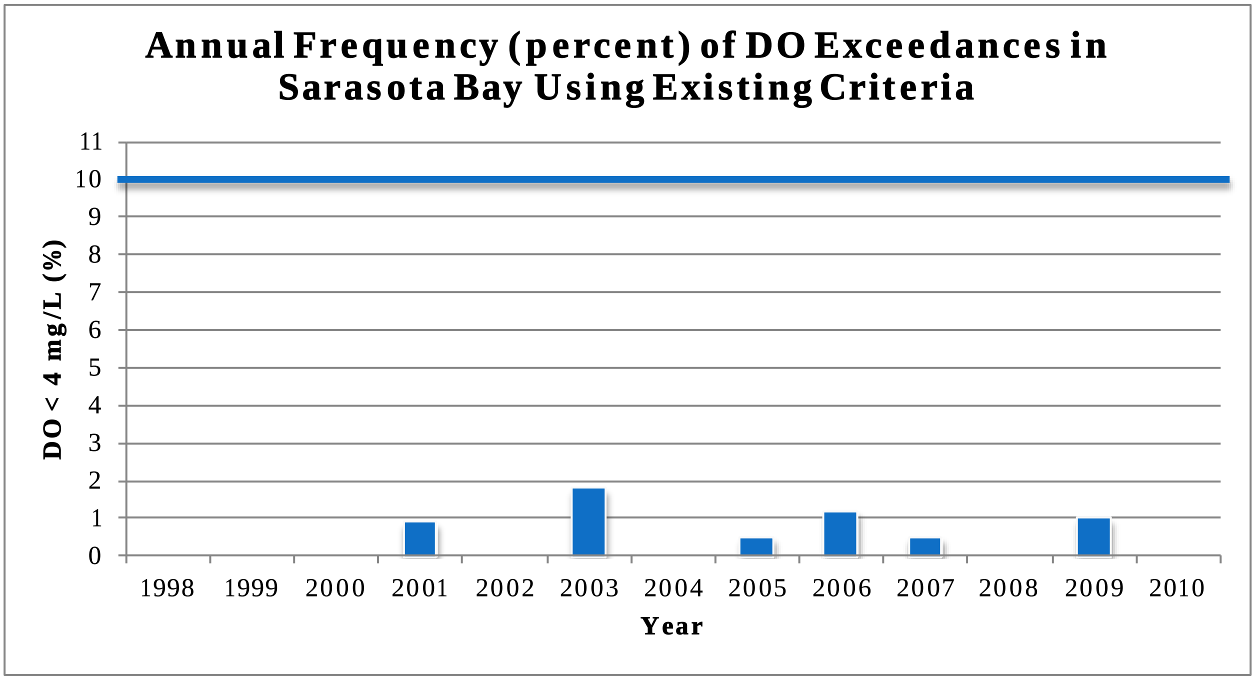


Figure 6-1 Annual Frequency (percent) of DO Exceedances in Sarasota Bay Using Existing Criteria
Horizontal line indicates 10% of samples.

The same DO sample data were also compared with the proposed DO standard for marine waters (41.7% saturation for daily values and 51 and 56% saturation for 7- and 30-day average, respectively) to determine if more or fewer exceedances would be likely using the new standards than the current criterion. Data used for the analysis included DO concentrations and percent saturation. Where concentration but not saturation was reported, percent saturation was calculated using the concentration, salinity, and temperature values.

6.5.2.2 Tributaries

DO levels in the County's tributaries were compared with the proposed FDEP standards. DO concentration and percent-saturation data for nine tributaries of the Sarasota Bay system were obtained from the State's STORET database and the County. The data were organized by water body, year, and whether the site was in fresh or tidal waters. If multiple values of a parameter at a site existed for a single day, the values were averaged to yield a daily value. Data sampling stations were identified as freshwater or marine water depending on salinity or conductivity values. The daily percent-saturation values were compared with the proposed DO standard (34% saturation for freshwater, 41.7% saturation for marine water for daily values, and 51.0 and 56% saturation for marine waters' 7- and 30-day average, respectively). Because of the different standard for freshwater and marine waters, tributaries are assessed based on their classification. Data used for the analysis included DO concentrations and percent saturation. Where concentration but not saturation was reported, percent saturation was calculated using the concentration, salinity, and temperature values.

The FDEP IWR requires that no less than 90% of samples meet water quality criteria (i.e., a maximum 10% exceedance) (Chapter 62-303, FAC). Therefore, years with more than 10% of the samples failing to meet the proposed standards were considered to fail. The results are summarized below.

6.6 RESULTS

6.6.1 DO Relationships with Other Estuarine Water Quality Parameters

A series of bivariate plots (DO vs potential explanatory variables) were completed and analyzed to better understand what factors influence DO concentrations in Sarasota Bay. In addition, multi-variate regression techniques were employed to identify variables that influence DO for each bay segment.

Attachment 1 presents plots of DO versus TN concentration, TP concentration, temperature, salinity, conductivity, chlorophyll *a*, TN loads, TP loads, and BOD loads. These analyses include all parameters listed in the original contract, with additional parameters. The plots show few discernible relationships between DO and other parameters. However, a higher probability of low DO concentrations occurs as temperature increases, as would be expected.

Likewise, the results of the stepwise linear regressions showed no strong statistical relationships between DO and any of the explanatory variables. The best multi-variate fit relationship for Sarasota Bay included explanatory variables salinity, temperature, BOD, and TN with a resulting r^2 of 0.43, meaning that changes in all variables combined could explain only 43% of variability in DO. Variation in DO can be largely attributed to variations in temperature, with lower DO concentrations during summer with warmer water temperatures and higher productivity and during the night when oxygen is consumed by respiration.

Although these relationships were statistically significant, they are all weak and several variables change in unison given the same influences, contributing to co-linearity between them. This further weakens the meaningfulness of the relationships.

6.6.2 DO Relationships with Other Tributary Water Quality Parameters

To better understand what factors are influencing DO concentrations in the tributaries, a series of bivariate plots (DO vs potential explanatory variables) were produced and analyzed. In addition, multi-variate regression techniques were employed to identify variables that influence DO for each tributary and class (freshwater or marine) in the Sarasota Bay system.

Attachment 1 presents plots of DO versus TN concentration, TP concentration, temperature, time of day, salinity, conductivity, chlorophyll *a*, TN loads, TP loads, and BOD loads for freshwater and tidal tributaries. These plots show no strong relationships between DO and any other parameter. However, a higher probability of lower DO concentrations occurs as color, TN, and TP concentrations increase.

Table 6-1 presents the results of the stepwise linear regressions by tributary and class (3M is marine water, 3F is fresh). As expected from the bivariate plots, strong statistical relationships between DO and potential explanatory variables cannot be found. While statistically significant relationships between DO concentrations and potential explanatory variables were identified for most tributaries, these relationships left a majority of the variation unexplained, which is expected given the complex interactions that affect DO concentrations in tidally influenced systems.

Table 6-1 Summary of Relationships between DO and Explanatory Variables by Tributary and Class for Sarasota Bay Tributaries

Creek	Class	n	Equation	r^2
Bowlees Creek	3M	156	DO = 9.29 - 0.13 (temperature)	0.13
Whitaker Bayou	3F	135	DO = 10.09 – 6.50(TP)	0.07
Hudson Bayou	3F	99	DO = 10.83 - 0.26 (temperature)	0.11
	3M	48	DO = 4.03 – 0.11 (salinity)	0.37

The best r^2 values for the regressions developed ranged from 0.07 to 0.37, meaning that between 7 and 37% of the variation in DO could be attributed to changes in the selected explanatory variables. As with the estuarine analysis, the most common influential explanatory variable in the tributaries of Sarasota Bay was temperature. A combination of diurnal and seasonal variation in DO can be largely attributed to variations in temperature, with lower DO concentrations during summer with warmer water temperatures and higher productivity and during the night when oxygen is consumed by respiration.

6.6.3 Comparison of Sarasota Bay and its Tributaries to Existing and Proposed FDEP DO Standards

FDEP evaluates water quality criteria using the provisions of Florida's IWR (Chapter 62-303, FAC). Using the binomial hypothesis test, no more than 10% of the samples collected during an assessment period are allowed to exceed the standard. Results presented below use an annual assessment period.

6.6.3.1 Estuary

DO levels in the estuary were compared to existing and proposed FDEP DO standards. The frequencies of occurrences of ambient DO meeting and not meeting the current standard of 4.0 mg/L in Sarasota Bay are presented in Figure 6-1, which shows that the annual frequencies of

DO exceedances in the bay are well under 10% of samples for all years assessed (1998 through 2010) and that DO levels comply with the current standard on a bay-wide basis.

Figure 6-2 presents the frequencies of occurrences of in-bay DO meeting and not meeting the proposed standard of 41.7% saturation. As with the existing standard, the annual frequencies of exceedances of the proposed marine DO criterion in the bay are well under 10% of samples for all years assessed (1998 through 2010) and thus DO levels for Sarasota Bay also comply with the proposed standard.

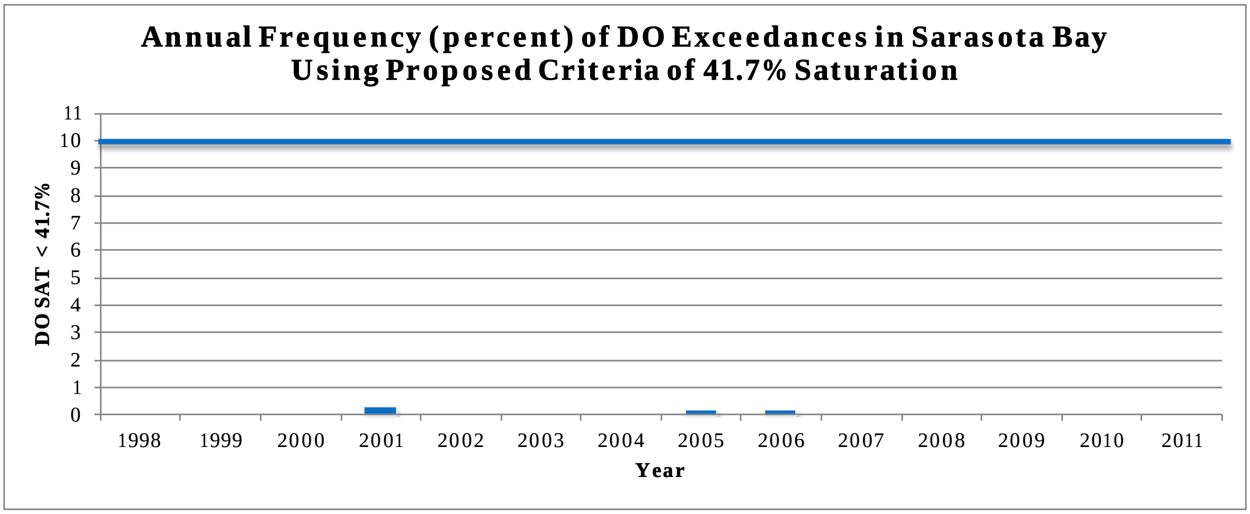


Figure 6-2 Annual Frequency (percent) of DO Exceedances in Sarasota Bay Using Proposed Criteria of 41.7% Saturation
Horizontal line indicates 10% of samples.

6.6.3.2 Tributaries

Ambient DO levels in Sarasota Bay tributaries and other tidal and freshwater tributaries in Sarasota County were compared to the proposed DO criteria. Table 6-2 presents the results including freshwater (Class 3F) and marine (Class 3M) areas of each creek and available data.

Table 6-2 Sarasota Bay and Other Tributaries Not Meeting Proposed FDEP DO Standards

Shading indicates years not meeting proposed standards. FW indicates freshwater, and TC indicates tidal creek.

Creek	Class	2003	2004	2005	2006	2007	2008	2009	2010	2011
Sarasota Bay Tributaries in Sarasota County										
Whitaker Bayou	3F (FW)									
	3M (TC)									
Hudson Bayou	3F (FW)				shaded	shaded	shaded	shaded	shaded	shaded
	3M (TC)					shaded	shaded	shaded		

Table 6-2 Sarasota Bay and Other Tributaries Not Meeting Proposed FDEP DO Standards

Shading indicates years not meeting proposed standards. FW indicates freshwater, and TC indicates tidal creek.

Creek	Class	2003	2004	2005	2006	2007	2008	2009	2010	2011
Other Sarasota County Tributaries										
Philippi Creek	3F (FW)									
	3M (TC)									
Matheny Creek	3F (FW)									
	3M (TC)									
Elligraw Bayou	3F (FW)									
	3M (TC)									
Clower Creek	3F (FW)									
	3M (TC)									
Catfish Creek	3F (FW)									
	3M (TC)									
North Creek	3F (FW)									
	3M (TC)									
South Creek	3F (FW)									
	3M (TC)									

Compiled data for nine creeks for 2003 through 2011 were examined using the same methodology used for the estuary. Whitaker Bayou met the criteria in all years tested while Hudson Bayou did not meet the criteria from 2006 through 2011 (freshwater) and from 2007 through 2009 (marine).

For all tributaries combined, the proposed standards were not met for a cumulative total of 32 years (25 freshwater stream segments and seven tidal segments). This means that the proposed criteria were met 80% of the time. Clower Creek had the most years of failing to meet the proposed standard (7 years for the freshwater area and 4 years for the marine area). Phillippi Creek and Catfish Creek had no failing years. The years with the most waterbodies failing to meet the proposed standard were 2007 and 2009, both with six.

6.7 RELATIONSHIP OF DISSOLVED OXYGEN WITH BIOTA IN TRIBUTARIES

As discussed above, DO is a critical factor in determining the health of aquatic systems. Opportunities for quantifying the relationship between DO levels and benthic and fish communities in Sarasota Bay's tributaries were examined.

SCI data collected by FDEP for the Sarasota Bay system were obtained and examined. The SCI uses an array of indicators of biological integrity to demonstrate whether benthic species composition, diversity, and functional organization are comparable to that of natural habitats in a region. DO has been shown to significantly influence SCI scores. However, environmental factors including but not limited to tributary morphometry, riparian vegetation, streamflow velocity, and substrate also influence the SCI score. Table 6-3 and Figure 6-3 present sample site locations and results of SCI testing in Sarasota Bay system tributaries. Ten SCI samples were collected from Sarasota Bay system tributaries between 1991 and 2006.

Table 6-3 FDEP Stream Conditions Index Sarasota Bay System Sites and Sample Results

Water Body	Station Name	Sample Date	SCI Class
Phillippi Creek	FLCITSOTST	8/20/1991	Poor
Phillippi Creek	FLCITSOREF	8/20/1991	Poor
Phillippi Creek	FLCTSOREF	8/1/1996	Excellent
Phillippi Creek	FLCTSOTST1	7/29/1996	Poor
Phillippi Creek	FLCTSOTST2	7/29/1996	Good
Catfish Creek	SSOTASW1	12/7/1998	Good
Whitaker Bayou	SSOTASW2	12/7/1998	Poor
Bowless Creek	SSOTASW3	12/7/1998	Poor
Phillippi Creek	SAR617US	6/28/2005	Poor
Phillippi Creek	SAR617US	1/9/2006	Very Poor

The scoring system has changed since the program started, so the earlier SCI numerical scores cannot be compared with more recent samples although the text categorizations have remained the same. Seven of the ten samples were taken in Phillippi Creek, and results range from “excellent” (1996) to “very poor” (2006) at different sites. Single samples were taken at Catfish Creek (1998, good), Whitaker Bayou (1998, poor), and Bowlees Creek (1998, poor).

Sarasota County’s Tidal Creek Condition Index (TCCI) program is the other source of biological sampling data for tributaries. The program and reported findings are further discussed in the *Critical Marine and Lotic Natural Resources* section of the WQMP.

Sixteen tidal creeks in Sarasota County were assessed annually for a variety of biological indicators including abundance and diversity of selected benthic invertebrates, density of burrows created by benthic invertebrates, oyster size and survival, and the extent of filamentous algae and periphyton covering the creek bottom. Two tidal creeks, Whitaker Bayou and Hudson Bayou, are in Sarasota Bay as shown in Figure 6-3. Results of the index scoring for all creeks sampled are shown in Figure 6-4.

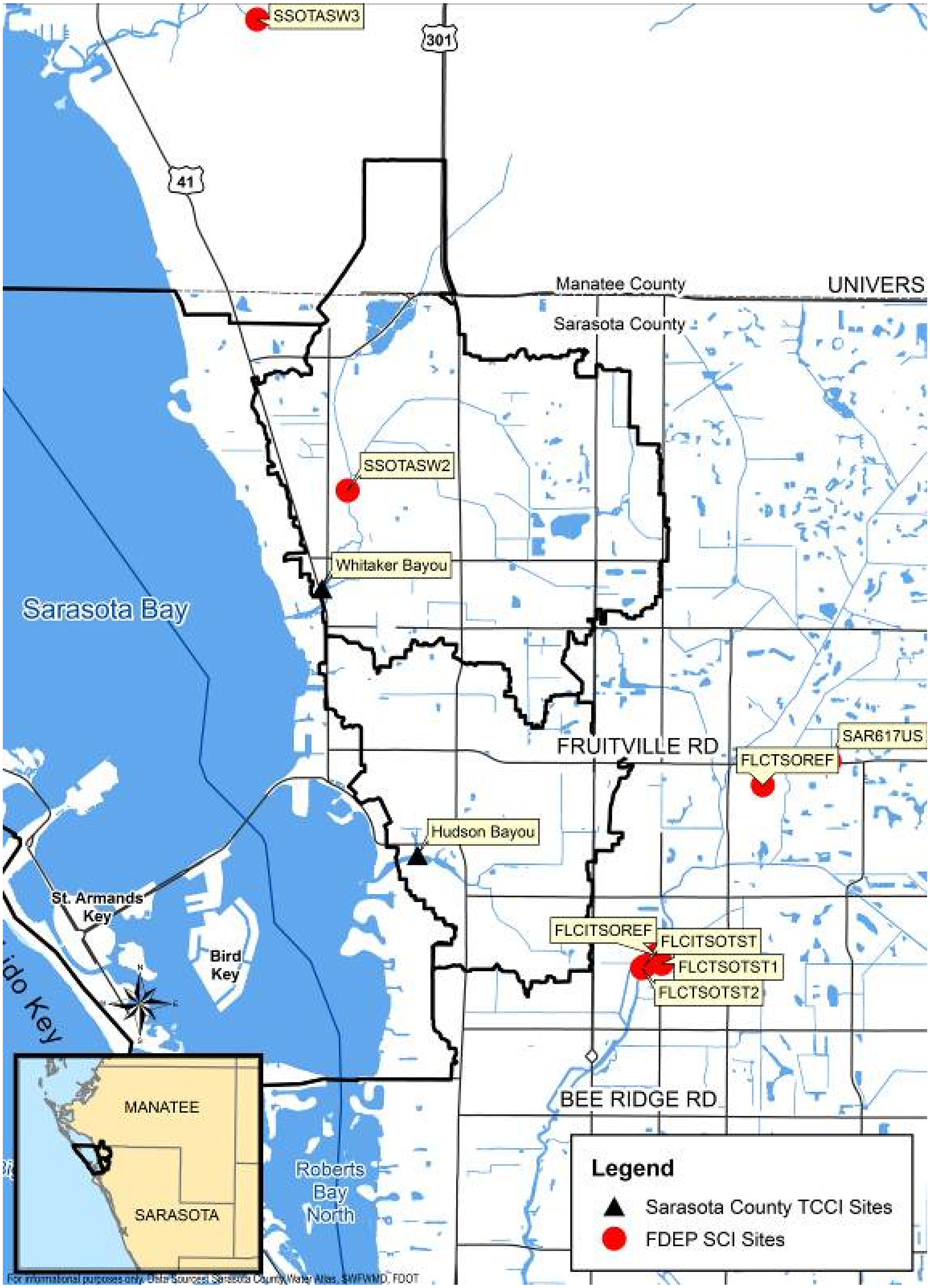


Figure 6-3 Biological Sampling Sites in Sarasota Bay Tributaries and Phillippi Creek

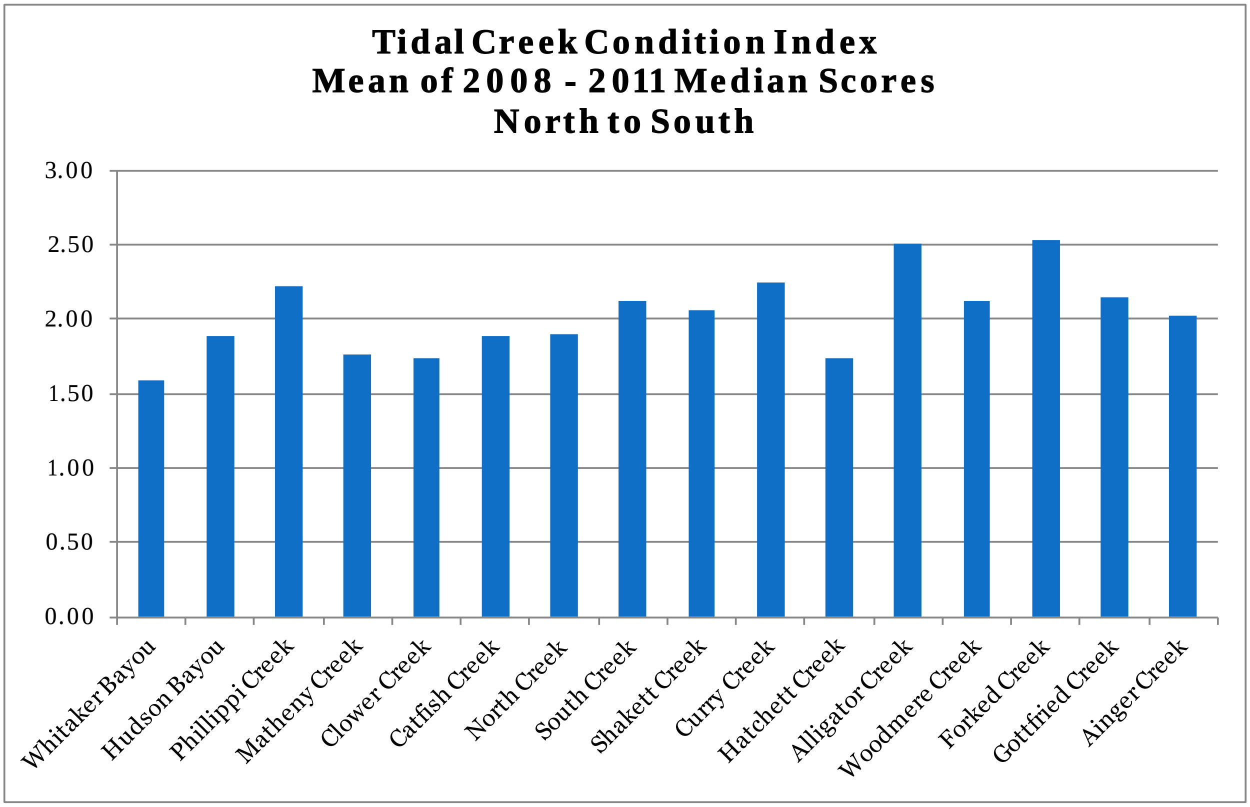


Figure 6-4 Sarasota County Tidal Creek Conditions Index Scores 2008 through 2011 Whitaker and Hudson bayous are tributaries of Sarasota Bay.

Samples were taken in these tributaries annually using the current methodology from 2008 to 2011 (the TCCI program has since been discontinued). Scoring, in which a low score indicates higher stress, indicates that Whitaker Bayou, in Sarasota Bay, was the most stressed of all creeks in the County, and Hudson Bayou was also among the most stressed.

The SCI and TCCI data are the only sources of biological data identified for the Sarasota Bay system's tidal streams. Other biological sampling (Serviss and Sauers, 2003; Culter and Leverone, 1993; MacDonald et al., 2010) was confined to the open water estuary. DO monitoring occurs in all these streams but only monthly.

The low density of data makes a quantitative assessment of the relationship between DO and tidal streams pelagic and benthic communities infeasible. Actions that can be taken to make this assessment possible include conducting a concentrated sampling effort involving synoptic biological and water quality sampling and developing a longer period of record and larger sample size.

6.8 CONCLUSIONS

DO has been shown to be a critical element of the tidal and freshwater environments. Reduced DO levels can lead to behavioral changes, harm, or death to aquatic organisms. A variety of natural and anthropogenic biological, physical, and chemical processes affect the distribution and availability of oxygen in the environment.

FDEP has proposed new water quality standards for DO that are intended to be protective of aquatic natural resources and to account for natural variability in aquatic systems. The proposed standards were applied to the Sarasota Bay estuary system and tributaries. All bay segments met the proposed standard, and all tributaries combined met the proposed standard 80% of the time; therefore, DO levels in the bay are protective of estuarine resources and DO levels in the tributaries is protective in the majority of cases.

Based on the results of the DO analysis, the Hudson Bayou tributary in the Sarasota Bay system should be examined to identify potential causes for the repeated low DO saturation. The Hudson Bayou basin is highly urbanized with extensive directly connected impervious area, and the stream channel is highly altered. Stormwater runoff discharging to the channel from the paved watershed is likely at a high temperature, and the downstream zone of the tributary may receive high nutrient and organic material loads. All of these factors would affect in-stream DO. However, the pollutant-loading analysis shows Hudson Bay to have only moderate nutrient loading rates.

Results of the TCCI sampling indicate that Whitaker Bayou and Hudson Bayou are stressed, as they both have low scores compared with most of the County’s other creeks. Although DO could be a factor in the low TCCI score for Hudson Bayou, other conditions are likely to be responsible for Whitaker Bayou’s low score.

Analyses were completed to examine the relationship of DO to other parameters in the aquatic environment. No strong relationships were identified in the estuary or tributaries. Some relationships were observed, such as the tendency of lower DO levels to occur with warmer water temperatures.

Using the existing DO criteria, FDEP has determined that several WBIDs in Sarasota Bay and tributaries are impaired under the State’s IWR (Chapter 62-303, FAC). WBIDs are impaired for DO as a result of either nutrients or BOD. The only Sarasota Bay WBID (with its waterbody type designated by FDEP) within the County that is impaired for DO because of nutrients is Whitaker Bayou (tidal). Hudson Bayou (tidal) is the only Sarasota Bay WBID in the County that is impaired for DO because of BOD.

The feasibility of identifying relationships between DO levels and the health of tidal and freshwater biota was explored; insufficient data exist to establish any quantifiable relationships.

7.0 SEDIMENT LEVELS OF SERVICE

Sediment is fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits and is transported by, suspended in, or deposited by water (EPA, 2003). Although sedimentation is a natural process, sediment becomes problematic when it is present in excessive quantities or is of poor quality.

Erosion and sedimentation plays an important role in influencing water quality, ecosystem health, and flood control. Population growth and development can increase stormwater runoff which delivers sediment and accelerate erosion and sediment deposition, overwhelming our natural systems. Excessive erosion and sedimentation are significant chemical and physical issues in watershed management. Excessive sediment alters the natural landscape, resulting in environmental and economic impairment. EPA recognizes sediment as a major contributor to impairment of the nation's waters and has cited sediment as the leading cause of impairment (EPA, 2003). Sediment-control strategies are therefore a key component of watershed management planning efforts.

Excessive erosion and sedimentation is an ongoing issue in Sarasota County. Excessive sedimentation generally occurs in two forms: mostly organic and mostly inorganic. The County recognizes that excessive sedimentation in its open-channel conveyances can significantly affect their natural character. This alteration can be due to the delivery of sediments through stormwater runoff or erosion to the conveyances or the accumulation of organic-rich sediments resulting from instream primary production.

The accumulation of organic sediments most often is the result of the responses in a stream to elevated nutrient loading. Elevated nutrient supply fuels primary production, primarily in the form of algal production within the water column and on the stream bottom. The decomposition of the organic-carbon compounds produced depends on the availability of DO. As the DO supply is depleted, incomplete decomposition or decomposition byproducts lead to accumulation of organic matter on the stream bottom. If the DO reduction is of such a degree that the DO standard is exceeded, the County will need to address this issue.

Inorganic sediment issues are most often related to excessive upstream channel erosion and the associated sediment transport, although shorter-term activities such as construction activities with inadequate erosion control can also contribute to the issues. For excessive channel erosion, visual identification and habitat response are better indicators of excessive inorganic sediment deposition which would lead the County to take preventative or remediation measures.

Irrespective of the source of the sediment, excessive sedimentation has deleterious impacts on the ecological health (e.g., low DO, impaired physical habitats) and the recreational and aesthetic nature of the stream. If sedimentation is to be effectively managed, the following must be addressed:

First, the current status of the sediment and physical characteristics in County streams needs to continue to be assessed. FDEP has developed a monitoring program that includes an assessment of the physical character of streams in Florida. This assessment includes several physical features: bank stability—the extent of erosion potential; habitat availability—the relative spatial abundance of productive habitats present; and habitat smothering—an assessment of sand and silt deposition onto what would otherwise be productive habitats. Field crews can be trained in the physical habitat assessment protocols, and the current status of the streams within the Sarasota Bay watershed can be determined. To achieve this objective, the County can segment the primary open-channel conveyances into reaches with similar geomorphic characteristics on which the County would collect the physical habitat parameters.

Second, in stream reaches where the organic accumulation of sediments is problematic, routine assessment of the longitudinal DO conditions would provide a means by which the current status can be determined.

Third, monitoring of trends in the conditions from Steps 1 and 2 can provide a temporal context to those conditions, i.e., temporal trends in sediment condition can be assessed. To this end, the frequency of sediment condition assessment can be defined. For those cases where inorganic sediments are the source of the sedimentation problem, stream sediment conditions should be assessed approximately once every 5 years. Where organic sediments are problematic, DO assessments should be conducted at a similar frequency employed for the ambient stream sampling.

7.1 INORGANIC SEDIMENT LOS

Physical habitat data collected in streams along the Florida gulf coast from Pasco County through Lee County have been obtained from FDEP. The statistical distribution of these data provides a framework for the sediment LOS recommendations. Excellent scores correspond to the range of conditions in the upper quartile of habitat scores. Good scores correspond to the interquartile range of conditions (i.e., between the 25th and 75th percentiles). Poor scores correspond to the range of conditions in the lower quartile of habitat scores. Using this framework, the recommended LOS for the physical habitat parameters are as follows:

- ❖ Bank Stability – scores range from 0 to 10.
- ❖ Excellent score when the bank stability exceeds 9.
- ❖ Good scores when the bank stability scores range from 5 through 8.
- ❖ Poor scores when the bank stability scores are less than 5.
- ❖ Habitat Availability – scores range from 0 to 20.
- ❖ Excellent score when the habitat availability exceeds 14.
- ❖ Good score when the habitat availability scores range from 7 through 13.
- ❖ Poor scores when the habitat availability scores are less than 13.
- ❖ Habitat Smothering – scores range from 0 to 20.
- ❖ Excellent score when the habitat smothering scores exceeds 16.

- Good scores when the habitat smothering scores range from 9 through 15.
- Poor scores when the habitat smothering scores are less than 9.

7.2 ORGANIC SEDIMENT LOS

With respect to the sediment LOS for those streams where the primary source of sediments is organic, the recommended surrogate for the sediment LOS is the level of DO in the stream. The recommended LOS is the same as that discussed in Section 6.6.3 for DO LOS.

8.0 WATER QUALITY IMPROVEMENTS

Jones Edmunds has identified 10 projects with the potential to reduce pollutant loading and improve water quality. Details concerning site and project selection are provided in Section 8.4.1and project and program recommendations are provided in Section 8.4.2.

8.1 BACKGROUND INFORMATION

The health of a watershed is reflected in the quality of the water. Numerous indicators, such as TN, TP, TSS, BOD, and fecal coliforms, can be assessed to determine water quality conditions and to provide clues as to why that condition exists. The objective of this section is to build on the results of previous sections to identify potential projects and programmatic recommendations that address pollutant loading within the Sarasota Bay watershed.

The major water quality problems in the Sarasota Bay watershed appear to stem from nonpoint source pollution. As water from rainfall and irrigation runs over the landscape of the watershed, it picks up pollutants and deposits them into tributaries, ponds, wetlands, and the bay. These pollutants include sediment, bacteria, chemicals, and nutrients. Nonpoint source pollution originates from an array of sources, such as agriculture, septic systems, boating, physical changes in stream channels, habitat degradation, and urban runoff. Reducing the quantity of pollutants entering the tributaries and bay is vital to the health of the watershed.

Watershed management includes identifying water quality problems, identifying the pollutant source(s), and recommending improvement projects. Using watershed health indicators, such as chlorophyll, DO, seagrass, and oysters, the County is working with local, state, and federal agencies to understand water quality conditions throughout the watershed, address impairments, and meet proposed water quality targets for the Sarasota Bay watershed. The ultimate goal is to improve water quality.

8.2 TMDL STATUS

FDEP has established criteria for evaluating water quality throughout Florida using a waterbody classification system and evaluative criteria for a variety of water quality constituents (Chapter 62-302.530, FAC). FDEP compiles surface water quality data collected throughout Florida primarily using its STORET database and its WBID system to assess water quality impairment of WBIDs under the IWR (Chapter 62-302.530, FAC). States are required to submit a list of surface waters that do not meet water quality standards (impaired waters) to EPA. This 303d list comprises waters that are impaired by pollution. Once verified, listed waterbodies require TMDLs to be developed. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Waterbodies can only be delisted when they have met the water quality standards or a TMDL has been developed and approved.

As of January 2010, the Sarasota Bay watershed had several waterbodies listed as impaired. Whitaker Bayou (WBID 1936), Hudson Bayou (WBID 1953), and Sarasota Bay Coastal (WBID 1916) were all listed as impaired for DO. The low DO in Whitaker Bayou is thought to be caused by elevated nitrogen, phosphorus, and BOD. A high oxygen demand (based on BOD measurements) was also identified as the cause of low DO in Hudson Bayou and Sarasota Bay Coastal. A detailed analysis of DO for these creeks was completed, see Section 6. Whitaker Bayou (WBID 1936), Hudson Bayou (WBID 1951 and 1953), and Sarasota Bay Coastal (WBID 1916, 1931, 1954, and 1961) are also listed as impaired for mercury based on high levels of mercury measured in fish tissue. In addition, Whitaker Bayou (WBID 1936) and Hudson Bayou (WBID 1953) are listed for fecal coliform based on the number of exceedances. Whitaker Bayou (WBID 1936) is impaired from excess nutrients based on elevated chlorophyll *a* as well. Additionally, a small portion of Sarasota Bay Coastal (WBID 1968BA) is listed for beach advisory based on excessive Department of Health (DOH) advisories. To date, no TMDLs have been developed for the Sarasota Bay watershed waterbodies.

8.3 WATER QUALITY IMPROVEMENT OPPORTUNITIES

Jones Edmunds identified potential water quality improvement opportunities in the Sarasota County portion of the Sarasota Bay Watershed. These projects and programmatic recommendations range from small, local improvement projects such as pervious pavers and curb cuts in the Bayfront Parking Lot (Section 8.4.1.2) to larger, regional programmatic recommendations such as Low-Impact Development (LID) (Section 8.4.2.6). Project selection methodology and results are provided in the following subsections.

8.3.1 Methodology

Jones Edmunds collected and assembled information, including previous studies, GIS data, and stakeholder input, to identify potential water quality improvement projects. Jones Edmunds began the investigation with a GIS desktop analysis to identify water quality 'hot spots' throughout the watershed. These hot spots were then refined to potential water quality project sites. Finally, Jones Edmunds conducted field investigation of these sites to evaluate potential water quality treatment options. This methodology is summarized in Figure 8-1 and detailed in the following sections. Results from the field analysis and potential project and program recommendations are provided in Section 8.3.2.3.

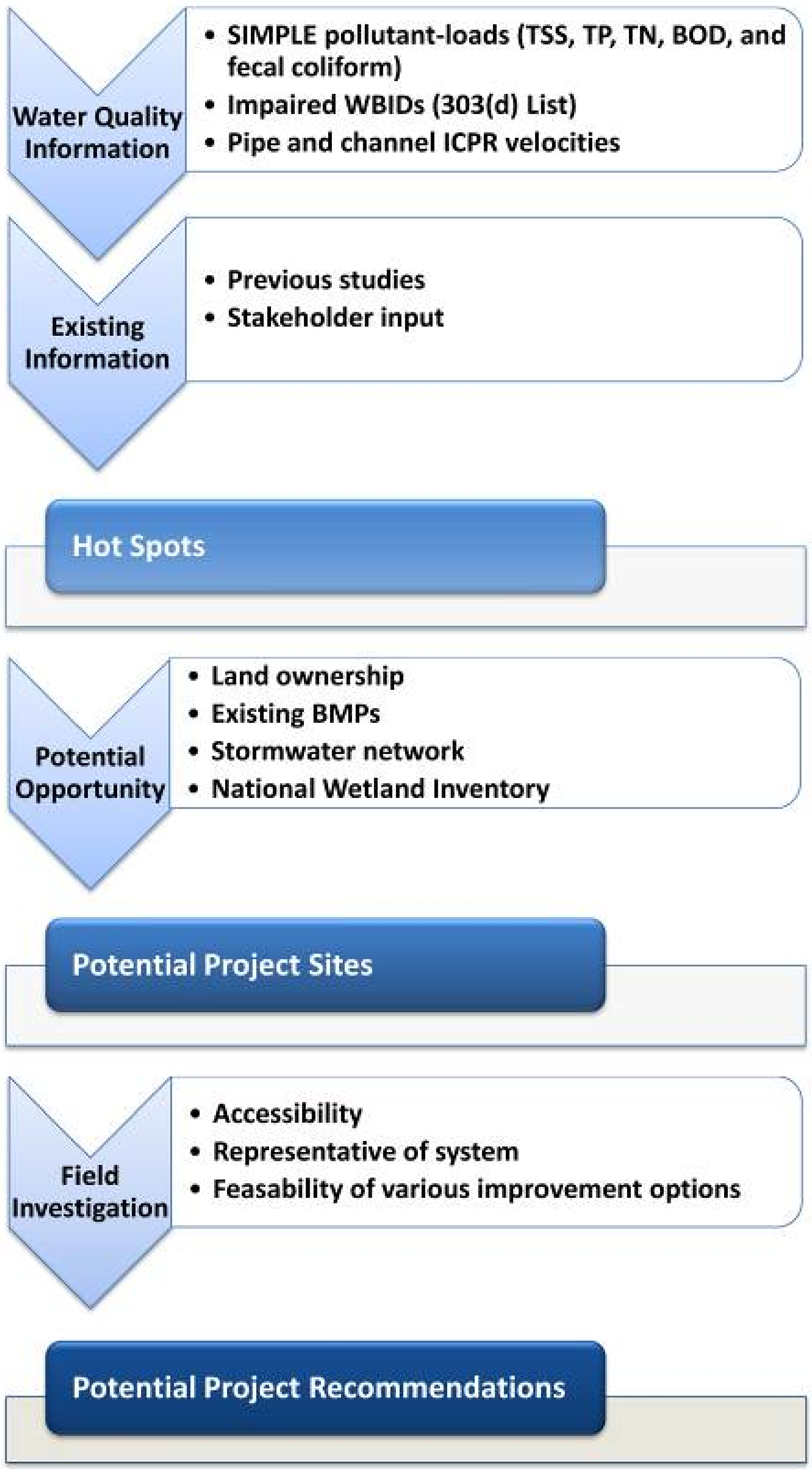


Figure 8-1 Water Quality Improvement Opportunity Identification Methodology

8.3.2 INVESTIGATION

Details concerning the elements of Jones Edmunds' investigations are provided in the following subsections.

8.3.2.1 Identification of Hot Spots

Jones Edmunds reviewed observations, input from stakeholders and County staff, and previous studies and data. A list of these water quality studies and data are in the Appendix. Jones Edmunds used GIS to compile and review data developed from the Pollutant Loading Model results together with aerials and other base data and information obtained from Sarasota County, SWFWMD, FDEP, and previous watershed studies and data. These datasets and information included the following:

- ❖ Pollutant-loads as estimated from the Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE) (TSS, TP, TN, BOD, and Fecal coliform).
- ❖ 303(d) list.
- ❖ 2010 SWFWMD aerial imagery.
- ❖ Areas of concern identified in previous studies.
- ❖ Areas of concern noted by stakeholders and County staff.

A GIS desktop analysis of the parameters above yielded potential pollution hot spots in the watershed. Pollutant-load results and listed WBIDs are shown in Figure 8-2, Figure 8-3, Figure 8-4, Figure 8-5, Figure 8-6, and Figure 8-7 and are detailed in the pollutant-loading analysis sections.

8.3.2.2 Identification of Potential Project Sites

Jones Edmunds compiled the potential pollution hot spots with additional base data obtained from Sarasota County. Specifically, these datasets included the following:

- ❖ Sarasota County parcels.
- ❖ Best Management Practices (BMPs).
- ❖ Sarasota County stormwater inventory.
- ❖ 2010 SWFWMD aerial imagery.

Jones Edmunds identified 10 potential water quality improvement project sites in the watershed from a GIS desktop analysis of the parameters above (Figure 8-8 and Table 8-1).

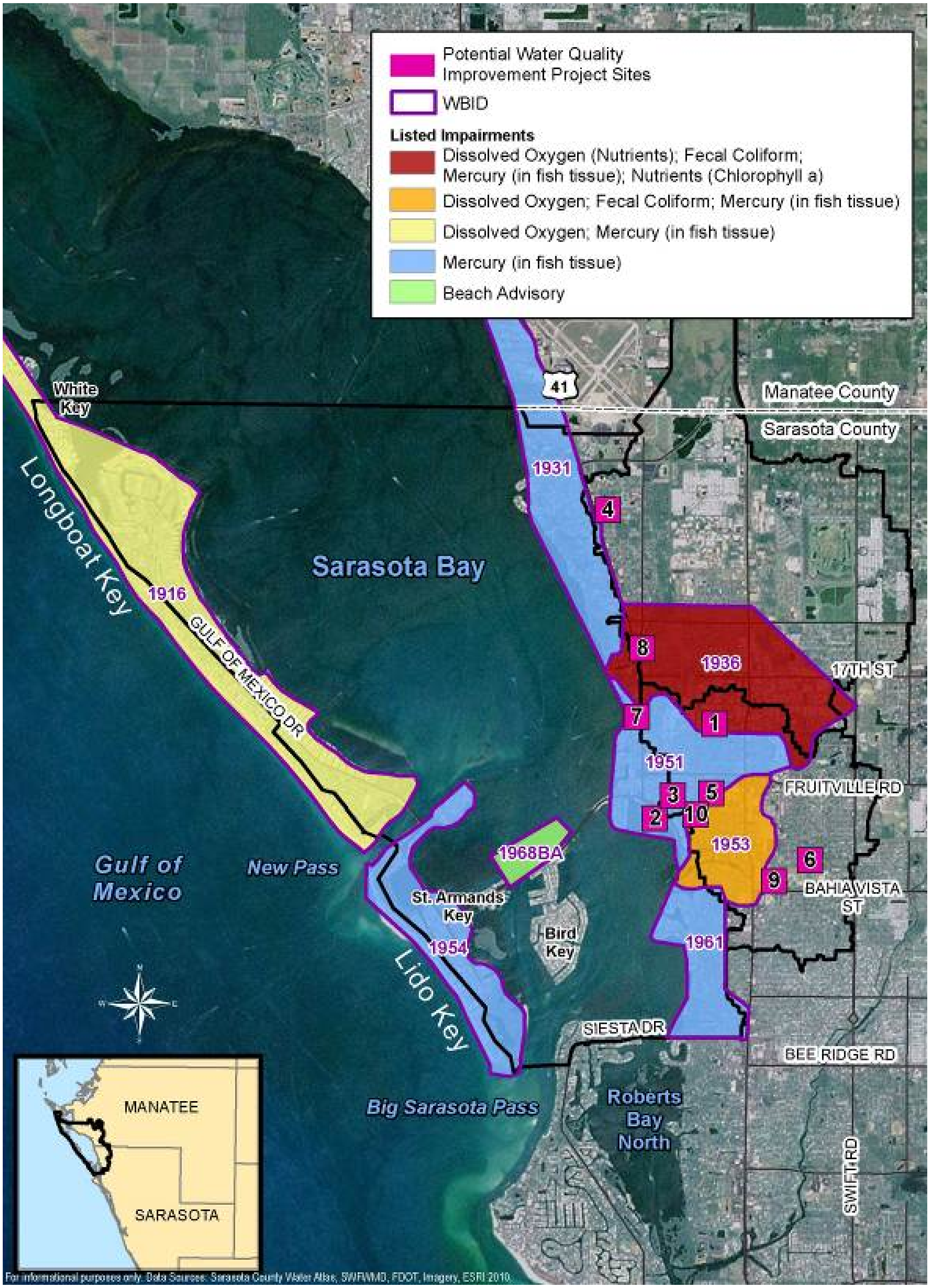


Figure 8-2 Sarasota County Sarasota Bay Watershed Impaired WBIDs

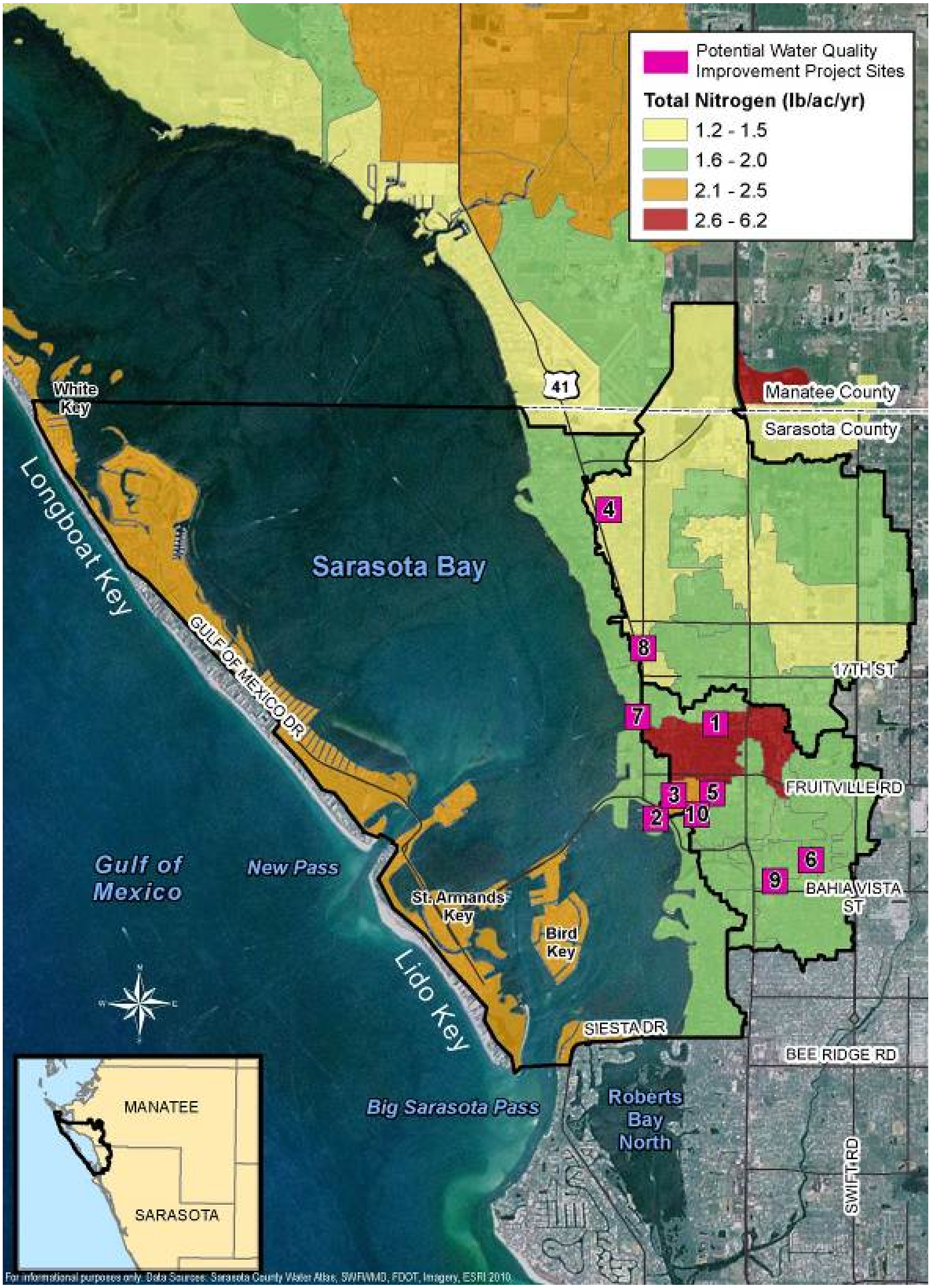


Figure 8-3 Sarasota Bay Watershed SIMPLE Total Nitrogen Loading

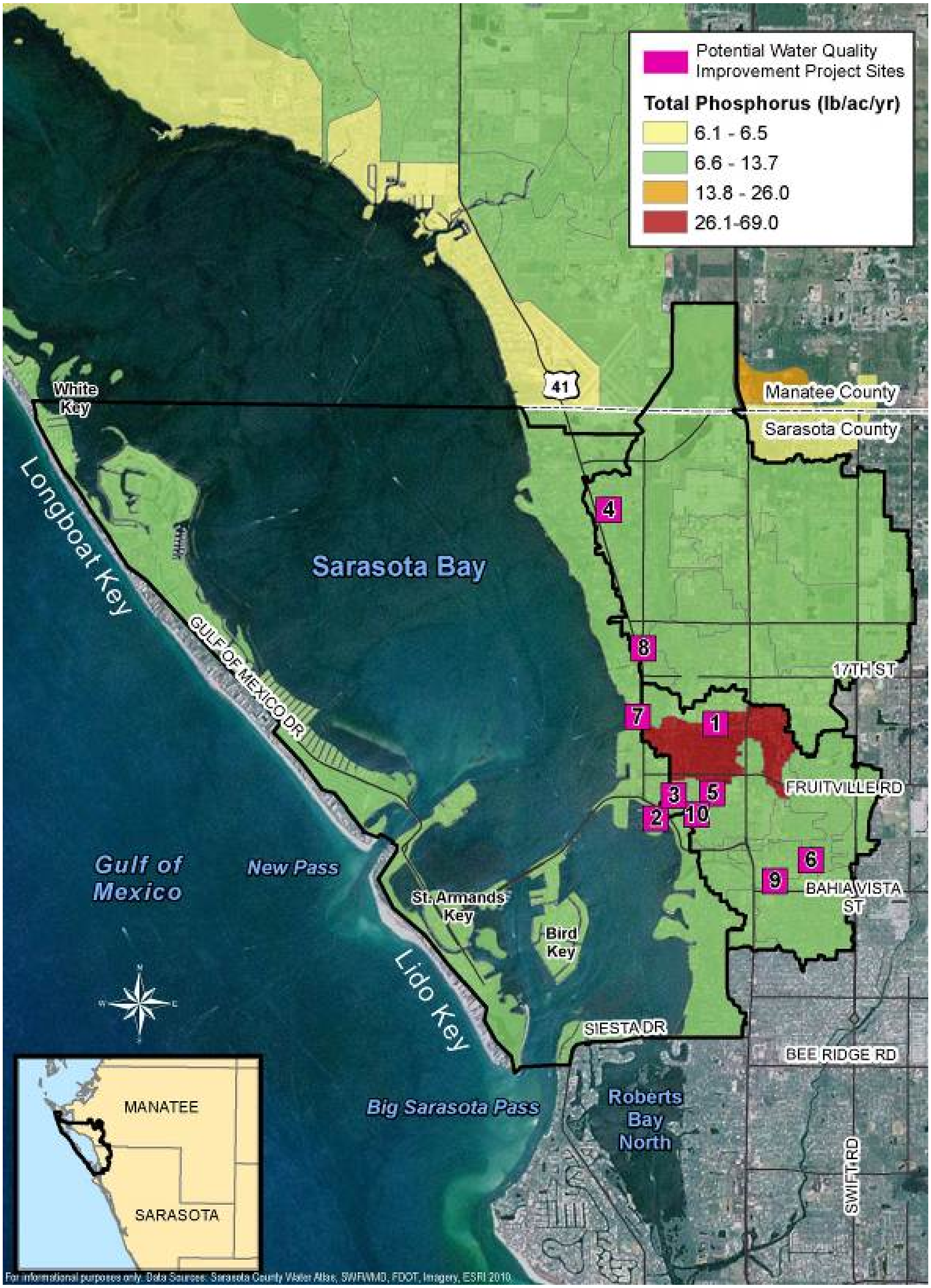


Figure 8-4 Sarasota Bay Watershed SIMPLE Total Phosphorus

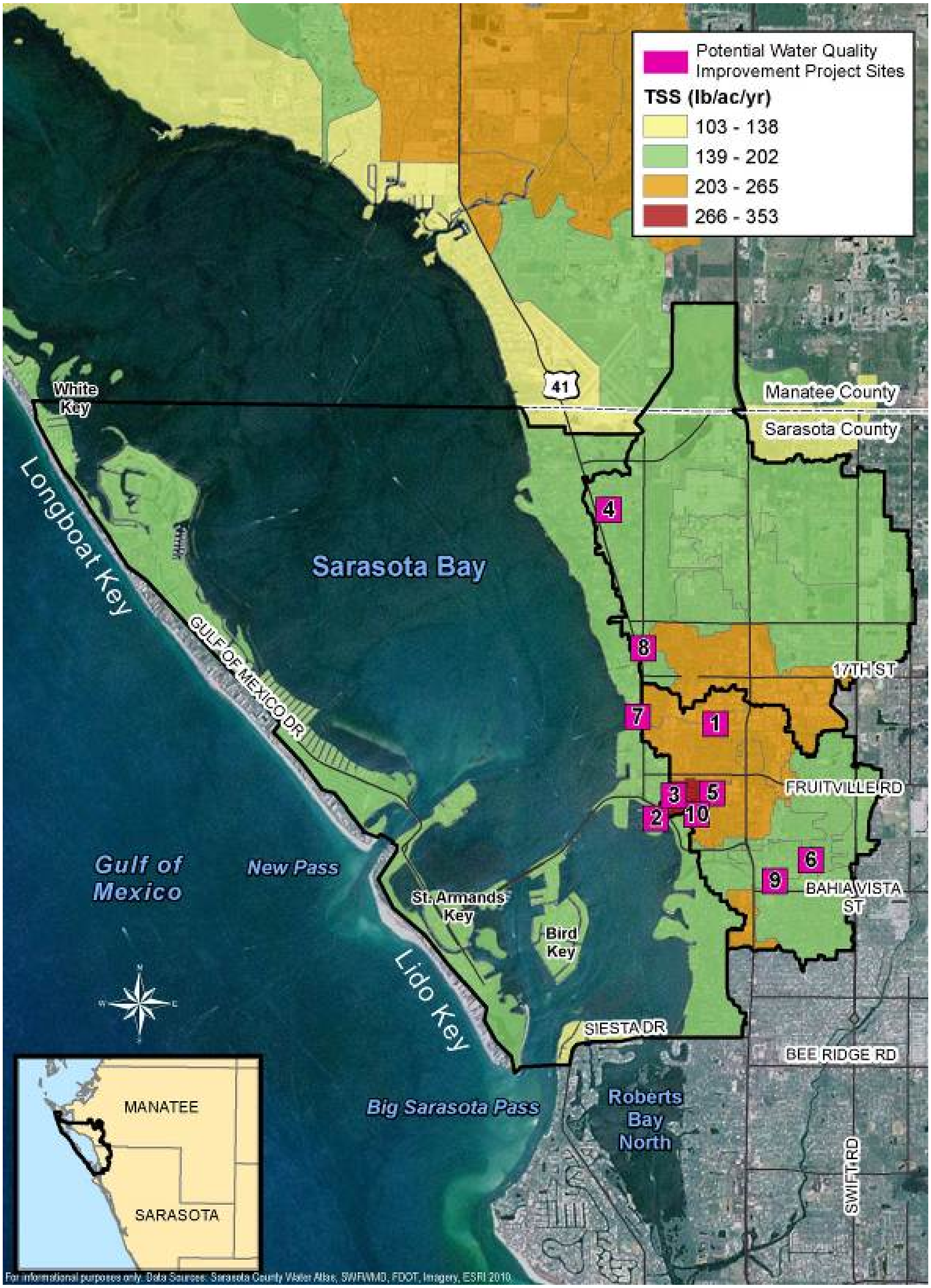


Figure 8-5 Sarasota Bay Watershed SIMPLE Total Suspended Solids (TSS)

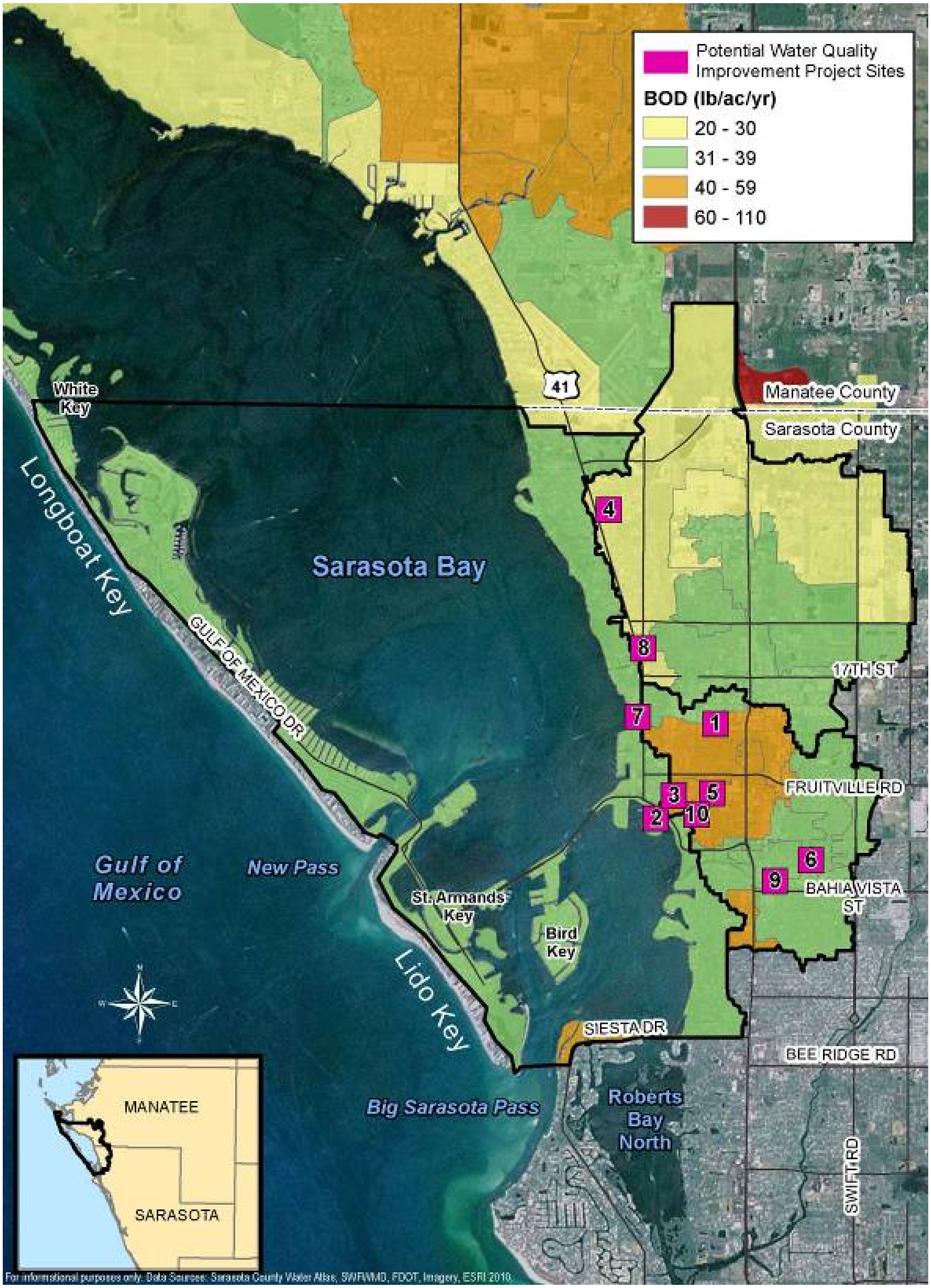


Figure 8-6 Sarasota Bay Watershed SIMPLE Biological Oxygen Demand (BOD)

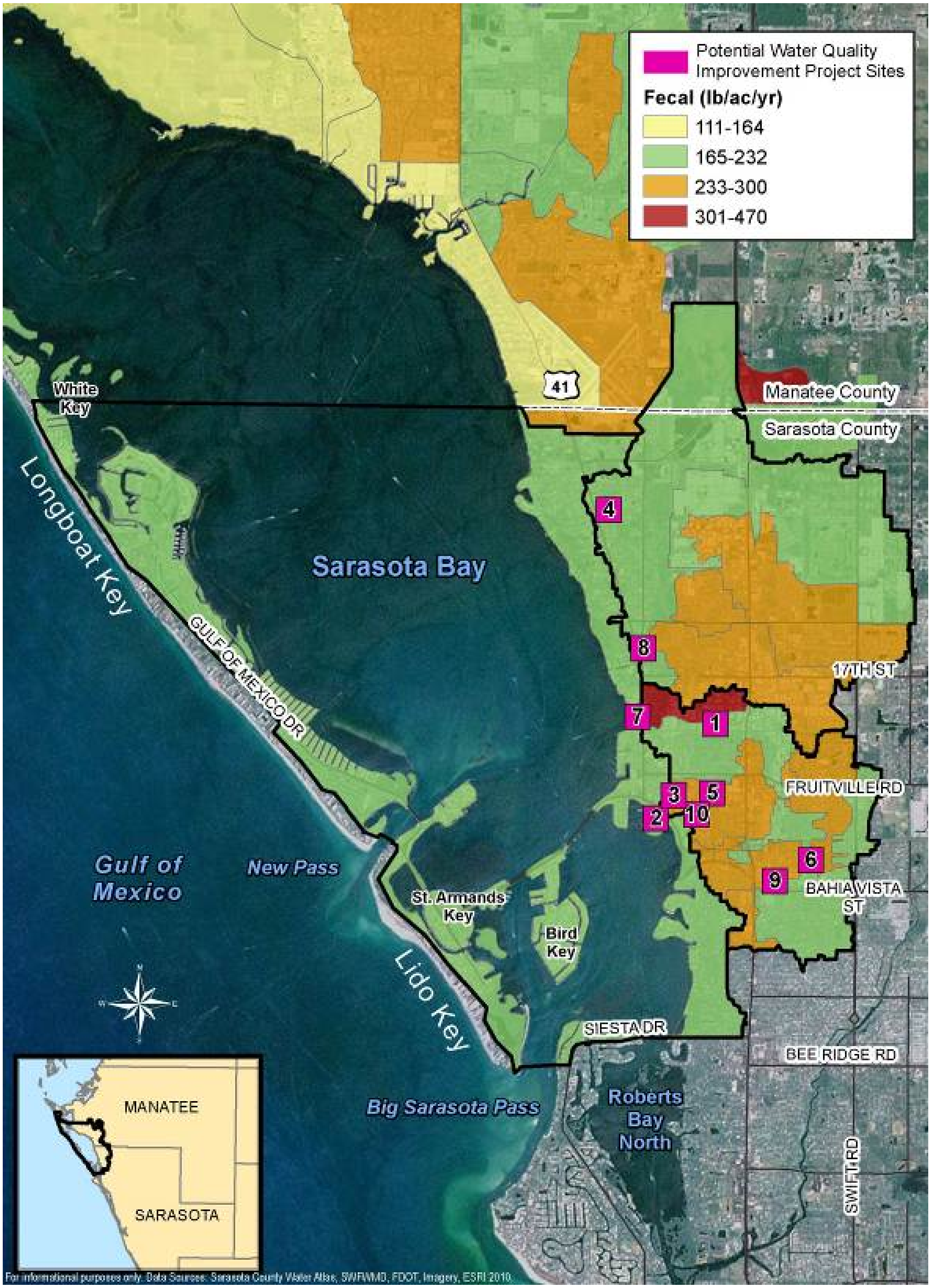


Figure 8-7 Sarasota Bay Watershed SIMPLE Fecal Coliform

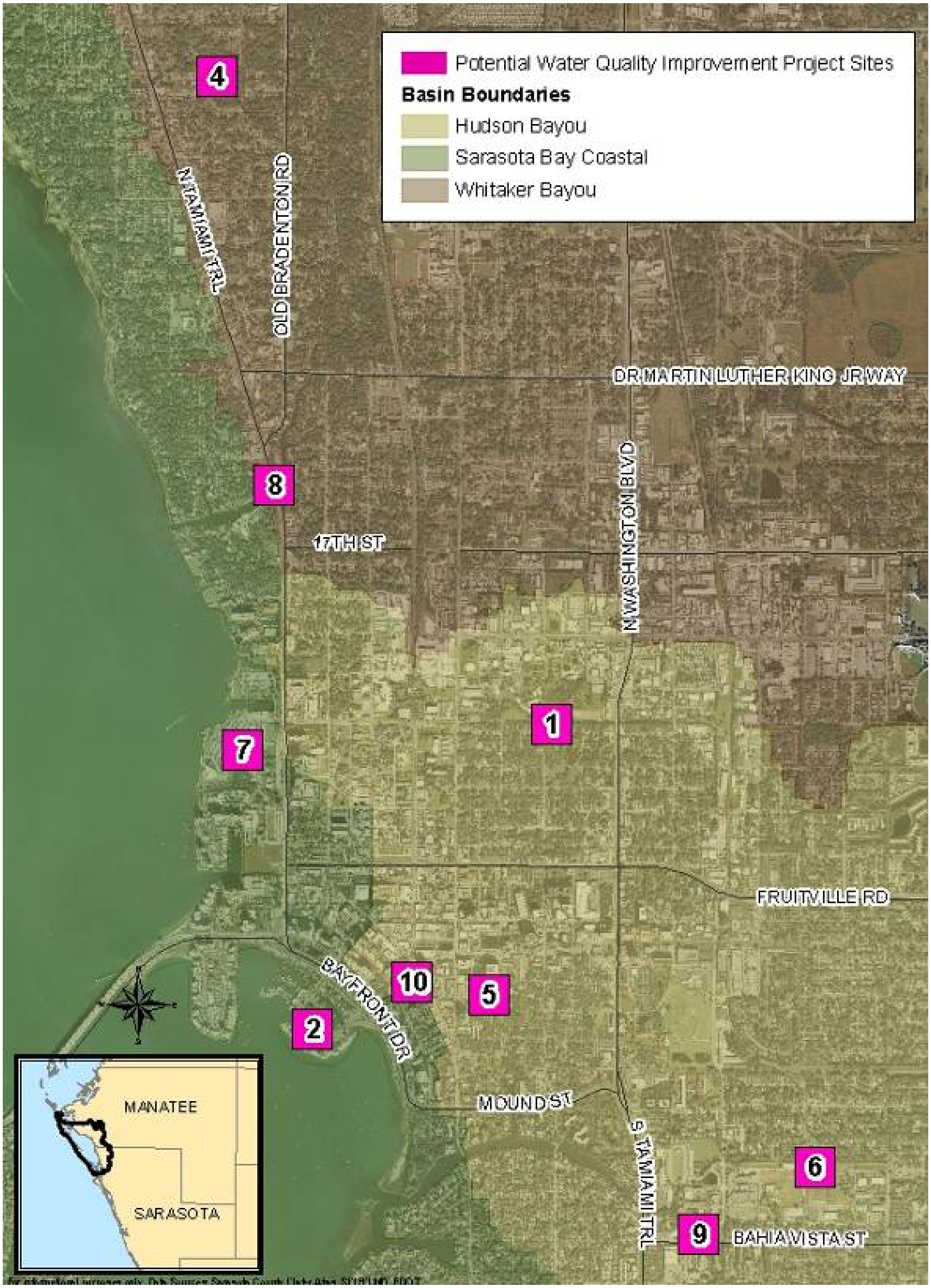


Figure 8-8 Potential Water Quality Improvement Project Site Locations

Table 8-1 List of Potential Water Quality Improvement Project Sites			
ID	Site Name	WBID	SIMPLE Basin ID
1	North Gillespie Park	1936	108
2	Bayfront Parking Lot	1951	101
3	Ringling Boulevard Diversion	1951	107
4	47th St Diversion	1936A, 1836	112
5	Hudson Bayou North Branch	1953	105
6	Hatton Street Ditch	1953A	102
7	10th Street Outfall	1951	101
8	Whitaker Bridge	1936	112
9	Hudson Bayou East Branch	1953A	103
10	Ringling Boulevard Sidewalks	1951	107

8.3.2.3 Field Investigation

Jones Edmunds conducted site visits to the proposed water quality improvement sites in April 2011 to characterize the potential project areas and to identify and determine potential water quality treatment options, including possible programmatic recommendations.

8.4 ANALYSIS\RECOMMENDATIONS

The following sections provide investigation summaries and recommendations for the selected project sites as well as program recommendations to help improve water quality in the watershed.

8.4.1 Projects

This section contains water quality improvement project descriptions.

8.4.1.1 Site 1 – North Gillespie Park

A. GIS Desktop Analysis

The North Gillespie Park site is northwest of Gillespie Park on the north side of 10th Street at Goodrich Avenue (Figure 8-9). Untreated stormwater runoff from a large contributing area flows via pipes into the channel that runs through this site. The channel flows to a large pipe that discharges the untreated runoff into the 10th Street boat basin in Sarasota Bay. The area has high TN, TP, TSS, and BOD load according to SIMPLE (Figure 8-10). In addition, the site is in WBID 1936, Whitaker Bayou Coastal, which is listed for DO, nutrients, and fecal coliform (Figure 8-10). The channel is entirely within the County-owned drainage easement but is bound by a power easement owned by the City of Sarasota on the north side. Parcel 2025-15-0019 is owned by the City and covers about a quarter of an acre adjacent to the north side of the channel on the west side of Goodrich Avenue.

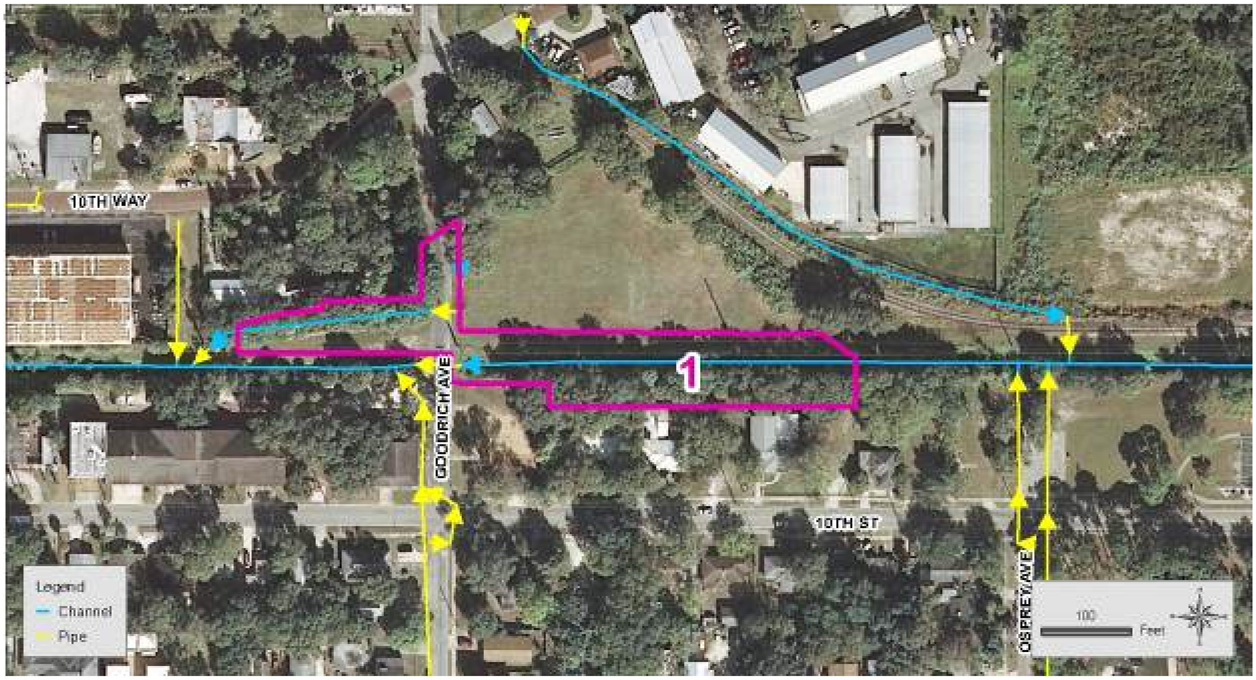


Figure 8-9 Aerial View of Site 1 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

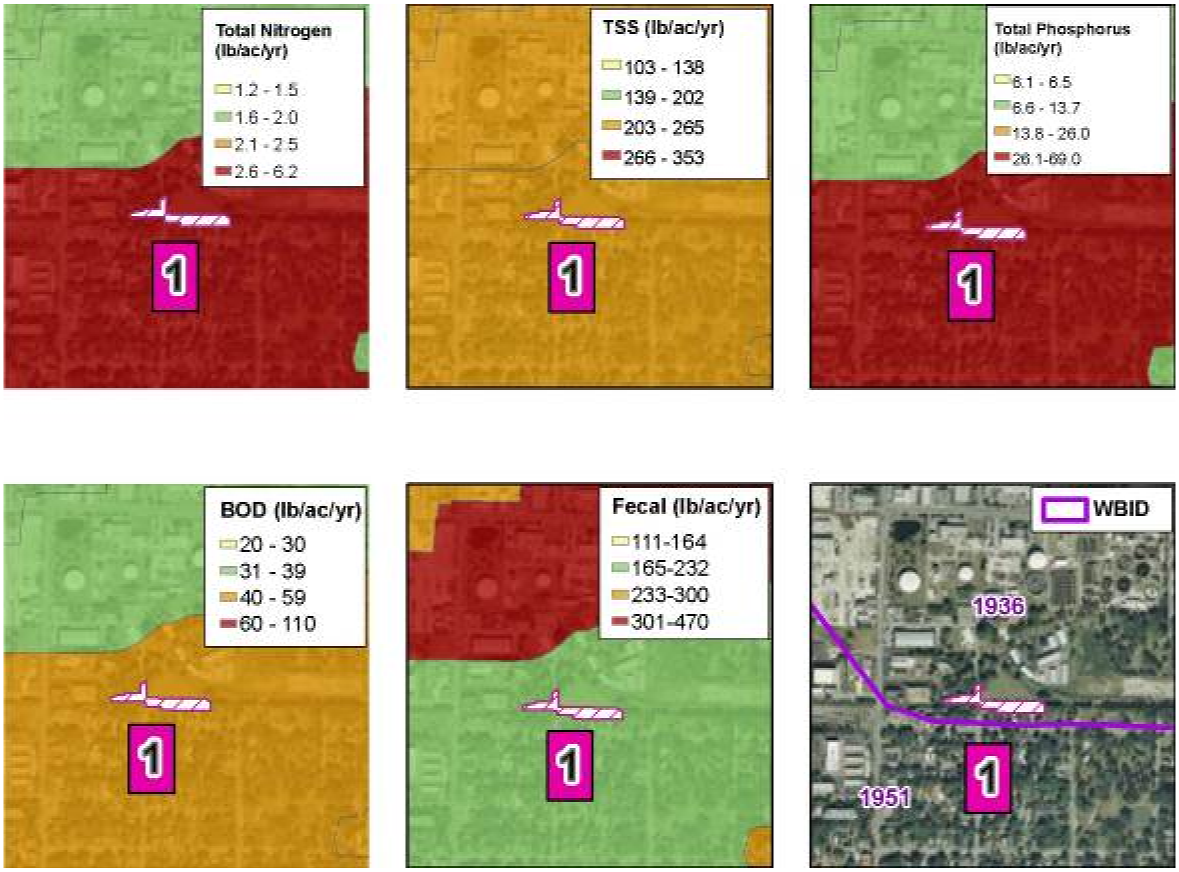


Figure 8-10 Site 1 Pollutant Loads and Listed WBIDs

B. Field Investigation

The channel runs east-west north of 10th Street as noted in the GIS desktop analysis. The banks on the north and south side have loose sands and are eroded (Figure 8-11). Multiple pipes (small PVC to 36-inch CMP) are discharging to the stream without signs of erosion control or water quality treatment. Several property owners have tried to stabilize the top of bank with bricks and sandbags. A small ditch carries flow parallel to the stream from Goodrich Avenue west approximately 200 feet.

A B

Figure 8-11 Site 1 Looking Downstream, West (A) and Upstream, East (B)

C. Recommendation

Jones Edmunds recommends bank restoration and education kiosks along this channel segment. We propose amending the soils and planting native vegetation on both banks. The soils should be evaluated to determine if organic or inorganic media would be best suited for the amendment to provide bank stabilization. The native plantings will help reduce bank erosion and will provide a buffer for stormwater runoff, which will help remove pollutants such as nutrients before they enter the waterway. Adding a sediment sump in the flowpath near Goodrich Avenue will provide the maintenance staff with an opportunity to remove sediments and particulates that enter the channel upstream.

We recommend working with the children's interactive garden on 10th Way to develop an education kiosk or signage that would explain the project elements and benefits.

Summary:

- ❖ Restore banks (soil amendment and vegetation).
- ❖ Add sediment sump.

- ❖ Add public education (partner with children's garden and kiosk).

8.4.1.2 Site 2 – Bayfront Parking Lot

A. GIS Desktop Analysis

The Bayfront Parking Lot site, owned by the City, is adjacent to Sarasota Bay along the west side of Bayfront Drive near Ringling Boulevard (Figure 8-12). Untreated stormwater from Bayfront Drive and the parking lot flows through curb inlet and grates that lead to several pipes that discharge into Sarasota Bay. Large pipes also discharge untreated runoff from Main Street, Ringling Boulevard, and an urbanized area on the east side of Palm Avenue to the bay at the parking lot. The drainage area just upstream of this project site contains high TN, TSS, BOD, and fecal coliform loads according to SIMPLE (Figure 8-13). Additionally, stakeholders and County employees have expressed concern about the amount of garbage and debris that comes out of these outfalls.

B. Field Investigation

Due to heavy traffic and a boat event, we were unable to access the Bayfront Parking Lot site.

C. Recommendation

Recommendations for the Bayfront Parking Lot site are based on the GIS desktop analysis and information provided by County staff. Jones Edmunds proposes adding a dedicated motorcycle and smart car parking area with pervious pavement and replacing foot traffic areas with pervious pavement to facilitate stormwater infiltration. Adding curb cuts and LID components to existing parking lot medians will provide water quality treatment before the flow enters the bay.

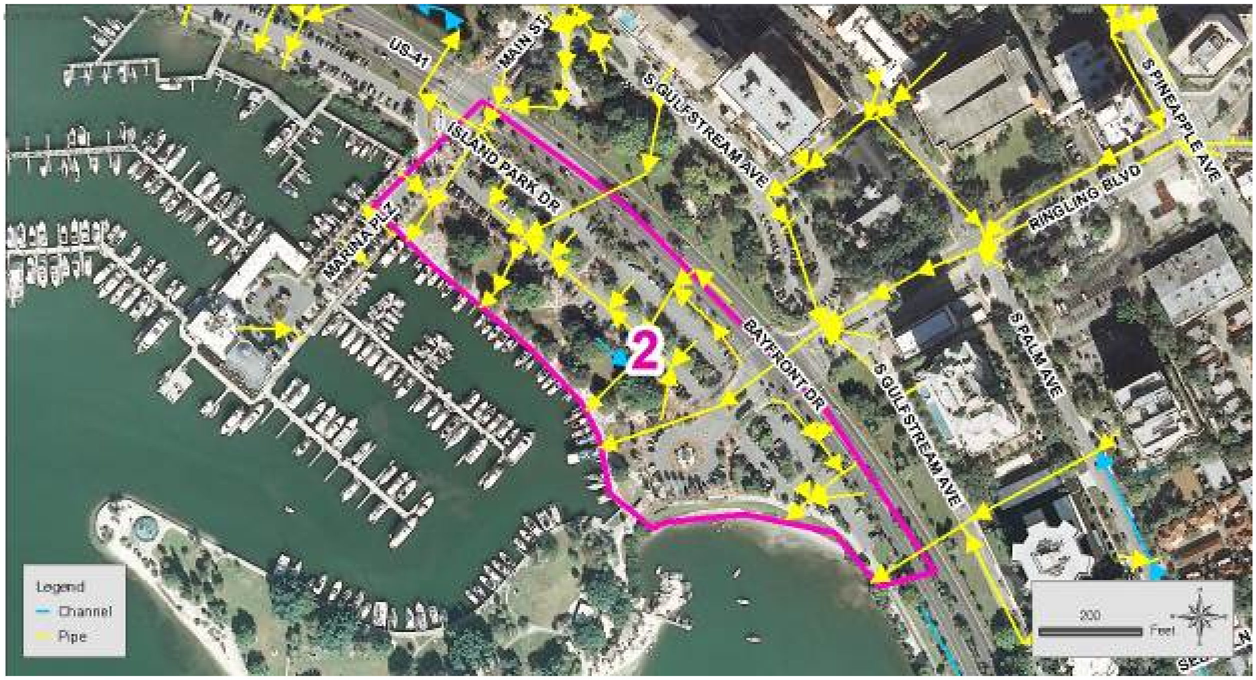


Figure 8-12 Aerial View of Site 2 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

Figure 8-13 Site 2 Pollutant Loads and Listed WBIDs

Jones Edmunds also recommends incorporating baffle boxes in the easement between the parking lot and Bayfront Boulevard to intercept litter from the downtown area before it reaches the outfall. A Subsurface Utility Exploration (SUE) should be done to find the exact locations of underground infrastructure.

Summary:

- ❖ Install pervious pavement to parking lot.
- ❖ Install curb cuts and LID to medians.
- ❖ Install baffle boxes.

8.4.1.3 Site 3 – Ringling Boulevard Diversion

A. GIS Desktop Analysis

Site 3 is at the corner of Ringling Boulevard and South Palm Avenue (Figure 8-14). A large pipe along Ringling Boulevard carries untreated stormwater from a heavily developed drainage basin to Sarasota Bay. The area has high TN, TP, TSS, BOD, and fecal coliform loads according to SIMPLE and would benefit from diverting low flows through a treatment train before discharging to the bay (Figure 8-15). Ownership of this parcel could not be verified with available data.

Figure 8-14 Aerial View of Site 3 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

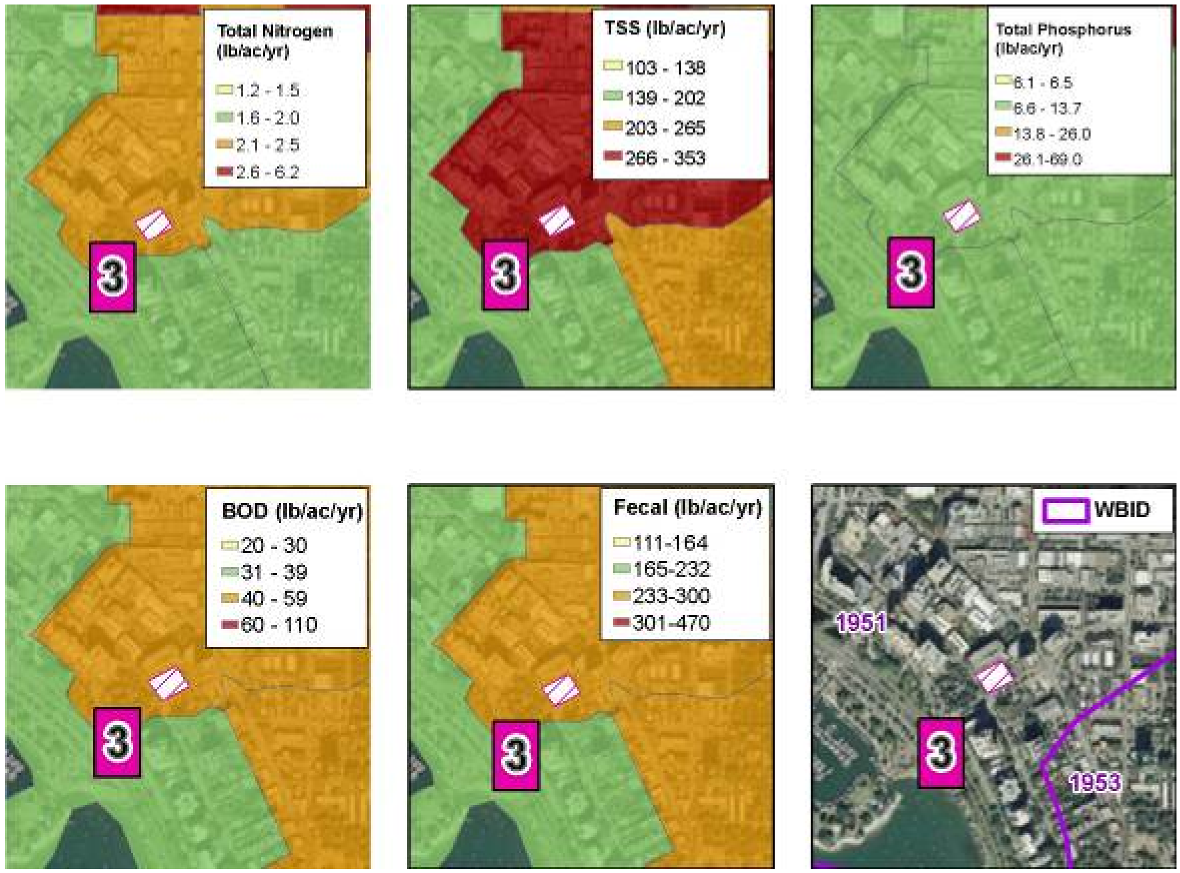


Figure 8-15 Site 3 Pollutant Loads and Listed WBIDs

B. Field Investigation

This parcel is at 1401 Ringling Boulevard, and a sign indicated that it is now owned by IStar Financial—a commercial real estate developer.

C. Recommendation

The stormwater system would benefit from a low-flow diversion through a treatment train; however, because this property is under private ownership and no other publicly owned parcels were identified adjacent to this system, no project is recommended. Jones Edmunds recommends that the County work with residents and stakeholders in the area using some of the programs listed in Section 8.4.2. For instance, rain barrels and cisterns would work well in this area to capture stormwater for beneficial use in landscaping irrigation, which would reduce direct runoff to the bay and provide much-needed treatment.

Summary:

- ❖ Work with private stakeholders to implement LID elements such as rain barrels and cisterns.

8.4.1.4 Site 4 – 47th Street Diversion

A. GIS Desktop Analysis

Site 4 is west of Water Tower Park (Figure 8-16). Untreated stormwater from a large contributing area currently drains from the Tamiami Trail (US 41) stormwater pipe network into a ditch adjacent to 42nd Street that leads to a channel that discharges to Whitaker Bayou. Stakeholders have expressed concern about the quality of stormwater that flows through the 42nd Street ditch and eventually into the bayou. Figure 8-17 shows the nutrient levels from the SIMPLE model.

Figure 8-16 Aerial View of Site 4 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

Figure 8-17 Site 4 Pollutant Loads and Listed WBIDs

A wetland enhancement/treatment train in North Water Tower Park is part of the conceptual plan developed for the Natural Systems component of this Water Quality Management Plan (WQMP). The stormwater inventory shows a north-to-south 42-inch stormwater pipe that crosses Tamiami Trail south of 47th Street and north of 46th Street (Figure 8-18). The parcels between 46th Street and 47th Street and the east portion of 46th Street are privately owned. The County owns 47th Street and Royal Palm Avenue.

Figure 8-18 Site 4 Storm Sewer System

B. Field Investigation

A storm sewer system carries untreated runoff along US 41 at this location. A connection to the system is midway between 46th Street and 47th Street on the east side of US 41. The sidewalk along the east side of US 41 between these two streets is cracked and in disrepair. No public stormwater conveyance infrastructure is currently on or adjacent to 47th Street or 46th Street (Figure 8-19). The east portion of 46th Street is privately owned. There is also a lift station where 46th Street meets the west side of Water Tower Park (Figure 8-20).

A

B

Figure 8-19 47th Street (Source: Google Maps) (A) and 46th Street (B)

Figure 8-20 46th Street, Facing East Toward Proposed Wetland in Water Tower Park

A 47th Street homeowner indicated that in the 1960s there was a ditch behind her property. She pointed out that the ditch had been "over my child's head" but has filled in over the years. Neighbors have since dug the trench shown in Figure 8-21 to alleviate flooding. The homeowner also said that water backs up in this trench at the park entrance during heavy rain. There is no easement parallel to the backyards of the homes along the south side of 47th Street.

There is an open area at the Water Tower Park Royal Palm Avenue entrance. To the east is a parking lot with more open area on the south side of the lot. There is a golf disc course and pathways to the south under the tree cover.

Figure 8-21 Ditch Adjacent to Private Properties on the South Side of 47th Street

C. Recommendation

To provide treatment, Jones Edmunds recommends diverting flow from the US 41 storm sewer system to a treatment train project in the north grassed areas of the park. Replacing the sidewalks along 47th Street and between 46th and 47th Street with pervious concrete or pervious pavers is also recommended.

Summary:

- Replace sidewalks with pervious concrete.
- Construct treatment train in the park.
- Divert flow from the US 41 storm sewer to treatment train.
- This project has been incorporated into the Natural Systems section to expand the Natural Systems improvement project in the park to include this diversion and treatment project.

8.4.1.5 Site 5 – Hudson Bayou North Branch

A. GIS Desktop Analysis

Site 5 includes the County Administration Parking Lots, which are on the south side of Ringling Boulevard east of Rawls Avenue (Figure 8-22). Morrill Street is between the lots. A small City park is on the north side of the lots parallel to Ringling Boulevard. The site is in WBID 1953, Hudson Bayou Tidal, which is listed for DO and fecal coliform. The area has high TN, TSS, BOD, and fecal coliform SIMPLE pollutant-load results (Figure 8-23). Untreated runoff from Morrill Street and the north parking lot flows into the Ringling Boulevard drainage system via a 48-inch pipe under the City park. This runoff discharges directly into Sarasota Bay without treatment. Runoff from the south parking lot discharges untreated runoff into a 48-inch pipe that flows into the north branch of Hudson Bayou.

Figure 8-22 Aerial View of Site 5 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

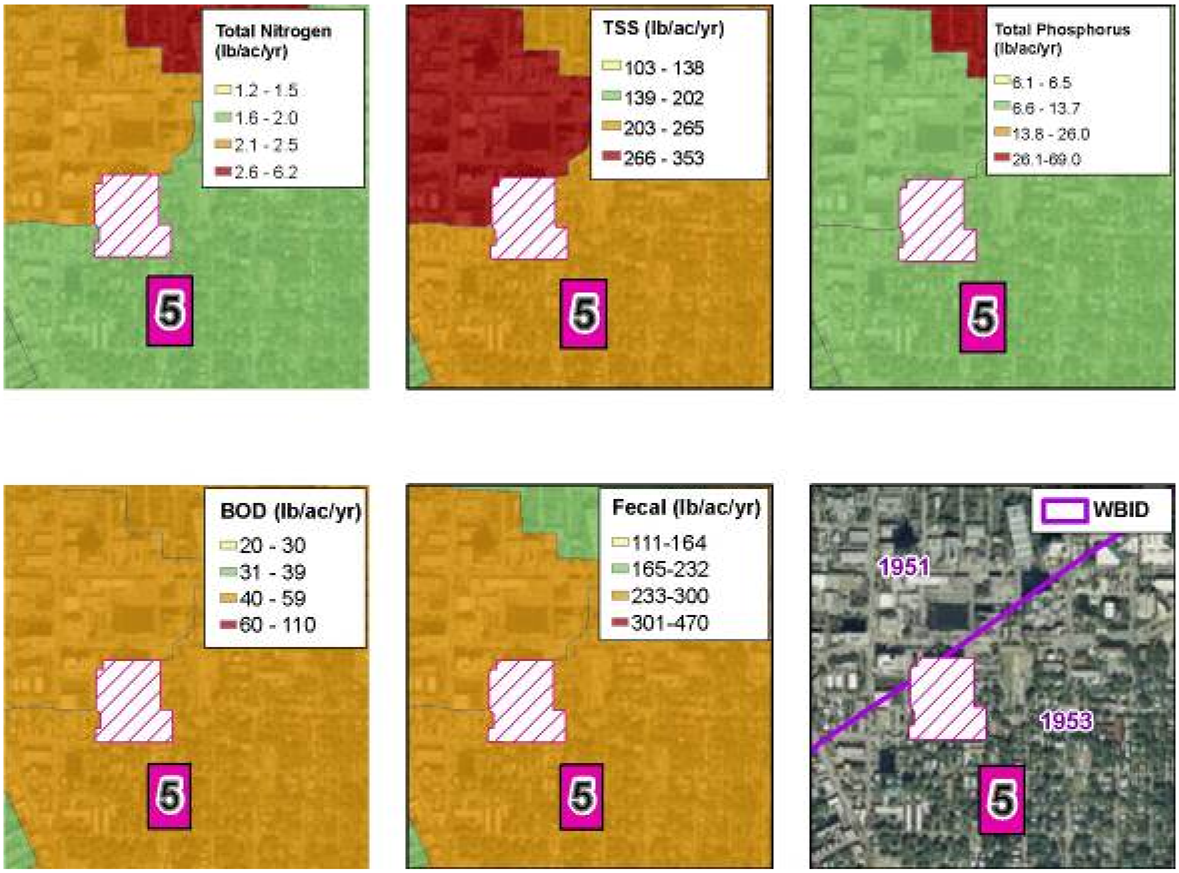


Figure 8-23 Site 5 Pollutant Loads and Listed WBIDs

B. Field Investigation

Runoff from the south lot flows through a rock-lined retention swale that runs the length of the lot on the south side of Morrill Street (Figure 8-24) and into a large outfall at the northwest corner (Figure 8-25). The outfall connects to the 48-inch pipe that discharges to Hudson Bayou. The retention area was full of leaves. There is a proposed 319 grant project to install a baffle box on the south side of the south parking lot.

Figure 8-24 Site 5 Retention Area at North Side of South Lot

Figure 8-25 Site 5 Outfall at North Side of South Lot

In addition to runoff from the parking lot, a steady flow of water from the cooling system in the County building was also being discharged to the Ringling Boulevard system.

C. Recommendation

This area is highly urbanized and consists primarily of directly connected impervious areas (DCIA). Jones Edmunds recommends adding LID components and curb cuts to the parking lot medians to treat the stormwater before it reaches the outfall structures. Retrofitting the retention areas in the south lot to be more LID-friendly will provide additional treatment without losing the flood-protection capacity. One option is to raise the bleed-down elevation in the control structure. Adding an architectural cistern or multiple rain barrels to the building in the north lot to capture roof runoff and air-conditioning condensation to be used for irrigation in the park is also recommended.

Summary:

- ❖ Install LID components and curb cuts to the parking lot medians.
- ❖ Install LID components to the retention areas in the south lot and raise the bleed-down elevation in the control structure.
- ❖ Install rain barrels or cistern on the building in the north lot.

8.4.1.6 Site 6 – Hatton Street Ditch

A. GIS Desktop Analysis

The Hatton Street Ditch site is adjacent to Hatton Street, north of Sarasota High School, and bisected by S. Shade Avenue (Figure 8-26). This site is on County property. SIMPLE pollutant-load results indicate high fecal coliform (Figure 8-27). Untreated runoff from much of the Hudson Bayou basin flows through this ditch, eventually discharging into Hudson Bayou.

Figure 8-26 Aerial View of Site 6 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

Figure 8-27 Site 6 Pollutant Loads and Listed WBIDs

B. Field Investigation

The Hatton Street Ditch has very steep banks and erosion (Figure 8-28). There are multiple discharges without erosion control. On the south side of the Hatton Street Ditch are two stormwater ponds for the high school.

Figure 8-28 Hatton Street Ditch, Facing East

C. Recommendation

Due to the major erosion and sedimentation issues at this site, this project site is better suited for a sediment management project. Recommendations for this site will be provided in Appendix F – Sediment Management Plan.

8.4.1.7 Site 7 – 10th Street Outfall

A. GIS Desktop Analysis

Site 7 is adjacent to Sarasota Bay and Tamiami Trail at the west end of 10^{th} Street (Figure 8-29). There are two areas of interest at this site—the Van Wezel Parking Lot and the 10^{th} Street Outfall area. The area draining to this site has high TN, TP, TSS, BOD, and fecal coliform SIMPLE pollutant loads (Figure 8-30). Untreated stormwater from the parking lot flows through curb inlets and grates that lead to several pipes that discharge into Sarasota Bay. The 10^{th} Street Outfall discharges untreated runoff from a large contributing area into the boat basin at the north end of the parking lot. Stakeholders and County employees have expressed concern about the amount of garbage and debris that comes out of the large pipe from 10th Street.

Figure 8-29 Aerial View of Site 7 (SWFWMD, 2010)

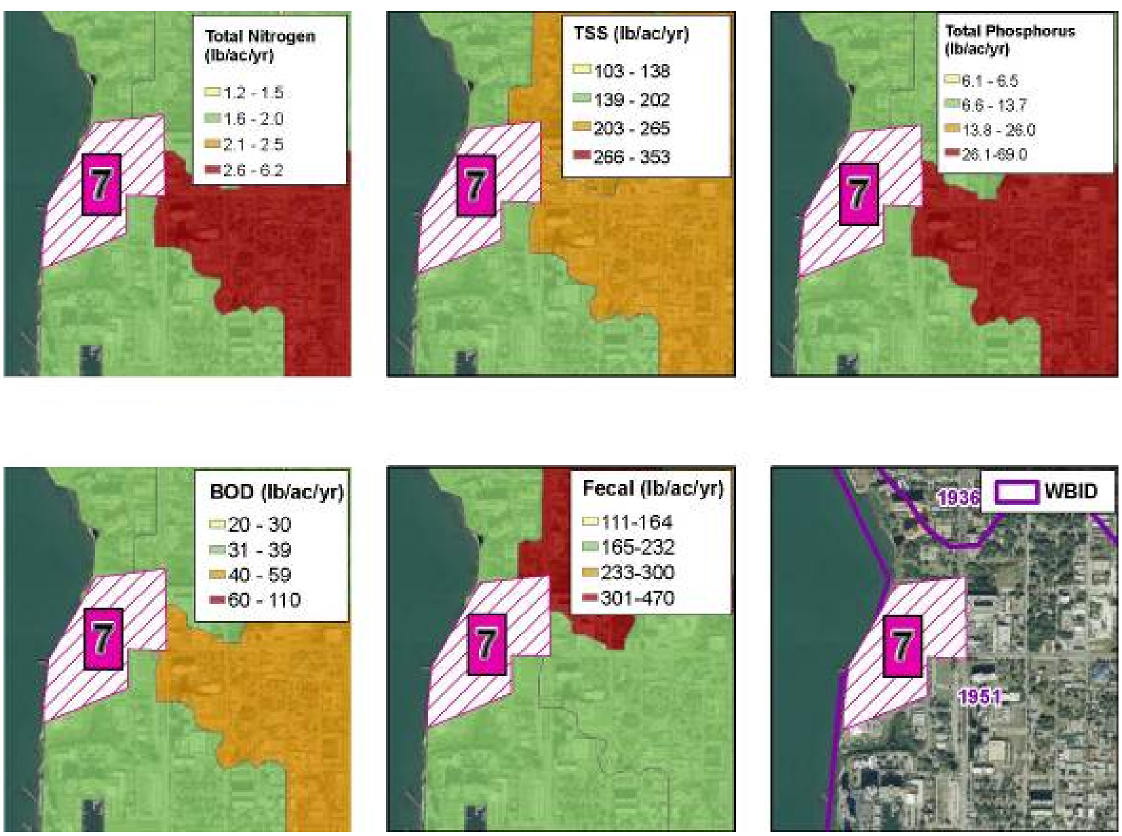


Figure 8-30 Site 7 Pollutant Loads and Listed WBIDs

B. Field Investigation

A U.S. Coast Guard station is at the northwest corner of the parking lot, and the Van Wezel Performing Arts Hall is at the southwest corner of the parking lot. There is a significant amount of median space in the Van Wezel Parking Lot as well as some small treatment areas close to the bay that could be improved for increased stormwater treatment (Figure 8-31).

Figure 8-31 Van Wezel Parking Lot

A large culvert in the southeast corner of the boat basin discharges untreated runoff from 10th Street and possibly Tamiami Trail (Figure 8-32). County staff noted that the boat basin typically acts as a settling basin for sediments and has many floatables after storm events. The northeast corner of the boat basin is sedimented and covered with terrestrial vegetation (Figure 8-33). A County employee suggested building a weir/baffle system across the boat basin to effectively catch the sediment and allow easy maintenance.

The sidewalks on either side of 10^{th} Street east of Tamiami Trail are cracked and broken. There is no existing stormwater treatment.

Figure 8-32 10th Street Outfall

Figure 8-33 10th Street Boat Basin, Northeast Corner

C. Recommendation

This area is highly urbanized with little open space to allow for stormwater infiltration. Jones Edmunds recommends adding curb cuts and LID practices to all parking lot medians along the west boundary to allow runoff into the existing retention areas. Replacing select parking spots and approximately 5,000 linear feet of sidewalk along 10^{th} Street with pervious pavement and adding rain barrels to all on-site buildings will reduce runoff. Regrading and adding vegetative buffers to existing retention areas between the parking lot and bay and constructing a sedimentation box (e.g., baffle box) upstream of the 10^{th} Street Outfall will help improve water quality by removing pollutants such as sediment and nutrients before they enter the bay. Jones Edmunds advises installing backflow prevention at the outfall to prevent the sediment sump from filling with bay water. Stormwater harvesting from the vault for irrigation in the area is also recommended. In addition, because there is a gas station at the intersection of Tamiami Trail and 10^{th} Street, the potential for groundwater contamination from underground storage tanks must also be considered at this site.

Summary:

- Install curb cuts and LID practices to all parking lot medians and along the west boundary.
- Install pervious pavement in the parking lot.
- Construct vegetative buffers in the retention areas.
- Install rain barrels at all onsite buildings.
- Construct a stormwater sedimentation box upstream of the 10^{th} Street Outfall.
- Provide stormwater harvesting for irrigation
- Replace pervious sidewalk.

8.4.1.8 Site 8 – Whitaker Bridge

A. GIS Desktop Analysis

The Whitaker Bridge site is on the north bank of Whitaker Bayou adjacent to Tamiami Trail (Figure 8-34). County staff has indicated that making bridges less accessible to foot traffic would reduce the amount of pollutants, such as human waste, entering the bayou. This site is in WBID 1936, Whitaker Bayou Coastal, which is listed for DO, nutrients, and fecal coliform (Figure 8-35).

Figure 8-34 Aerial View of Site 8 (SWFWMD, 2010)

Figure 8-35 Site 8 Pollutant Loads and Listed WBIDs

B. Field Investigation

This site was not accessible.

C. Recommendation

There are no recommendations for this site due to inaccessibility.

8.4.1.9 Site 9 – Hudson Bayou East Branch

A. GIS Desktop Analysis

Site 9 is on the north side of Bahia Vista Street, west of School Street at Sarasota High School (Figure 8-36). Untreated runoff from a significant contributing area flows north through a ditch and into Hudson Bayou. The west portion of this site is in WBID 1953, Hudson Bayou Tidal, which is listed for DO and fecal coliform (Figure 8-37).

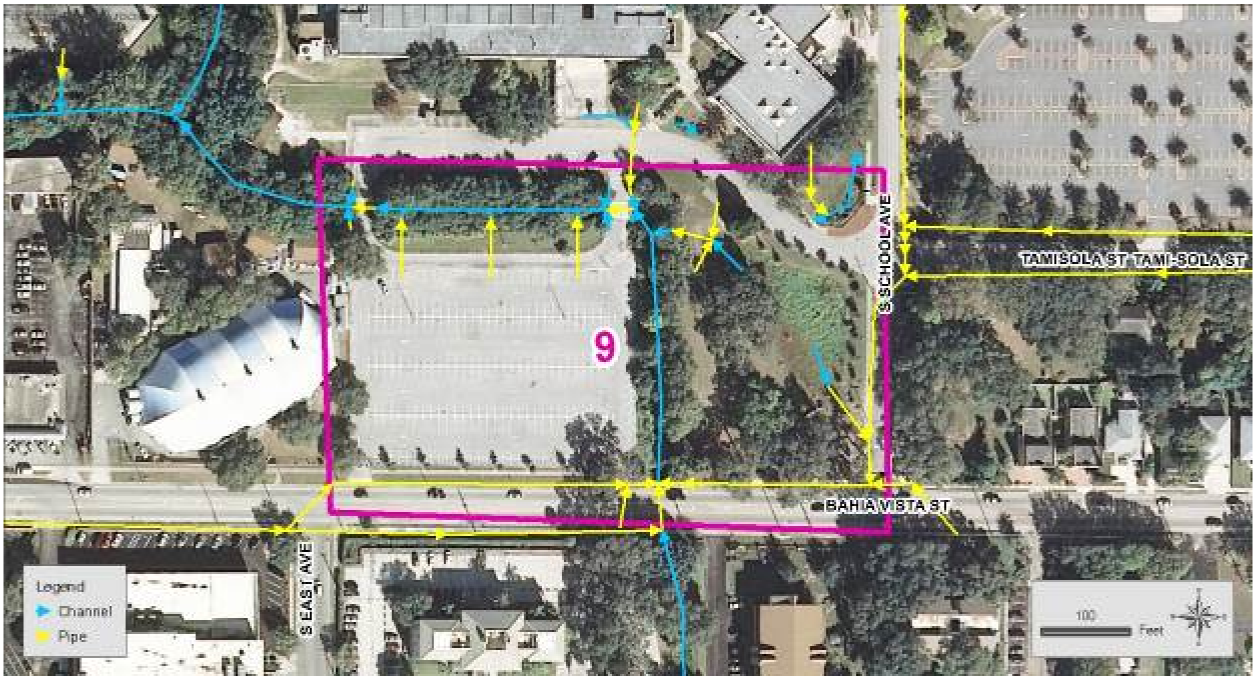


Figure 8-36 Aerial View of Site 9 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

Figure 8-37 Site 9 Pollutant Loads and Listed WBIDs

B. Field Investigation

The south-to-north ditch from Bahia Vista Street is full of muck and trash (Figure 8-38). A 10-inch pipe discharges from a retention area to the north end of the ditch. The bank around the pipe is eroded, and the ditch is sedimented and heavily vegetated at this point. Approximately a meter north of this, the ditch bends 90 degrees to the west to a skimmer and 82-inch square culvert. The skimmer is full of debris, and both sides of the culvert contain muck and garbage (Figure 8-39).

Figure 8-38 Ditch to East Branch of Hudson Bayou, Facing South

Figure 8-39 Skimmer and Culvert to East Branch of Hudson Bayou, Facing Southwest

C. Recommendation

To minimize the floatables, sediment, and other pollutants flowing directly into the east branch of the Hudson Bayou, the following actions are recommended:

- Clean out the existing skimmer.
- Dredge ditch from the bend to the skimmer and the area on the opposite end of the square culvert (approximately 30 linear feet on either side of the culvert).
- Stabilize the ditch banks.
- Widen the ditch and add a baffle box for sediment and floatable collection on the north side of Bahia Vista Street.

8.4.1.10 Site 10 – Ringling Boulevard Sidewalks

A. GIS Desktop Analysis

Site 10 includes the length of Ringling Boulevard through downtown Sarasota (Figure 8-40). This area has high TN, TSS, BOD, and fecal coliform SIMPLE pollutant-load results (Figure 8-41). Untreated stormwater from Ringling Boulevard and surrounding developed areas enters the stormwater conveyance along Ringling Boulevard via curb inlets. A large pipe drains directly to Sarasota Bay.

Figure 8-40 Bird's Eye View of Site 10 (Source: Bing Maps)

Figure 8-41 Site 10 Pollutant Loads and Listed WBIDs

B. Field Investigation

The area is highly urbanized and consists mostly of DCIA. There is very little space for infiltration to occur.

C. Recommendation

To increase infiltration of runoff in this highly urbanized area, Jones Edmunds recommends a phased replacement of traditional sidewalks with pervious concrete or pervious pavers along Ringling Boulevard from US 41 east to S. Orange Avenue.

Summary:

- Replace concrete sidewalks with pervious concrete or pavers.

8.4.2 Programs

This section describes programs and programmatic recommendations to promote environmental stewardship and improve water quality.

8.4.2.1 Sarasota County Fertilizer and Landscape Management Code

A. Description

The Sarasota County Commission approved an ordinance regulating the use of fertilizers containing nitrogen and/or phosphorus in Sarasota County in 2007. Ordinance No. 2007-062, the Sarasota County Fertilizer and Landscape Management Code, regulates the proper use of fertilizer and requires the use of BMPs to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers. The ordinance establishes a restricted season, fertilizer content and application rates, fertilizer-free zones, low maintenance zones, exemptions, and training and licensing requirements for commercial and institutional fertilizer applicators.

Negative effects from fertilizer have been observed in and on Sarasota County's natural and artificial stormwater and drainage conveyances, lakes, canals, estuaries, interior freshwater wetlands, the Myakka River, and nearshore waters of the Gulf of Mexico. The health of these waterbodies is critical to the environmental, recreational, cultural, and economic wellbeing of stakeholders and the health of the public. Water quality problems, including harmful algal blooms, hypoxic zones, and declines in wildlife and habitat, can arise when excess nutrients get into waterbodies. Overgrowth of algae and vegetation can hinder the effectiveness of flood attenuation provided by natural and artificial stormwater and drainage conveyances. Regulation of nutrients, including phosphorus and nitrogen in fertilizer, therefore, is critical to improve and maintain water and habitat quality (Sarasota County Ordinance No. 2007-062).

B. Recommendation

Jones Edmunds recommends that Sarasota County continue to enforce Ordinance No. 2007-062, the Sarasota County Fertilizer and Landscape Management Code. In addition, the County should retain the support and funding required to continue the educational component of this ordinance.

8.4.2.2 Neighborhood Environmental Stewardship Team, NEST

A. Description

Sarasota County has developed a program for Neighborhood Environmental Stewardship Teams (NEST). NEST is a voluntary association of County residents (neighbors, civic groups, student organizations and others) who want to better understand and improve the environmental conditions in the watershed. The public purpose is two-fold: to provide constructive and meaningful activities to help residents improve the environmental quality of the watershed and their neighborhoods and to develop educational activities and materials regarding and advocacy for watershed improvement policies and management strategies. NEST's activities address issues such as water quality, natural system preservation, neighborhood drainage, landscaping, and other water-related issues. NEST activities may include water quality or biological monitoring, volunteer restoration, research, and planning input. NEST provides individual and community awareness of appropriate fertilizer usage, buffer zones, LID practices, and conservation. Additionally, public outreach includes developing web/email campaigns and educational materials.

B. Recommendation

To maximize this program's potential, Jones Edmunds recommends that NEST:

- Solicit private landowners and condominium complexes in the downtown area to implement LID practices, such as rain barrels, cisterns, and pervious pavement, with the help and guidance of NEST.
- Solicit private landowners in residential areas, especially properties along tributaries, to implement LID practices, such as rain barrels, pervious pavement, and gutter bubblers (Figure 8-42 and Figure 8-43), with the help and guidance of NEST.
- Work with businesses along the US 41 corridor in Whitaker, especially to prevent litter and implement LID retrofits on their properties.

Figure 8-42 Rain Barrel System

Figure 8-43 Rain Gutter Bubbler System

8.4.2.3 National Pollutant Discharge Elimination System (NPDES)

A. Description

Sarasota County is a Municipal Separate Storm Sewer System (MS4) operator and holds a National Pollutant Discharge Elimination System (NPDES) permit (Number FLS000004) from FDEP. To maintain the permit, the County has developed a stormwater management program that includes BMPs with measurable goals to effectively implement eight minimum control measures outlined in the 2006 Comprehensive Plan.

B. Recommendation

Jones Edmunds recommends that Sarasota County continue to incorporate stormwater BMPs with other neighborhood redevelopment projects to meet the overall goals of the NPDES permit, which is to reduce or prevent pollutant loads from reaching waterbodies.

8.4.2.4 Septic to Cistern

A. Description

In June 2009 the County Health Department implemented a procedure for converting abandoned septic tanks into cisterns based on 64E-6.011, FAC. This conversion allows a single-family residence to convert an abandoned septic tank to a cistern by permit within 90 days of connecting the building plumbing to sanitary sewer.

B. Recommendation

Jones Edmunds recommends active public outreach and education to help homeowners permit and repurpose septic tanks to cisterns. Sarasota County should add a webpage about this program to the existing County website. The site should contain details about the program, the permitting and repurposing procedure, and all applicable documents. The County should send informative literature, including a reference to the webpage, to residences that have switched from septic tanks to the municipal system.

8.4.2.5 Strategic Maintenance Plan

A. Description

The *Strategic Maintenance Plan*, adopted in 1999, establishes level-of-service (LOS) goals for maintenance activities in the County. The plan identifies maintenance practices and classifies practices into *Routine*, *Extraordinary*, and *Support* activities in which the staff engages for maintenance repairs, improvement, management, and operation of the public stormwater system.

Stormwater maintenance has traditionally played an active role in maintaining the flood capacity of the stormwater system throughout the County. A more robust maintenance program incorporating the recommendations described below will play a larger role in improving the quality of the runoff reaching the estuaries and bays of Sarasota County.

B. Recommendation

Jones Edmunds recommends the following approach to expand and enhance the focus of the stormwater maintenance process to include water quality in addition to flood protection:

- Implement the 1999 Strategic Maintenance Plan.
- Achieve the inspection and maintenance frequency required in the MS4 Permit.
- Update the Strategic Maintenance Plan.
- Adopt practices listed below when fiscally feasible.

Updating the *Strategic Maintenance Plan* and adopting several non-structural BMPs and source control practices may provide the best opportunities to increase awareness and implement maintenance improvements aimed at improving water quality. The following modifications, additions, or removal of maintenance practices will help the County meet its water quality goals:

- Inspection and Permit Compliance:
  - NPDES Inspection.
  - Asset Management.
- FEMA Community Rating System.
- Facility Maintenance and BMPs:
  - Facilities: Scheduling.
  - Facilities: Denuding Conveyance Features.
  - Non-Structural BMPs: Buffer Zones.
  - Non-Structural and Structural BMPs: LID.
  - Source Control: Street Sweeping.
  - Source Control: Herbicides.
  - Source Control: Fertilizer Management.
  - Source Control: Harvesters.

Jones Edmunds analyzed current maintenance policies and procedures as part of the Roberts Bay North and Lemon Bay Watershed Management Plans (WMPs). The recommendations listed above are detailed in the Roberts Bay North and Lemon Bay WMPs.

8.4.2.6 Low-Impact Development (LID)

A. Description

LID is a stormwater management approach that uses a suite of hydrologic controls (structural and non-structural) distributed throughout the site and integrated as a treatment train (i.e., in series) to replicate the natural hydrologic functioning of the predevelopment landscape. Unlike conventional systems, which typically control and treat runoff using a single engineered stormwater pond located at the "bottom of the hill," LID systems are designed to promote volume attenuation and treatment at or near the source of stormwater runoff via distributed retention, detention, infiltration, treatment, and reuse mechanisms. The fundamental goal of applying LID concepts, design, and practice is to improve the overall effectiveness and efficiency of stormwater management relative to conventional systems, reducing total and peak runoff volumes and improving the quality of waters discharged from the site.

A site-specific suite of LID integrated management practices can be applied to most if not all development scenarios in Sarasota County. Regardless of the project context, LID requires the following core site planning and design objectives to be considered:

1. Preserve or conserve existing site features and assets that facilitate predevelopment hydrologic function.
2. Minimize the generation of runoff from impervious surfaces (i.e., use peak and total volume controls) and contamination (i.e., use load controls) as close to the source as possible.
3. Promote distributed retention, detention, treatment, and infiltration of runoff.
4. Capture and reuse stormwater on site.
5. Minimize site disturbance and compaction of soils through low-impact clearing, grading, and construction measures.

The toolbox of LID-integrated management practices to facilitate these objectives is extensive, including structural and non-structural designs, and LID projects are most effective when applied in a treatment train or series of complementary stormwater management tools and techniques. In addition, a LID stormwater management approach is most effective when sites are evaluated for LID compatibility as early as possible in the planning process and site features are considered carefully in the design and construction of each LID practice. A County manual to help incorporate LID projects into new development and infrastructure retrofit projects was developed in 2010.

B. Recommendation

To achieve optimal performance of LID systems, project planners and engineers must adopt a comprehensive and iterative approach to site evaluation, planning and design, and monitoring and feedback. Fundamental LID principles such as those listed below should be considered in the development planning and design process:

1. Preserve or conserve site features and assets that facilitate natural hydrologic function.
2. Minimize generation of runoff from impervious surfaces (i.e., use peak and total volume controls).
3. Minimize runoff contamination (i.e., use load controls) as close to the source as possible.
4. Promote distributed retention, detention, treatment, and infiltration of runoff.
5. Capture and harvest stormwater on site.
6. Minimize site disturbance and compaction of soils through low-impact clearing, grading, and construction measures.

Consistently implementing LID concepts, design, and practice will improve the overall effectiveness and efficiency of stormwater management relative to conventional systems, reducing runoff and improving water quality. Jones Edmunds also recommends fully implementing the LID manual.

8.4.2.7 Keep Sarasota County Beautiful

A. Description

Keep Sarasota County Beautiful is a County-wide program with a mission to enhance and promote public interest and participation in the general improvement of the environment throughout Sarasota County. This is done through education, cleanup programs, recycling, and other methods of reducing solid waste. Keep Sarasota County Beautiful is an affiliate of Keep America Beautiful, Inc., a national, non-profit, public education organization dedicated to improving waste handling practices in American communities.

B. Recommendation

Litter is one of the most visible stormwater pollution issues in the watershed. Jones Edmunds recommends that the County increase the number of community cleanup projects in the watershed through the Keep Sarasota County Beautiful program. The County should work with homeowner associations and neighborhoods to recruit volunteers and organize educational and cleanup events. The County should also work with marinas to organize boating cleanups.

In addition, Jones Edmunds recommends that the County review dumpster and trashcan locations and handling and inspection procedures. The County should make sure that there are adequate trash receptacles in public areas, especially in marinas, along the waterfront and near major storm drains and that they are being properly emptied and maintained.

8.4.2.8 Wet Detention Pond Study

A. Description

Urban waterways receive pollutant loads from stormwater generated by impervious surfaces. Constructed wet detention ponds are effective for localized stormwater treatment; however, there is question about the accuracy of discharge volume and removal efficiencies generated by and/or used in model simulations.

Wet detention ponds are intended to maintain several feet of water in a permanent pool; however, this level can be affected by local conditions, such as drought. Wet detention ponds are designed to hold runoff for treatment for varying periods depending on the pond detention volume, the storm runoff rate and duration, and the antecedent water level.

In line with current literature, Sarasota County models wet detention ponds as impervious areas, regardless of antecedent conditions. This may be appropriate during wet season. During dry season, however, a wet detention pond may have enough storage to accommodate all of the runoff and therefore would not discharge during a storm event. Modeling such a pond as impervious would result in an overestimate of volume and an underestimate of removal efficiency. Therefore, there is debate as to the accuracy of current modeling techniques.

B. Recommendation

Jones Edmunds recommends implementing a pilot study to monitor discharge from wet detention ponds. These data can be used to develop appropriate values to be used in Sarasota County model simulations.

9.0 CONCLUSION

Seven of the potential project sites were deemed viable locations for projects designed to improve water quality (Table 9-1). Implementation of these projects and programmatic recommendations will significantly reduce pollutant loading and improve water quality in the Sarasota Bay Watershed. Two of the project sites were better suited for a different area of responsibility and will be evaluated further under separate tasks.

Jones Edmunds will calculate pollutant-load reduction, develop conceptual plans and cost estimates, and provide project and program rankings for the selected project sites in Appendix G – Project and Program Recommendations.

Table 9-1 List of Recommended Water Quality Improvement Project Sites

ID	Site Name	WBID	SIMPLE Basin ID	Recommended
1	North Gillespie Park	1936	108	✓
2	Bayfront Parking Lot	1951	101	✓
3	Ringling Boulevard Diversion	1951	107	
4	47th St Diversion	1936A, 1836	112	✓
5	Hudson Bayou North Branch	1953	105	✓
6	Hatton Street ditch	1953A	102	
7	10th Street Outfall	1951	101	✓
8	Whitaker Bridge	1936	112	
9	Hudson Bayou East Branch	1953A	103	✓
10	Ringling Boulevard Sidewalks	1951	107	✓

10.0 APPENDIX—EXISTING DATA, STUDIES, AND INFORMATION

- Conceptual Design Report for Whitaker Bayou 32nd Street Greenway Park and Watershed Restoration (2010).
- Bradenton Road LID Project (2010).
- State of the Bay 2010 (2010).
- Numeric Nutrient Criteria for Sarasota Bay (2010).
- City of Sarasota Compliance Monitoring—2010 (2010).
- Five-year Habitat Restoration Plan 2010–2014 (2010).
- Sarasota City Plan 2030 (2008).
- Sarasota Bay Estuary Program Outfall Prioritization Project (2008).
- Final Report, Task 7: A Tidal Creek Condition Index & Task 8: Evaluation of the Tidal Creek Condition Index (2007).
- Tidal Creek Condition Index for Coastal Streams in Sarasota County, Florida (2007).
- Recommendations for the Development of a Water Quality Response Model and an Approach to Assessing Water Quality in the Estuarine Waters of Sarasota County (2007).
- Establishing Water Clarity Benchmarks for Sarasota County Estuarine Waters (2007).
- Sarasota Bay TMDL Support (2007).
- National Estuary Program Coastal Condition Report (2007).
- Effects of Karenia Brevis Blooms on Wild Coastal Bottlenose Dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida (2007).
- Sarasota County Comprehensive Plan (2006).
- Establishment of Estuarine Water Clarity Targets for Sarasota County Estuarine Waters (2006).
- Sarasota County Comprehensive Oyster Monitoring Program Annual Report 2006 (2006).
- Sarasota Bay Estuary Program Oyster Habitat Monitoring Results: Year 1 (2006).
- Modeling Channel Erosion at the Watershed Scale: Model Review and Case Study (2006).
- State of the Bay 2006 (2006).
- Reconnaissance of Listed Waterbodies on Roberts Bay, Little Sarasota Bay, Blackburn Bay, Donna Roberts Bay, and Lemon Bay and Recommendations for Future sampling (2006).
- Reconnaissance of listed water bodies on Roberts Bay, Little Sarasota Bay, Blackburn Bay, Donna Roberts Bay, and Lemon Bay and recommendations for future sampling (2006).
- Establishment of Estuarine Water Clarity Targets for Sarasota County (2006).
- Water Quality Assessment Report (2006).

- Sarasota Bay Reasonable Assurance Plan (2005).
- Whitaker Bayou Reconnaissance Report (2005).
- Water Quality Status Report (2003).
- Five-year Habitat Restoration Plan 2004–2009 (2003).
- Town of Longboat Key 2007 Comprehensive Plan (2003).
- County-wide Survey of Sediment Quality at Weir Structures (2003).
- Analysis of Changes in Seagrass Coverage, 1996–1999 and 1999–2001, for Anna Maria Sound, Sarasota, Roberts, Little Sarasota, Blackburn Bays. Final report (2003).
- Sarasota Bay SWIM Plan (2002).
- Hudson Bayou Stormwater Study (2001).
- Hudson Bayou Press Release (2001).
- Assessment and Impact of Microbial Fecal Pollution and Human Enteric Pathogens in a Coastal Community (2001).
- A Chronicle of Florida Gulf Coast (n.d.)
- A Historical Geography of Southwest Florida Waterways (n.d.)
- Stormwater Environmental Utility Strategic Plan (2000).
- Southern Coastal Watershed Comprehensive Watershed Management Plan (2000).
- The Occurrence, Distribution and Transport of Human Pathogens in Coastal Waters of Southwest Florida (2000).
- Surface Water, Sediment, and Biological Sampling for "Big Slough, Hudson Bayou, and Phillippi Creek Basins, Sarasota County, Florida (1999).
- Trend Analysis of Water Quality Data for the Sarasota Bay National Estuary Program (1999).
- Contaminant Survey of Sarasota Bay Priority Watershed—Cedar Hammock Creek, Bowlees Creek, Whitaker Bayou, Hudson Bayou, and Phillippi Creek (1999).
- Biological Effects of Atmospheric Deposition on Algal Assemblages. Draft Final Report (1999).
- Technical Synthesis of Sarasota Bay (1997).
- Sarasota County NPDES Sampling (1997).
- Hydrogeology of the Surficial and Intermediate Aquifer Systems in Sarasota and Adjacent Counties, Florida (1996).
- Potential for Water-Quality Degradation of Interconnected Aquifers in West-Central Florida (1996).
- The Effects of Anthropogenic Nutrient Enrichment on Turtle Grass (*Thalassia testudinum*) in Sarasota Bay, Florida (1996).
- Sarasota Bay: The Voyage to Paradise Reclaimed (1995).
- Integration of Flood Control, Wetland Habitat, Reuse, Recreational Features and Stormwater Treatment (1995).
- Light Attenuation with Respect to Seagrasses in Sarasota Bay, Florida (1995).

- Modeling the Impact of Nutrient Load Reduction on Water Quality and Seagrass in Roberts Bay and Little Sarasota Bay (1995).
- Baseline survey of pesticide and PAH Concentrations from Sarasota Bay, Florida, USA (1995).
- Characterization of Ecological Conditions and Impacts of Stormwater Runoff on Hudson Bayou and Phillippi Creek, with Recommendations for Analytical Methods and Management Objectives (1994).
- Hudson Bayou Basin Master Plan (1994).
- Phillippi Creek Basin Master Plan—Hudson Bayou Basin Master Plan (1994).
- Water and Sediment Quality: Trends and Status for Sarasota Bay (1993).
- Framework for Action Chapter 2: Physical and Chemical Properties—Bay Water and Sediment Quality (1993).
- Physical and Chemical Properties of Bay Water and Sediment Quality (1993).
- Bay Bottom Assessment; Final Report (1993).
- Point/Non-Point Source Pollution Loading Assessment (1992).
- Sediment Contaminants in Selected Sarasota Bay Tributaries (1992).
- Sarasota Bay National Estuary Program Pollutant Loading Assessment Phase I (1992).
- Sarasota Bay National Estuary Program Pollutant Loading Assessment Phase II (1992).
- Bivalved Shellfish of Sarasota Bay: A Framework for Action (1992).
- A Segmentation System for the Sarasota Bay Project National Estuary Program (1990).
- Potentially pathogenic marine Vibrio species in seawater and marine animals in the Sarasota, Florida, area (1990).
- A Bibliography on Sarasota Bay, Florida (1988).
- Sarasota Bay, Florida Identification of Resource Management Problems and Issues and National Estuary Program Analysis (1988).
- City Wide Master Drainage Plan City of Sarasota (1987).
- Tampa and Sarasota Bays: Issues, Resources, Status, and Management: Proceedings of a Seminar held Dec 10, 1987, Washington, D.C. (1987).
- Hydrogeology and the Surficial and Intermediate Aquifers of Central Sarasota County, Florida (1986).
- Proposed Designation of Sarasota Bay and Lemon Bay as Outstanding Florida Waters (1986).
- Coprostanol distribution from sewage discharge into Sarasota Bay, Florida (1984).
- Hydrogeology of the Sarasota-Port Charlotte Area, Florida (1983).
- Sarasota Bay Water Quality Study (1983).
- Water Resources and Data-Network Assessment of the Manasota Basin, Manatee and Sarasota Counties (1982).
- Environmental status of Sarasota Bay: Selected studies (1980).
- Hydrologic and Biological Monitoring of Lower Sarasota Bay 1975–1978 (1979).

- Checklist of Benthic Invertebrate Communities in Sarasota Bay with Special Reference to Water Quality Indicator Species (1974).
- The Florida Gulf Coast Red Tide (1955).
- A Field and Modeling Study of Circulation and Transport in Sarasota Bay.
- www.flrules.org
- www.sarasota.wateratlas.usf.edu
- www.ourgulfenvironment.net

11.0 REFERENCES

Benson, B.B., and D.D. Krause, Jr. 1984. *The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere*. Limnol. Oceanogr. 29: 620–632.

Culter, J.K. and J.R. Leverone. 1993. *Bay bottom habitat assessment (Draft Final Report)*. Prepared for Sarasota Bay Estuary Program. Mote Marine Laboratory Technical Report No. 303. Sarasota, FL.

Estevez, E.D. and C. Palmer. 1990. A segmentation system for Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report No. 161. Prepared for Sarasota Bay National Estuary Program. Sarasota, FL.

Florida Department of Environmental Protection. 2011a. Chapter 62-302. F.A.C., Draft. Surface Water Quality Standards. Tallahassee, FL.

Florida Department of Environmental Protection. 2011b. Numeric Nutrient Criteria Briefing for the Environmental Regulatory Commission. November 3, 2011. Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2011c. Verified List of Impaired Water Bodies “sbpm-verified-c2”. Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2012a. *Technical support document: derivation of dissolved oxygen criteria to protect aquatic life in Florida’s fresh and marine waters (Draft). May 2012*. Prepared by Bureau of Environmental Assessment and Restoration Support. Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2012b. Stream Condition Index for Sarasota Bay Waterbodies. Prepared by Bureau of Environmental Assessment and Restoration Support. Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2012c. Florida’s Adopted Numeric Nutrient Criteria and Proposed Revisions to the Dissolved Oxygen Criteria. Prepared by Bureau of Environmental Assessment and Restoration Support. Tallahassee, FL.

Holland, A.F., D.M. Sanger, C.P. Gawle, S.B. Lerberg, M.S. Santiago, G.H.M. Riekerk, L.E. Zimmerman, and G.I. Scott. 2004. *Linkages between tidal creek ecosystems and the landscape and demographic attributes of their watersheds.* Journal of Experimental Marine Biology and Ecology. 298:151–178.

Janicki Environmental, Inc. 2010a. *Numeric Nutrient Criteria for Sarasota Bay*. Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

Janicki Environmental, Inc. 2010b. Empirical Approaches to Establishing Numeric Nutrient Criteria for Southwest Florida Estuaries. Prepared for Tampa Bay Estuary Program, Sarasota Bay Estuary Program, and Charlotte Harbor National Estuary Program. St. Petersburg, FL.

Janicki Environmental, Inc. 2011a. *Sarasota Bay Numeric Nutrient Criteria: Task 1 – TN and TP Concentration and Loading Based Criteria*, Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

Janicki Environmental, Inc. 2011b. *Sarasota Bay Numeric Nutrient Criteria: Tidal Creeks - Letter Memorandum.* Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

Janicki Environmental, Inc. 2011c. *Sarasota Bay Numeric Nutrient Criteria: task 3 – dissolved oxygen.* Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

MacDonald, T.C., E. Weather, P.W. Stevens, and R.H. McMichael, Jr. 2010. *Nekton of Sarasota Bay and a comparison of Nekton community structure in adjacent Southwest Florida estuaries.* Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute. St. Petersburg, Florida.

Mallin, M.A., D.C. Parsons, V.L. Johnson, M.R. McIver, and H.A. CoVan. 2004. *Nutrient limitation and algal blooms in urbanizing tidal creeks.* Journal of Experimental Marine Biology and Ecology. 298:211–231.

Manatee County. 2012. Ambient surface water data. Department of Air/Watershed Management. Bradenton, FL.

Serviss, G.M. and S. Sauers. 2003. *Sarasota Bay juvenile fisheries habitat assessment*. Prepared for Sarasota Bay National Estuary Program. Sarasota, Florida.

Ray, D. 1999. Ecological and morphological significance of old growth deadhead logs in The Blackwater River. Florida Department of Environmental Protection, NWD Unpublished Report.

Sarasota County. 2011. Tidal Creek Index Data for 2008–2010. Department of Natural Resources. Sarasota, FL.

Sarasota County. 2012. Ambient surface water quality data. Department of Natural Resources. Sarasota, FL.

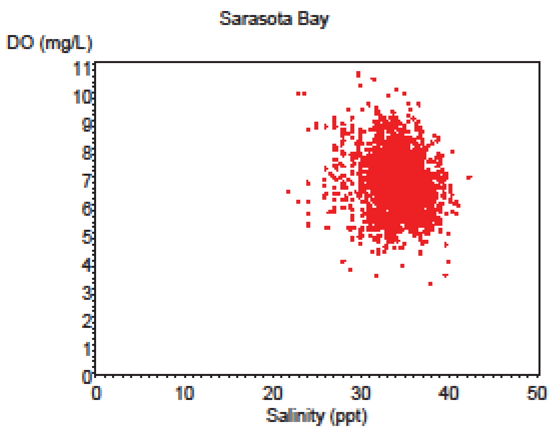
Sherwood, E.T. ed. 2008. *Tampa Bay Tidal Tributary Habitat Initiative Project: final report and management recommendations.* Tampa Bay Estuary Program Technical Report 02-08. Report to the Pinellas County Environmental Fund. Tampa Bay Estuary Program, St. Petersburg, FL. 83 pp.

Southwest Florida Water Management District (SWFWMD). 2011. Seagrass coverage for 1950, 1988, 1994, 2001, 2004, 2006, 2008, and 2010. Geographic Information System library. Brooksville, FL.

U.S. Environmental Protection Agency (EPA). 2010. Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters. Washington, D.C.

ATTACHMENT 1

BIVARIATE PLOTS OF DO VERSUS TN, TP, TEMPERATURE, TIME OF DAY, SALINITY, CONDUCTIVITY, CHLOROPHYLL *A*, TN LOADS, TP LOADS, AND BOD LOADS FOR SARASOTA BAY AND SARASOTA COUNTY TRIBUTARIES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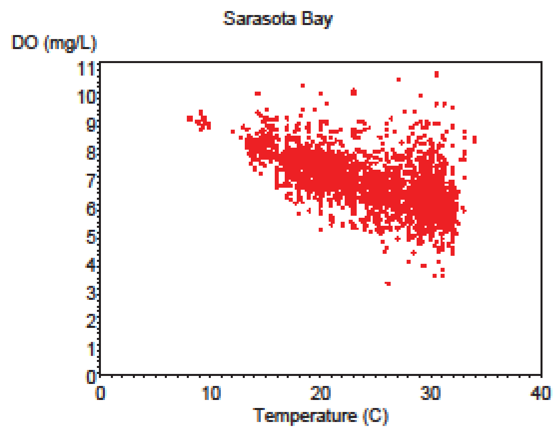
0 10 20 30 40 50
Salinity (ppt)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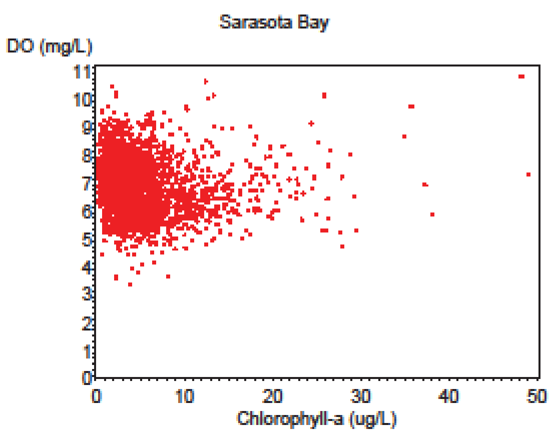
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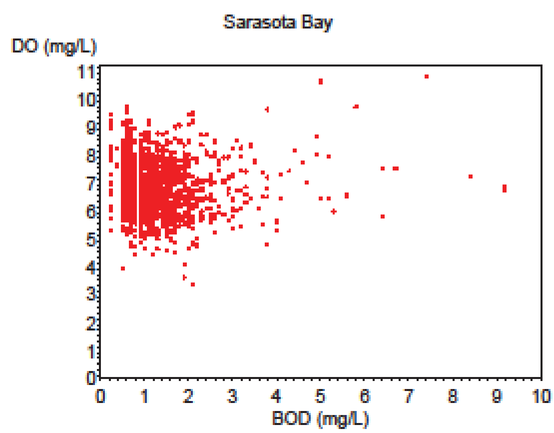
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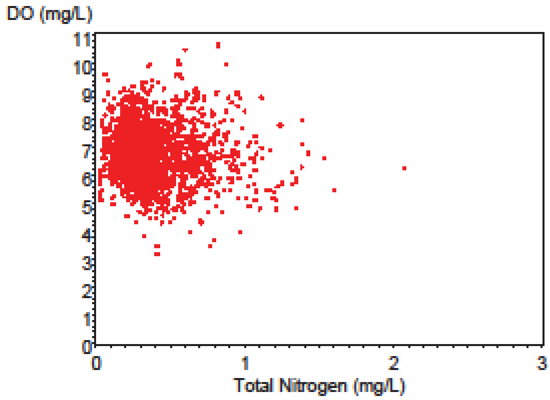
0 1 2 3 4 5 6 7 8 9 10
BOD (mg/L)

Sarasota Bay



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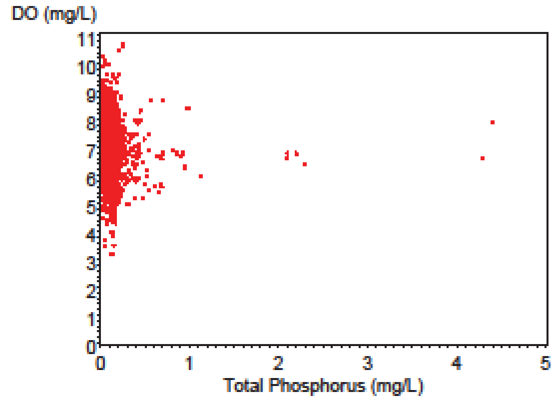

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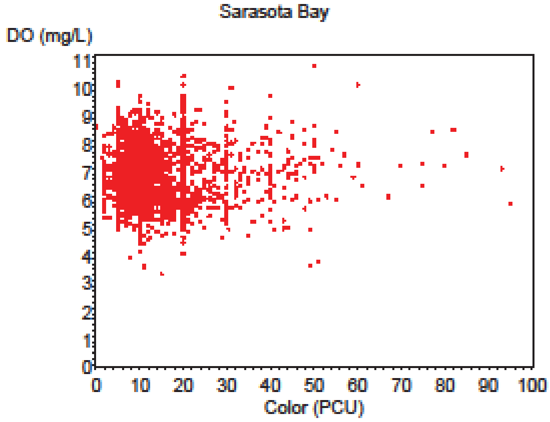

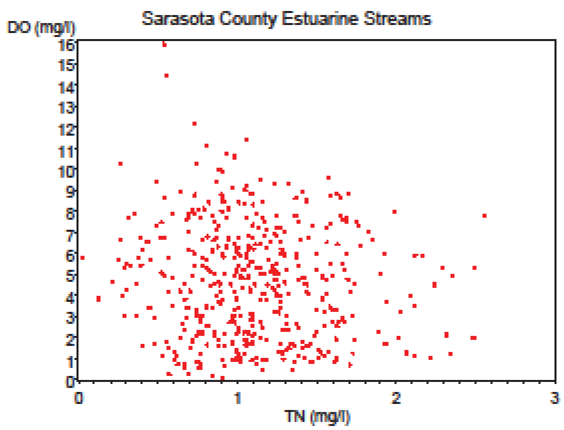
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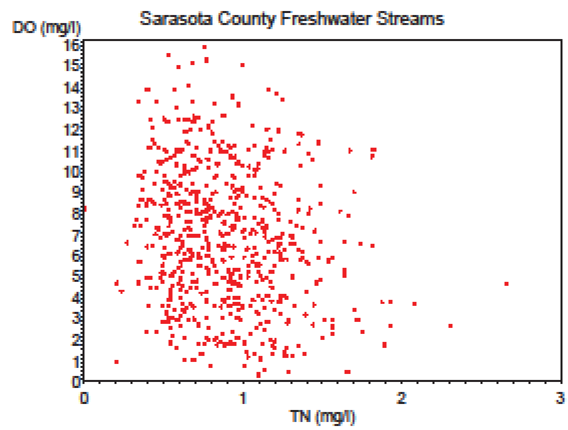
DO (mg/l)
TN (mg/l)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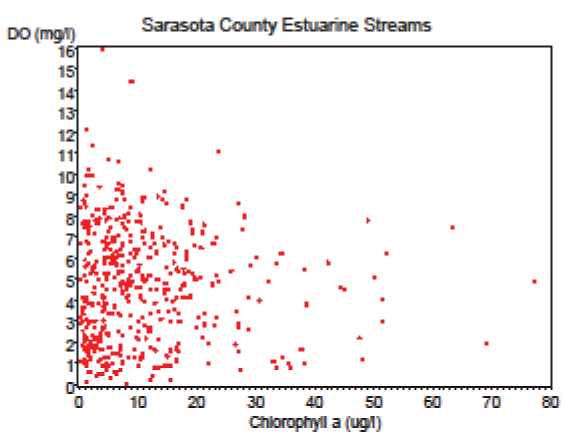
TN (mg/l)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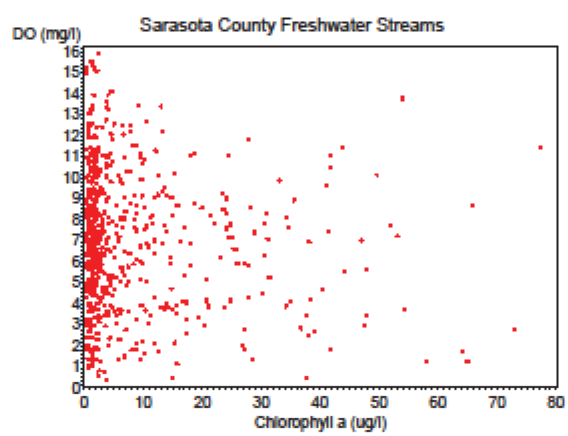
Chlorophyll a (ug/l)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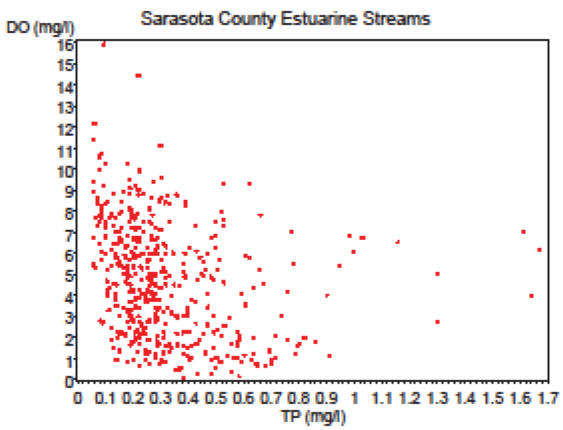
Chlorophyll a (ug/l)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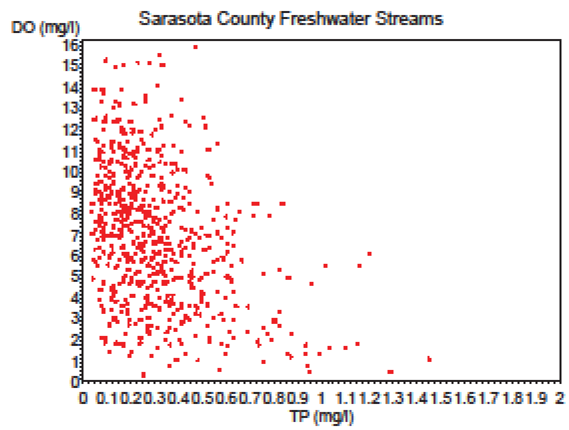
TP (mg/l)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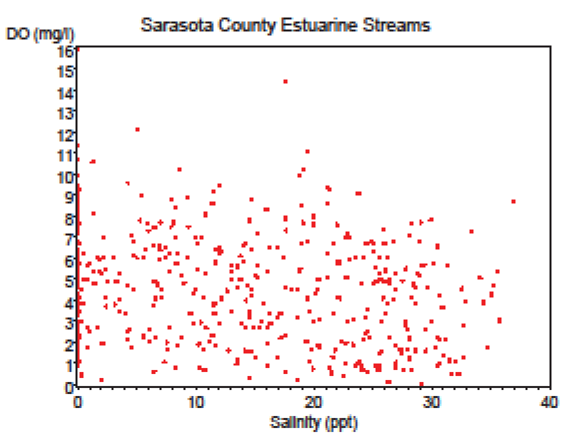
TP (mg/l)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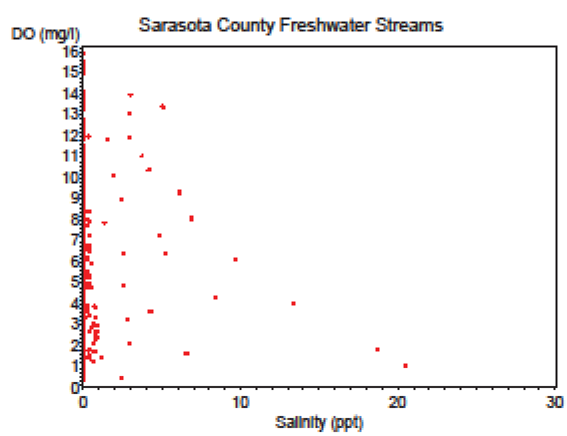
Salinity (ppt)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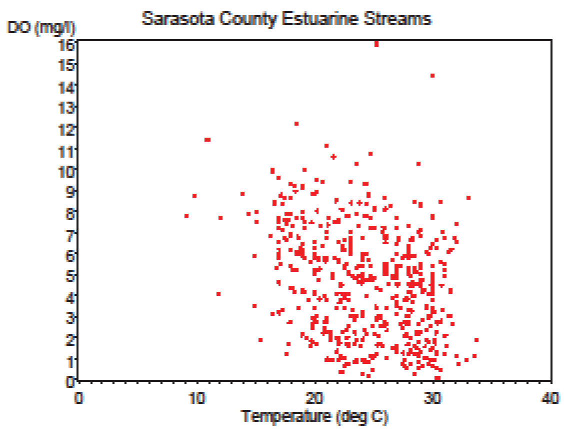
Salinity (ppt)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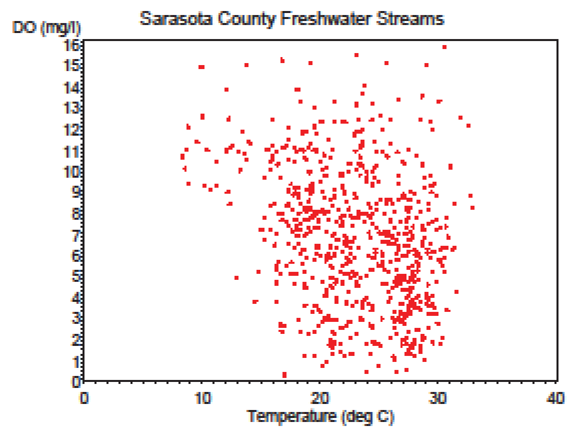
Temperature (deg C)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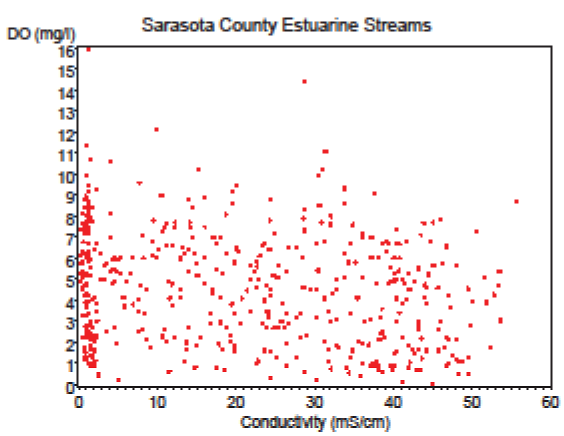
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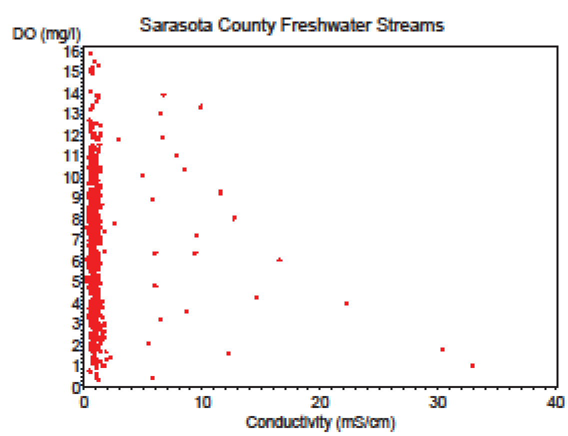
DO (mg/l)
Conductivity (mS/cm)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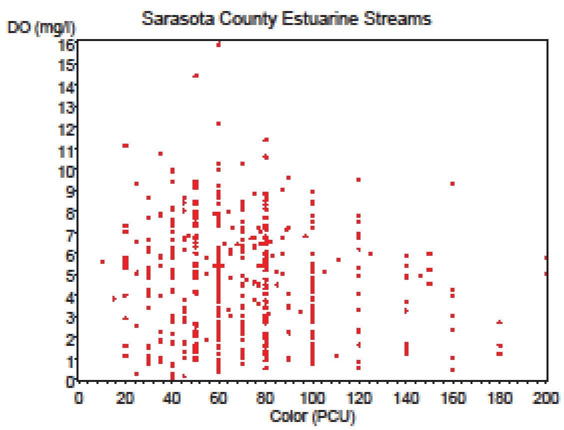
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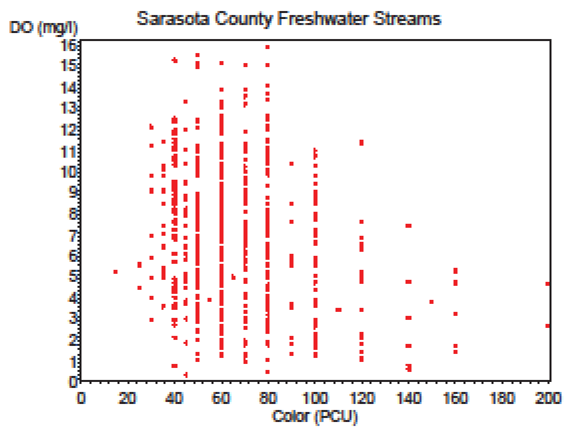
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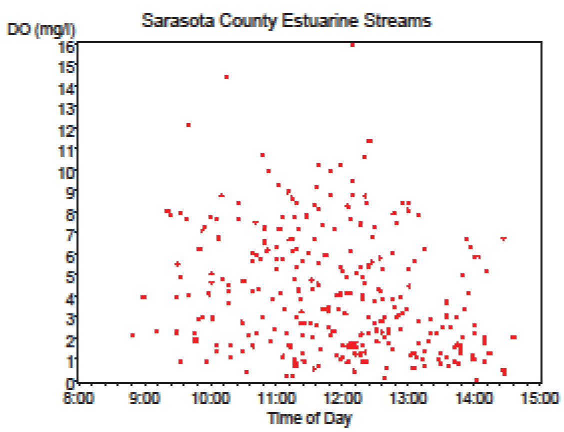
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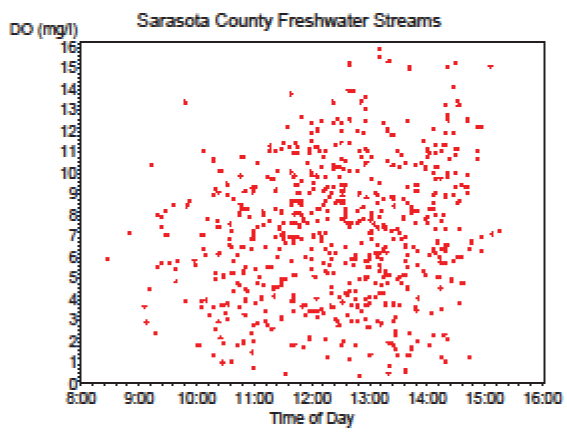
DO (mg/l)
Time of Day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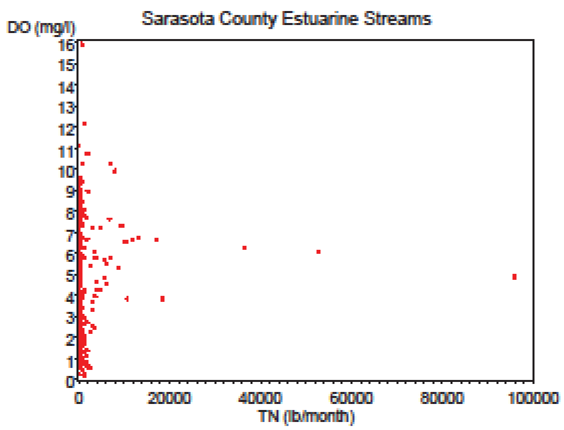
Time of Day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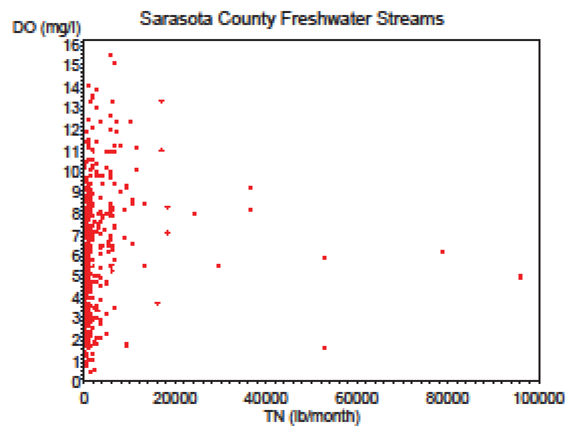
DO (mg/l)
TN (lb/month)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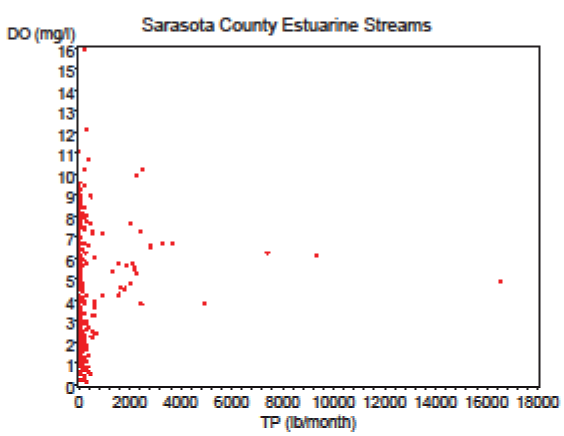
DO (mg/l)
TN (lb/month)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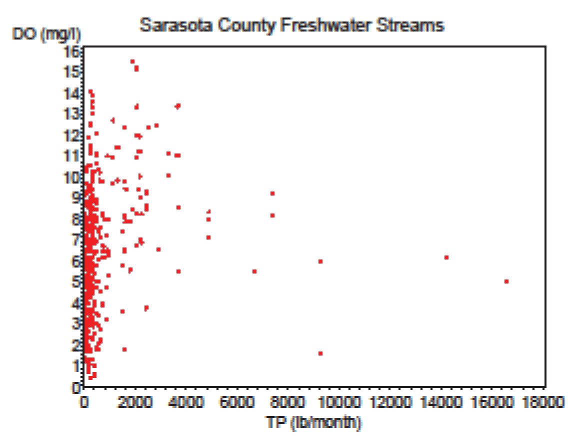
DO (mg/l)
TP (lb/month)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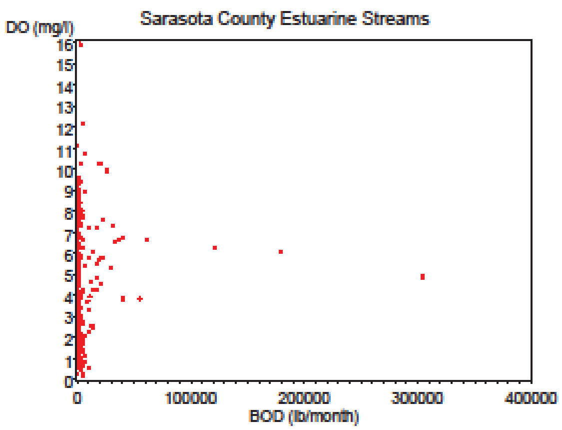
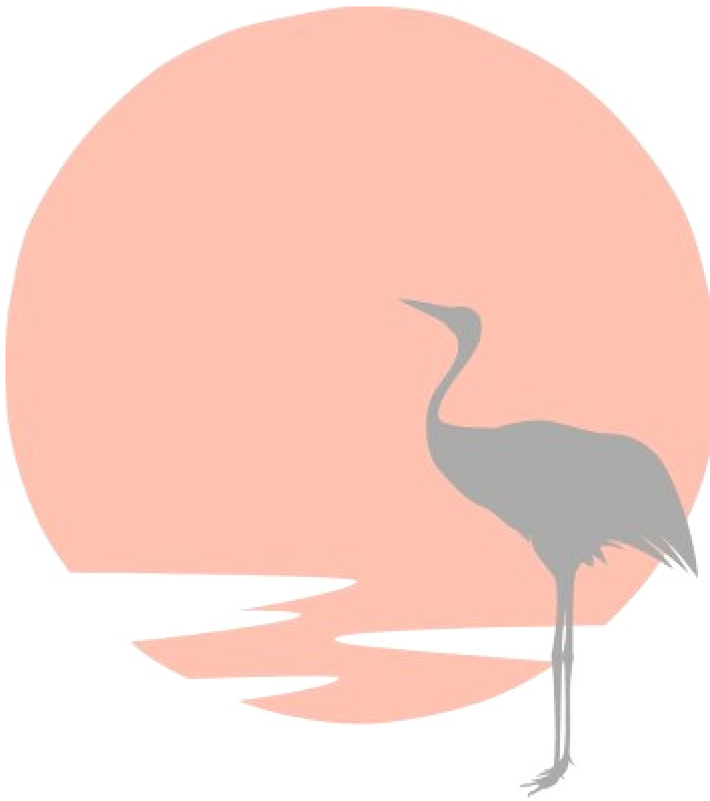
DO (mg/l)
TP (lb/month)


Sarasota County Estuarine Streams
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
0
100000
200000
300000
400000
BOD (lb/month)

Appendix D

Natural Systems

Appendix D
Natural Systems



December 2012

Sarasota County
Southwest Florida Water Management District
Jones Edmunds
Janicki Environmental, Inc.

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1.0 INTRODUCTION

1.1 WHAT ARE NATURAL SYSTEMS?

Natural systems are self-sustaining living ecosystems that include wetlands, streams, seagrass beds, and upland vegetation communities that support an interdependent network of aquatic, wetland-dependent, and upland living resources. In a natural system, plants and animals interact with physical and chemical elements such as water resources, soil, and nutrients.

Natural systems provide many valuable ecosystem services, including flood control, water quality improvement, habitat for plants and animals, and passive recreation. The natural systems of Sarasota Bay and its watershed are based on complex interactions and interrelationships among natural processes such as hydrology, nutrient loading, erosion and sedimentation, and vegetation coverage. The interactions between upland, wetland, stream, and estuarine natural systems are critical to the overall health of Sarasota Bay and its watershed. Upland and wetland areas control the quality as well as the timing and volume of freshwater flows to surface water drainage systems and the estuary. Although these flows provide the bay with essential freshwater, they also contain sediment, nutrients, and other pollutants that can be damaging to the bay.

1.2 DOES THE SARASOTA BAY WATERSHED HAVE NATURAL SYSTEMS?

There are upland, wetland, stream, and estuarine natural systems in the watershed.

While the Sarasota Bay watershed still contains some beneficial upland, wetland, stream, and estuarine natural systems, the effects of urbanization and other land development have diminished their abundance, diversity, and beneficial functions. Approximately 16% of the watershed is comprised of undeveloped upland habitats and freshwater and estuarine (mangroves and saltmarsh) wetland natural systems, but only a fraction of these natural systems is in public ownership. As a result, the protection of the benefits provided by these remaining natural systems is even more essential.

A key component of this Water Quality Management Plan (WQMP) is to recognize the remaining natural systems throughout the Sarasota Bay watershed and to protect their vital components and functions to continue to protect the Bay. The following sections present background information and trends for critical estuarine and freshwater natural systems. In addition, recommended natural system habitat improvement sites and level of service analyses are presented.

2.0 CRITICAL ESTUARINE NATURAL RESOURCES

2.1 INTRODUCTION

Estuaries are highly productive natural systems that provide vital habitat for many species of fishes, birds, invertebrates, and plants. Supporting the biodiversity of estuaries is paramount to maintaining estuarine food webs. Natural estuarine systems such as seagrasses, emergent vegetation, oyster reefs, and sediment processes all play an important role in dynamic estuarine food webs.

Sarasota Bay is a lagoonal estuarine system bounded by the peninsular Florida mainland to the east and barrier islands to the west. The Sarasota Bay system, as defined by the Sarasota Bay Estuary Program (SBEP), encompasses all coastal waters from south of Palma Sola Bay in the north to just north of Venice Inlet to the south and includes, from north to south, Sarasota Bay, Roberts Bay North, Little Sarasota Bay, and Blackburn Bay. This document addresses natural estuarine systems in Sarasota Bay only.

Relative to other bay segments in the Sarasota Bay estuarine system, Sarasota Bay proper has a low watershed (land): estuary (saltwater) area ratio. As a result, conditions in Sarasota Bay are largely affected by interactions with the Gulf of Mexico.

An in-depth characterization of the physical features of the Sarasota Bay watershed and estuary is presented in this section, including the following natural resources/habitats:

- Seagrass
- Shorelines
- Emergent vegetation
- Sediment and benthos
- Oysters
- Scallops
- Fish
- Tidal creeks

The following background information and analysis are presented for each Sarasota Bay resources/habitats:

- Resource summary and its ecological function
- Existing regulations
- Literature review or trend analysis

2.2 SEAGRASS

2.2.1 The Resource and Its Functions

Seagrasses are a fundamental component of the ecological structure of most Florida estuaries. Seagrasses provide numerous benefits including stabilizing sediments, providing refuge for juvenile fishes and invertebrates, and serving as a food source for manatee and sea turtles. In addition, microscopic algae (epiphytes) that grow on seagrass blades support a diverse community of grazing organisms. Decaying seagrasses contribute organic material to the food web that plays an important role in the transfer of energy in the various strata of estuarine and coastal biological communities. Seagrasses support a diverse and productive macroinvertebrate community that lives in and around seagrass meadows and in the surrounding sediments. These organisms are an important food resource for higher trophic levels.

Seagrasses are also important and accurate indicators of the ecological health of an estuary. The spatial extent of seagrass growth is limited by light penetration in the water column. Like other plants, seagrasses need a minimum level of light to survive. High nutrient levels in water can cause increases in algal growth that can decrease light penetration in the water column. The following sections present existing seagrass regulations and examine historical and current seagrass extents. Also, the spatial longevity of seagrasses (persistence) was examined and areas with different persistence characteristics were identified.

2.2.2 Existing Regulations for Resource Protection

The following regulations address the protection of seagrasses. There are several elements of a comprehensive seagrass protection strategy, including prohibiting dredging and filling in submerged lands, restricting motor boat traffic in seagrass areas to reduce propeller scarring, protecting water clarity, and providing public education. Local, state, and federal rules are included as appropriate.

2.2.2.1 Sarasota County

❖ Sarasota County Comprehensive Plan Chapter 2 – Environment: Management Guidelines for seagrass protection

- Preserve the remaining seagrass beds in Sarasota County.
- Prohibit dredging of seagrass beds except to maintain existing previously permitted or grandfathered drainage canals, man-made canals and basins, and navigation channels as authorized by County Codes.
- Prohibit filling.
- Develop and implement restrictions on stormwater discharge.

- Monitor the conditions of marine grass beds and restrict power boat traffic in areas where propellers and wakes are found to cause significant disruption.
- Enhance water quality to encourage the re-establishment and proliferation of seagrass bed habitat.
- Increase public awareness, especially boaters, to the sensitivity and importance of this habitat through public education.
- Submit a resource management plan for perpetually protected areas, based on best available technology, for review and approval by the County prior to or concurrent with the preliminary plan or site and development plan development review process.

❖ County Code of Ordinances, Chapter 54 Environment and Natural Resources

- Article XX. – Water and Navigation Control Authority

  - ➢ This article provides regulation and control of altering jurisdictional areas and the repair and construction of associated water-dependent structures such as docks, piers, davits, shoreline protection structures; the preservation of the natural beauty and attractiveness of the jurisdictional areas; and assistance to boating activities and navigation.

- Article VII. – Water Pollution Control

  - ➢ This article provides for the control of the water pollution in the streams, bays, lakes, estuaries, gulf, or underground waters and safeguards the peace, health, safety, and welfare of human, animal, marine, and plant life within Sarasota County against water pollution caused by or resulting from any toxic, poisonous, or noxious substances, raw or inadequately treated sewage, or any combination thereof.

- Article XXXII. – Fertilizer and Landscape Management

  - ➢ This article regulates the proper use of fertilizers by any applicator by requiring proper training of commercial and institutional fertilizer applicators and by establishing a restricted season, fertilizer content and application rates, fertilizer-free zones, low maintenance zones, exemptions, training, and licensing requirements. The ordinance requires the use of best management practices that provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers.

2.2.2.2 Florida Department of Environmental Protection (FDEP)

❖ Environmental Resource Permit (ERP) Program

- The Environmental Resource Permit (ERP) program regulates activities involving the alteration of surface water flows and dredging and filling in wetlands and other surface waters. The ERP program is implemented under Part IV of Chapter 373 of the Florida Statutes (FS), is in effect statewide, and is implemented jointly by FDEP and the five water management districts.

- The ERP program operates *in addition to* the federal program that regulates activities in waters of the United States. All state, local, and regional governments in Florida delineate wetlands in accordance with state methodology (Chapter 62-340, FAC) instead of the federal method. A joint ERP permit application is used with the U.S. Army Corps of Engineers (USACE). USACE reviews the ERP application pursuant Section 401 of the Clean Water Act, which enables the USACE to take separate action to issue or deny any needed federal permit under Section 404 of the Clean Water Act.

- In addition to the *regulatory* permit programs above, activities on submerged lands owned by the State of Florida, otherwise called state-owned, or sovereign, submerged lands (SSL). also require a *proprietary* authorization for such use under Chapter 253, FS, and Chapter 18-21, FAC. Such lands generally extend waterward from the mean high water line (of tidal waters) or the ordinary high water line (of fresh waters).

- Surface Water Quality Standards
  FDEP, as authorized by the federal Clean Water Act, is responsible for reviewing, establishing, and revising water quality standards. Florida's surface water quality standards system is published in Chapters 62-302 and 62-302.530, FAC. The components of this system include classifications, criteria, including site specific criteria, an anti-degradation policy, and special protection of certain waters (Outstanding Florida Waters). FDEP has recently been developing biological criteria and numeric nutrient criteria for estuaries.

- Total Maximum daily Load (TMDL) Program—A TMDL is a scientific determination of the maximum amount of a given pollutant that a surface water can absorb and still meet the water quality standards that protect human health and aquatic life. Water bodies that do not meet water quality standards are identified as "impaired" for the particular pollutants of concern. TMDLs must be developed for impaired water bodies based on criteria listed in Chapter 62-304, FAC (the Impaired Waters Rule) for those pollutants to reduce pollutant concentrations to meet state water quality standards.

2.2.2.3 Florida Fish and Wildlife Conservation Commission (FWCC)

❖ Chapter 68, Florida Administrative Code

- Section D – Boating Regulations – Seagrass awareness guidelines for public education.

- The FWCC also may object to issuing an ERP or wetland resource permit under Florida's Approved Coastal Zone Management Act coordination process. FDEP and the water management districts do not rely on, but will also consider, comments from the federal resources agencies (U.S. Fish and Wildlife Service and the National Marine Fisheries).

2.2.3 Trend Analysis

2.2.3.1 Methods

Data from the following monitoring programs and other sources were used for this analysis:

❖ Seagrass monitoring program conducted by Southwest Florida Water Management District (SWFWMD): mapping surveys (1988 through 2010).

❖ Photo-interpretation of 1948 aerial photographs for historical coverage (Photo Science, 2007).

A digitized seagrass coverage (SWFWMD, 2010) for current conditions (2010) was reviewed. Historical (1948) seagrass coverage mapped by Photo Science (2007) was also reviewed, and the two coverages were visually compared. Areas exhibiting differing durations of seagrass survival were identified.

As part of a previous effort to define water clarity targets for Sarasota County estuarine waters, Wessel et al. (2007) created a cartographic grid cell system for Sarasota County estuarine waters using 45-meter (m)-square cells. The grid was overlaid on all SWFWMD seagrass coverages taken since 1988. This allowed the presence (≥50%) or absence of seagrass within each grid cell to be documented by survey year. The persistence of seagrass within each cell could then be characterized by the number of years in which seagrass was present in a particular grid cell.

2.2.3.2 Results and Discussion

SWFWMD has performed aerial seagrass mapping surveys approximately biennially since 1988. Mapping occurred using photography taken in 1988, 1994, 1996, 1999, 2001, 2004, 2006, 2008, and 2010. The results of the most recent (2010) mapping efforts indicate that seagrass coverage in Sarasota Bay is 9,917 acres (Figure 2-1). The extent of seagrass digitized from 1948 aerials (7,557 acres) is shown in Figure 2-2. The resolution and clarity of the circa 1950 aerial photographs are less than that of more recent efforts. Thus, current accuracy in mapping using the older photos should not be expected. However, the historical seagrass extent shown in Figure 2-2 appears reasonable, especially in shallower waters.

Seagrass persistence in Sarasota Bay is presented in Figure 2-3. Based on this analysis, Sarasota Bay appears to be somewhat unstable with respect to seagrass persistence over time relative to other segments in Sarasota County. A large proportion of the total seagrass acreage occurred in only one survey year (though not necessarily the same year), as shown in Figure 2-4. These areas tend to be the deeper edges of the seagrass beds, which are considered frontiers for colonization and more heavily depend on water clarity. However, over 30% of the cells had seagrass present for all 10 survey years. Seagrass persistence is greatest in shallower areas.

Despite the lack of persistence, the estimated acreage in 2010 (9,917 acres) was 31% higher than that estimated from historical photographs (7,557 acres). The reason for the increase over time is not known but could reflect improved water clarity and quality. The improved water clarity and quality observed within Sarasota Bay are likely a result of improvements to the wastewater treatment system and expansion of the service area, as well as stormwater regulations and low impact development retrofits/improvements that have been made.

As previously mentioned, seagrasses are a critical component of estuaries such as Sarasota Bay and are important and useful indicators of the ecological health of an estuary. The recovery and positive seagrass coverage trends observed in Sarasota Bay are a true ecological success story. Continuing water quality improvement programs and projects, seagrass mapping, public education, and natural resource protection efforts by the County, the SBEP, and other stakeholders are critical to ensure that this trend continues.

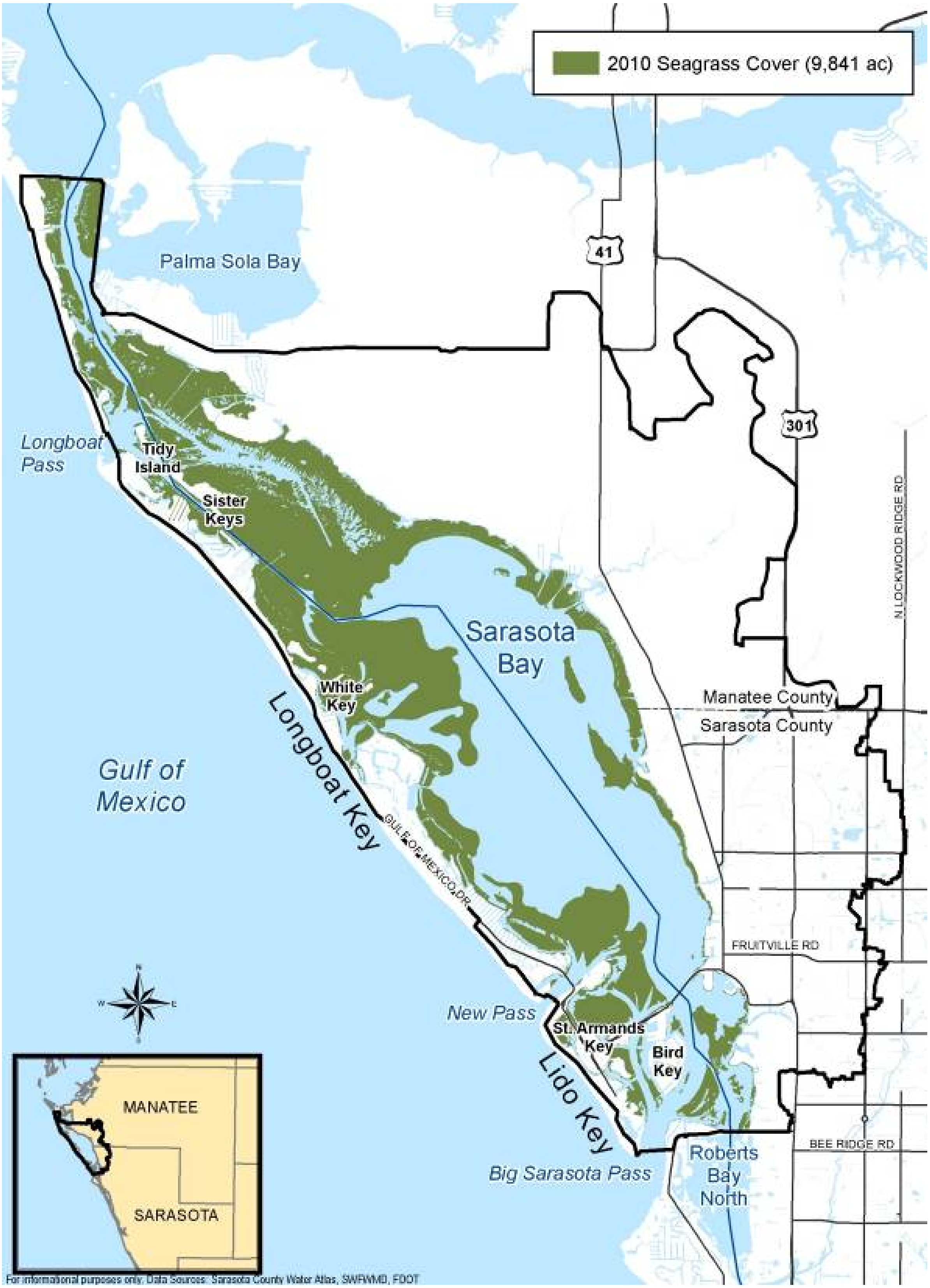


Figure 2-1 2010 Seagrass Coverage in Sarasota Bay

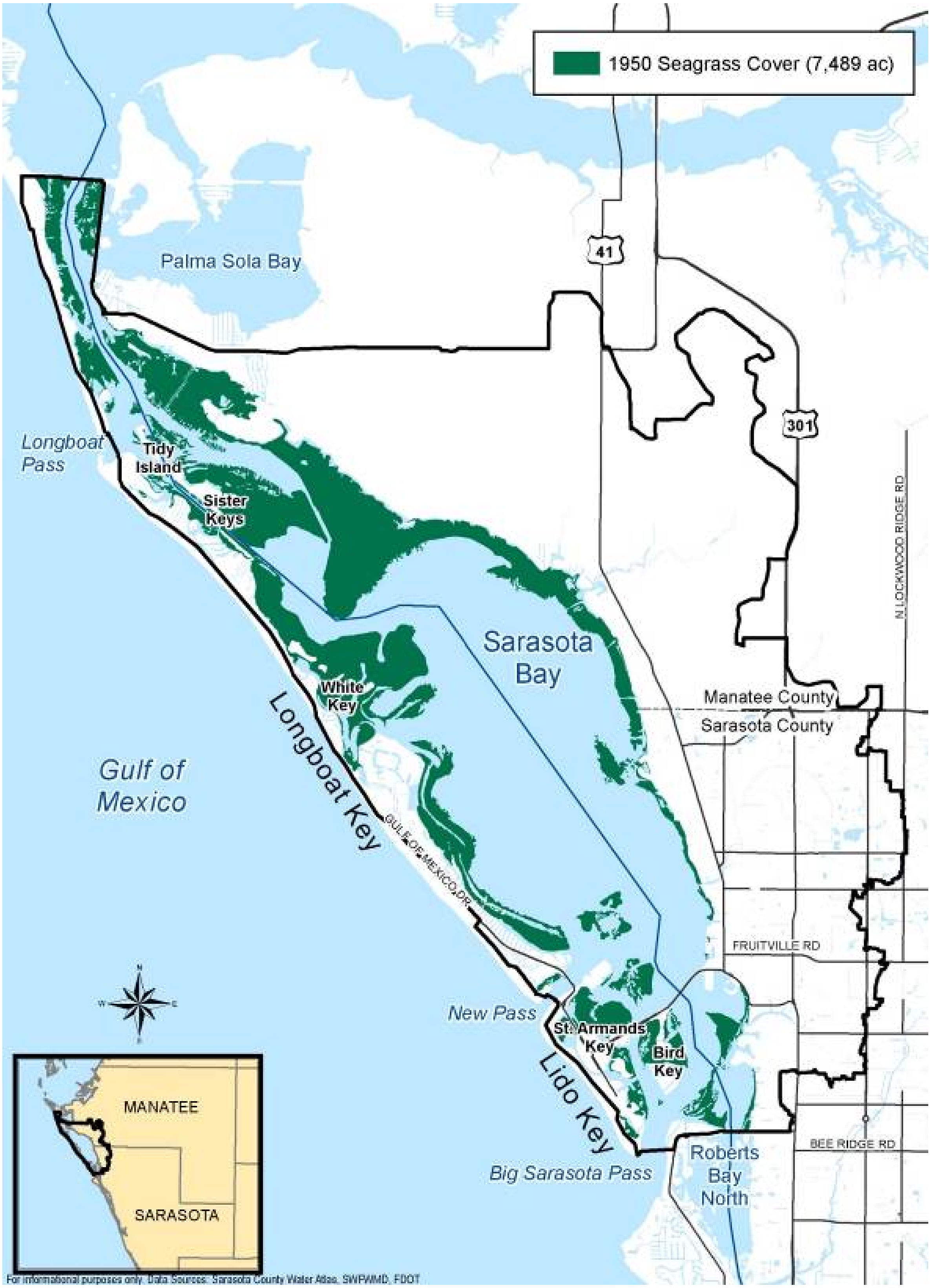


Figure 2-2 Circa 1950 Seagrass Coverage in Sarasota Bay

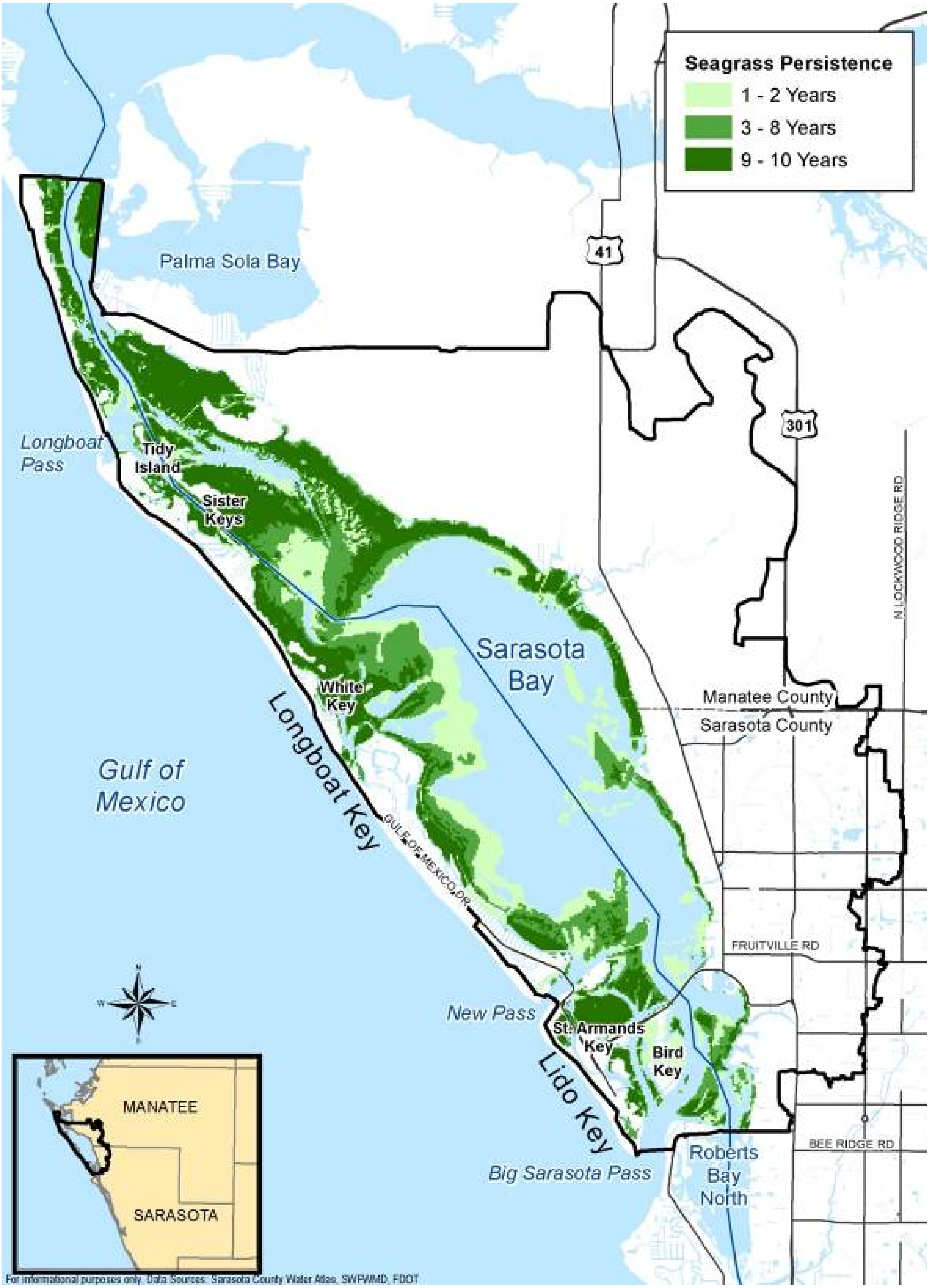


Figure 2-3 Seagrass Persistence in Sarasota Bay

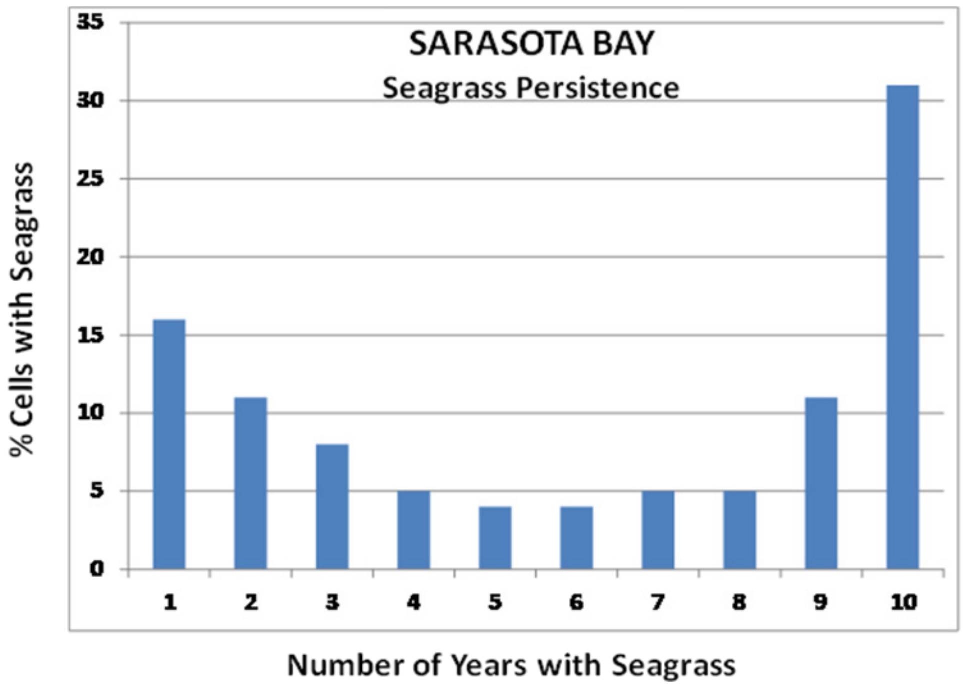


Figure 2-4 Number of Grid Cells in Figure 2-2 Corresponding to Persistence Rankings of Seagrass in Sarasota Bay

2.3 SHORELINE

2.3.1 The Resource and Its Functions

The Sarasota Bay shoreline is not only the boundary of the estuary and the watershed, but plays an important role in the ecology of the system. Shorelines define the land-water interface and are ecological transition zones between terrestrial and aquatic life. Shorelines include a littoral zone where diverse habitat types affect the organization of floral and faunal assemblages and the interactions between terrestrial and aquatic plants and animals. Littoral zones are especially important in tidal water bodies.

Shoreline morphology affects physical, chemical, and biological processes that determine water quality and biotic community diversity and composition. A wide range of natural shoreline types occur regionally, including mangrove forest, mud flats, and salt grass marshes. The greatest differentiator in shoreline function is whether it retains natural functions, often called a “soft” shoreline, or has been fundamentally altered by the removal of vegetation and construction of seawalls or rip rap, known as “hardened” shorelines.

Human activities including mechanical dredging and filling and depositing channel spoil material have significantly altered Sarasota Bay’s shorelines since population began growing along the coast in the 1920s. Shoreline hardening in Florida usually consists of vertical concrete seawalls or bulkheads composed of concrete or rock rubble (i.e., riprap). The main purposes of shoreline hardening were to delineate the extent of developable land, increase accessibility to coastal waters for recreation, and provide physical stability to the new waterfront uplands. Shoreline alterations have had widespread effects on Florida's coastal resources. Sarasota Bay is a prime example of the impacts of human development on coastal lands in Florida. The following section presents existing shoreline regulations and methods and results of a trend analysis between the lengths of hardened and natural shoreline under historical (circa 1950) and current (2010) conditions.

2.3.2 Existing Regulations for Resource Protection

The following regulations address the protection of natural and non-hardened shorelines. Alternatives to hardening shorelines (for example with seawalls) include using vegetation buffers or stone rip rap. Local, state, and federal rules are included as appropriate.

Regulations specific to natural shoreline protection are presented below. Many existing laws and policies that protect seagrasses such as County policies, the FDEP ERP program, and mangrove trimming rules (discussed in 2.2.2) also protect natural shoreline protection and are not repeated here.

- ❖ Sarasota County Comprehensive Plan Chapter 2 – Environment

  - Environmental Policy 1.1.2.: Prohibit hardening of Gulf beaches or passes unless such hardening has been found to be in the public interest.

  - Environmental Policy 4.2.1.: Use the County's regulatory authority to encourage shoreline softening rather than shoreline hardening practices. Where practical, shoreline planting and enhancement projects shall be required during development orders proposing shoreline hardening in accordance with Policy 2.2.3. Require effective vegetative buffer zones for all new construction adjacent to watercourses, wetlands, and bays.

2.3.3 Trend Analysis

2.3.3.1 Methods

Several datasets that include a linear shoreline were reviewed for this analysis:

- ❖ Current monitoring program that addresses changes in the shoreline includes the periodic land use mapping and conducted by SWFWMD. Since 1996, SWFWMD's biannual seagrass mapping also notes changes in shoreline features.

- 1944 digitized US Geological Survey (USGS) 1:24,000, 7.5-minute quadrangle maps.
- 1948 US Department of Agriculture aerial photographs.
- 2010 shoreline GIS coverage obtained from SWFWMD seagrass mapping program.
- 2008 aerial photography obtained from SWFWMD.
- Sarasota Bay Estuary Program (SBEP) shoreline inventory (Serviss and Sauers, 2003).

After these datasets were reviewed, the 2010 SWFWMD seagrass mapping shoreline was used as a baseline and modified to reflect historical shoreline conditions. This current shoreline was overlain on 1948 aerial photographs using GIS (ArcGIS9.1), and pre-alteration conditions to the shoreline were identified and digitized, replacing portions of the current coverage shoreline. The photographs were used as the primary data source, and the quadrangle sheets were used to verify areas identified as mangrove or other natural habitat. Because major dredge-and-fill and navigation channel projects had been conducted in Sarasota Bay since the early 20th century, significant alterations had already occurred to many parts of the coastline by the late 1940s. Although the resolution and clarity of the historical photographs are less than of current photos, this was the best available information to use for this analysis.

Existing shorelines were characterized using the 2010 shoreline GIS coverage overlain on the 2008 aerial photographs. GIS was used to differentiate and delineate hardened shoreline. Hardened, or modified, shoreline was defined as shoreline with seawall or riprap exposed to the open water. In many areas a solid mangrove fringe area waterward of the hardened structure was classified as soft, or natural, because although shoreline structures had been constructed, the mangrove fringe provides many of the benefits of truly natural shorelines such as structural habitat, nursery areas for fauna, sediment stability, and reduction in erosion caused by wind-driven waves and boat wakes.

To assess the degree to which the Sarasota Bay shoreline has been modified by human activities, the extents of hard and soft shorelines around Sarasota Bay were inventoried. Shoreline conditions for a historical period were examined and compared to current conditions.

2.3.3.2 Results and Discussion

A previous shoreline inventory identified juvenile fish habitat within the SBEP study area (Serviss and Sauers, 2003). This dataset was based on an analysis of composite aerial photography taken between 1998 and 2001 and was used to corroborate the new delineation.

The extent of hardened and natural shoreline in 1948 was overlain on 1944 quadrangle sheets and is shown in Figure 2-5, Figure 2-6, and Figure 2-7. Based on the analysis above, in 1948 Sarasota Bay had approximately 150 kilometers (km) of shoreline, 37% of which was hardened.

Figure 2-5 1948 Quad Map of Sarasota Bay with 1948 Hardened and Natural Shoreline Shown (North Area)

Figure 2-6 1948 Quad Map of Sarasota Bay with 1948 Hardened and Natural Shoreline Shown (Central Area)

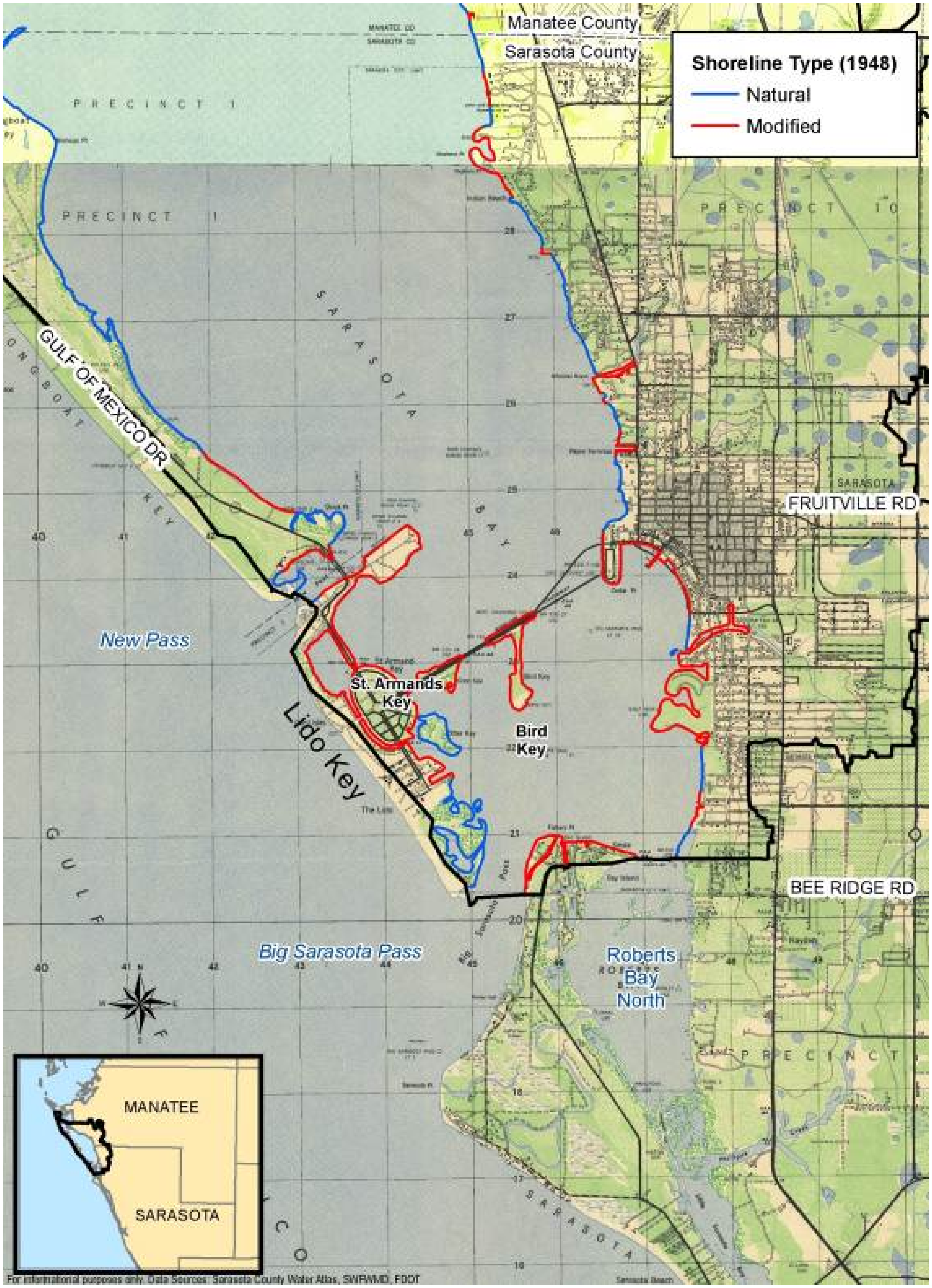


Figure 2-7 1948 Quad Map of Sarasota Bay with 1948 Hardened and Natural Shoreline Shown (South Area)

The areas with the most significant modification included the mainland in the City of Sarasota downtown waterfront as well as the barrier islands south of Longboat Key. Bird Key, St. Armands Key, Coon Key, City Island, and Bay Island were all products of early dredge-and-fill operations. Other areas along the mainland shoreline had also been modified by the late 1940s, as had the village of Cortez to the north, the north end of Longboat Key, and Anna Maria Island.

By 2008 the bay had 242 km of total shoreline, an increase of over 60%. The additional shoreline is mainly dredge-and-fill canals but is also due to the emergence of numerous mangrove islands in the bay. Substantial shoreline hardening had taken place as well, increasing by over 150% to 138 km. Hardened shoreline expanded significantly along the mainland coast north to the Whitfield area and the Sarasota-Manatee County boundary. Another area of post-1950 shoreline modification was central and south Longboat Key. The extent of hardened shoreline in 2008, overlain on current quadrangle sheets, is shown in Figure 2-8, Figure 2-9, and Figure 2-10.

Despite the extensive shoreline modifications that have occurred in Sarasota Bay, management actions can preclude future impacts to coastal resources. Management actions should encourage avoiding hardening the shoreline with seawalls, riprap, and other structures and instead promote natural vegetated intertidal buffers that stabilize shoreline sediments and create habitats for fish and wildlife. Where seawalls and bulkheads exist, native vegetation can be planted seaward of structures to reduce the wave energy and provide habitat. Exotic vegetation can be removed and replaced with native plants. Additionally, oyster bars can be colonized waterward of structures to provide similar benefits.

2.4 EMERGENT VEGETATION

2.4.1 The Resource and Its Function

This section summarizes the value and physical extent of emergent vegetation, including mangroves, in the Sarasota Bay estuary. Estuaries are often fringed by marshes and, in tropical and subtropical latitudes, mangroves. This emergent vegetation helps stabilize shorelines; reduces erosion; provides nursery and protective habitat; and can sequester sediments, nutrients, and contaminants that enter the estuary from precipitation and runoff. Mangroves provide habitat for animals that favor estuarine/marine muddy intertidal habitats as well as animals found in terrestrial woodlands (Hutchings and Saenger, 1987). Based on measurements of plant biomass and litter (particularly fallen leaves and woody material), mangroves can be highly productive. The litter supports a detritus-based community in the mangrove forest itself and by its export to estuarine and coastal environments (Odum et al., 1982; Hutchings and Saenger, 1987). Emergent vegetation in disturbed areas also may include exotic species that in some cases out-compete native plants. Brazilian pepper is a prime example of this invasive plant growth.

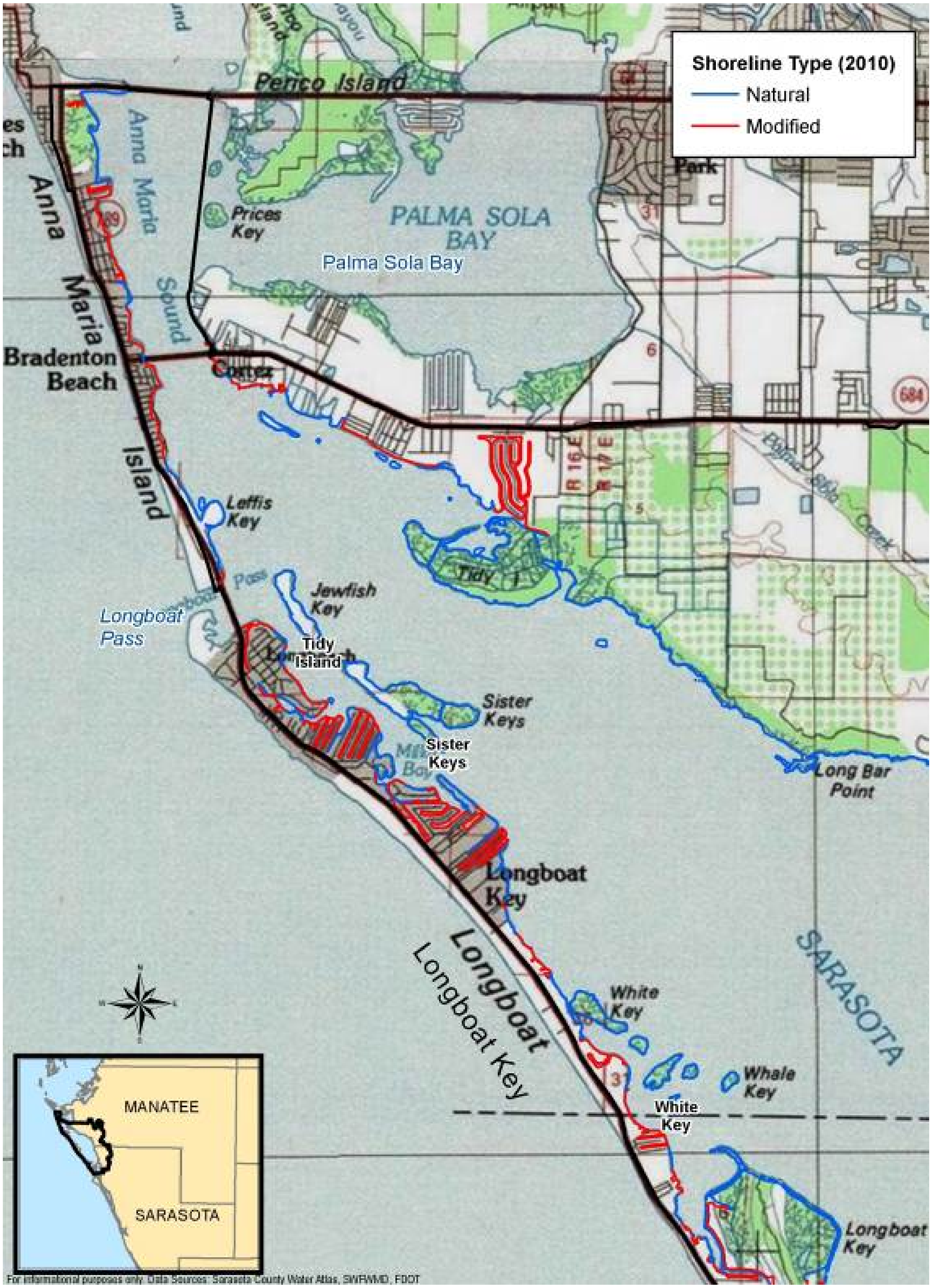


Figure 2-8 Composite Current Quad Map of Sarasota Bay with 2008 Hardened and Natural Shoreline Shown (North Area)

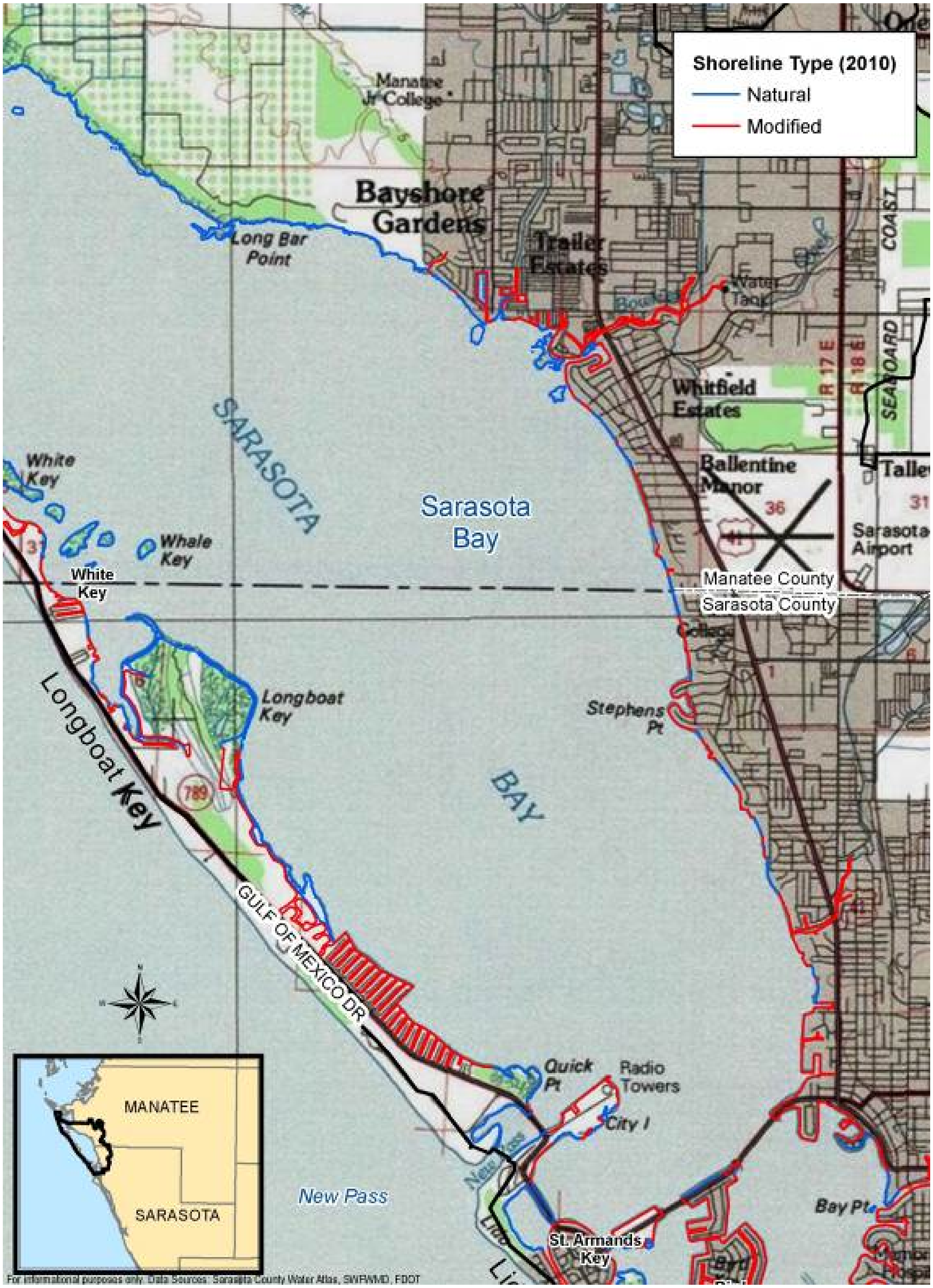


Figure 2-9 Composite Current Quad Map of Sarasota Bay with 2008 Hardened and Natural Shoreline Shown (Central Area)

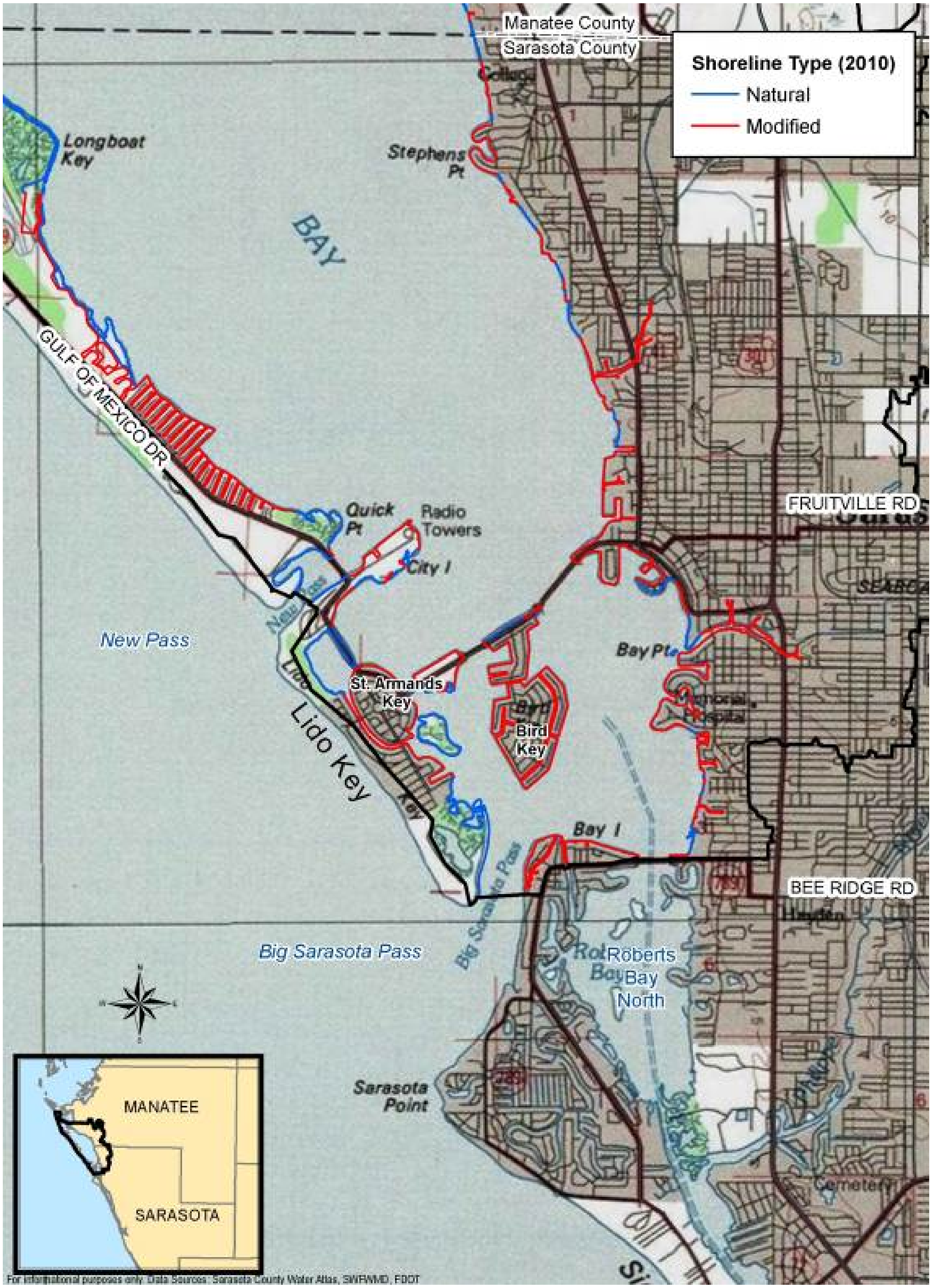


Figure 2-10 Composite Current Quad Map of Sarasota Bay with 2008 Hardened and Natural Shoreline Shown (South Area)

2.4.2 Existing Regulations for Resource Protection

The following regulations address the protection of emergent estuarine vegetation, including mangroves and tidal marshes. Vegetation can be protected by prohibiting dredging and filling in vegetated intertidal lands, protecting water quality, regulating mangrove trimming, providing public education, and requiring mitigation for unavoidable impacts. Local, state, and federal rules are included as appropriate.

Regulations specific to emergent estuarine vegetation are presented below. Many laws and policies that protect seagrasses such as County policies, the FDEP ERP program, and TMDLs (discussed for other resources) also protect mangroves and tidal marshes and are not repeated here.

2.4.2.1 Sarasota County

- Sarasota County Comprehensive Plan Chapter 2 – Environment: Management Guidelines for Mangrove Swamps

  - Mangrove swamps shall be preserved or enhanced.
  - Dredging and filling of mangrove swamps shall be strictly prohibited.
  - To the maximum extent practical or consistent with applicable ordinances, invasive and nuisance vegetation shall be removed from Mangrove Swamps.
  - Previously cleared mangrove swamps should be restored.
  - Encourage education programs oriented toward protection of this habitat.
  - Discourage shoreline hardening adjacent to mangrove swamps and promote shoreline softening through vegetation projects.
  - A resource management plan for perpetually protected areas, based on best available technology, shall be submitted for review and approval by the County prior to or concurrent with the preliminary plan or site and development plan development review process.

  - Tidal Marshes

    - Tidal marshes shall be preserved or enhanced.
    - Dredging and filling of tidal marshes shall be strictly prohibited.
    - To the maximum extent practical or consistent with applicable ordinances, invasive and nuisance vegetation shall be removed from Tidal Marshes.
    - Discourage shoreline hardening adjacent to tidal marshes and promote shoreline softening through vegetation projects.

- ➢ A resource management plan for perpetually protected areas, based on best available technology, shall be submitted for review and approval by the County prior to or concurrent with the preliminary plan or site and development plan development review process

❖ Environmental Policy 4.5.15

- The County shall protect mangroves to the fullest extent allowed by County and State law.

❖ County Code of Ordinances, Chapter 54 – Environment and Natural Resources

- Article XVIII. – Trees
  - ➢ The objective of this article is to safeguard the public health, safety, welfare, and economy through tree protection (including mangroves) and to promote the findings of this article by following the provisions contained herein.

2.4.2.2 FDEP

❖ Sections 403.9321 through 403.9333, Florida Statutes – Mangrove Trimming

- Florida implements a permitting program for trimming or altering mangroves under although mangrove trimming and alteration can be incorporated into an ERP permit.

2.4.3 Trend Analysis

2.4.3.1 Methods

Several datasets that include a linear shoreline were reviewed and used in this analysis:

- ❖ Routine monitoring and mapping of land use by SWFWMD: 2009 Florida Land Use and Cover Classification System (FLUCCS) for saltwater wetlands.
- ❖ Emergent vegetation inventory of Sarasota Bay (Serviss and Sauers, 2003).
- ❖ Shoreline Inventory for Sarasota County (Evans and Evans, 1988).
- ❖ Marine Habitat Trend Analysis Sarasota County (Mangrove Systems, 1988).
- ❖ 2006 and 2009 Mangrove Trimming Study. Sarasota County conducts annual inspections at numerous sites supporting mangroves to monitor tree-trimming activities. Although the County visits sites in Roberts Bay North, Grand Canal, Little Sarasota Bay, Blackburn Bay, Lyons, Dona, and Roberts Bays, and Lemon Bay, no active sites are in Sarasota Bay.

The extent of mangrove forests and saltmarshes in Sarasota Bay was determined by overlaying the SWFWMD's 2009 land-use dataset for saltwater wetland types on the current shoreline coverage. Additional information was obtained by reviewing a recent shoreline inventory by Serviss and Sauers (2003).

2.4.3.2 Results and Discussion

The latest survey of Sarasota Bay's mangroves was conducted as part of the SWFWMD's 2009 land-use survey. Estimates of the areal extent of mangroves based on SWFWMD's 2009 land-use dataset indicate that 937 acres of mangroves were in the bay (Figure 2-11). Most of the mangroves associated with Sarasota Bay in Sarasota County are just north of Big Pass adjoining Lido Key and Otter Key and on the southeast tip of Longboat Key. The majority of mangrove growth associated with Sarasota Bay is in Manatee County, near Tidy Island, along central and north Longboat Key, and on Anna Maria Island. SWFWMD's 2009 land-use dataset also identifies 28 acres of saltmarsh located north of Tidy Island and along the nearby coast interspersed through the mangrove fringe.

Serviss and Sauers (2003) characterized the emergent vegetation in Sarasota Bay as part of a juvenile fisheries habitat assessment for SBEP. They report that mangroves covered approximately 297,750 linear feet of shoreline in Sarasota Bay, which is equivalent to 36% of the overall shoreline length (Figure 2-12). All other vegetation types had 1% or less coverage. Almost 61% of the shoreline was reported to be unvegetated (Table 2-1).

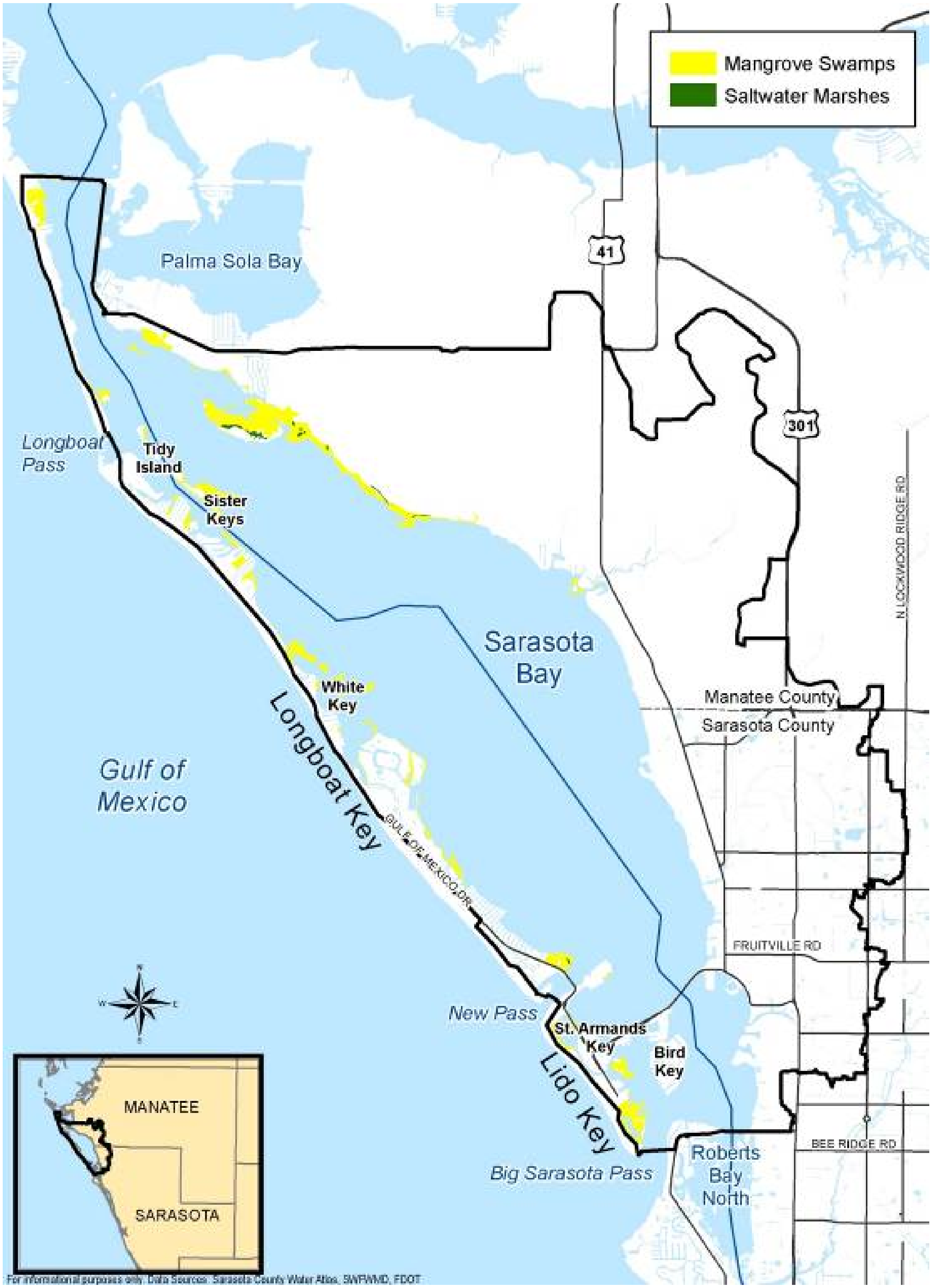


Figure 2-11 2009 Sarasota Bay Saltwater Wetland Coverage (SWFWMD, 2009)

Figure 2-12 Extent of Saltwater Wetlands in Sarasota Bay (Serviss and Sauers, 2003)

Table 2-1 Sarasota Bay Shoreline Emergent Vegetation (Serviss and Sauers, 2003)		
Type	Linear Feet	Percent
Australian Pine	1232	0.1
Brazilian Pepper	2403	0.3
Cattail	400	<0.1
Leather Fern	0	0.0
Juncus	569	0.1
Mangrove	297,550	35.9
None	503,915	60.9
Other	8395	1.0
Spartina	6457	0.8
Terrestrial	6877	0.8
Total	**827,798**	**100.0**

A marine habitat trend analysis that compared the extent of Sarasota's marine habitat resources in 1948 and in 1988 was conducted by Mangrove Systems, Inc. (1988). Mangrove Systems (1988) stated that losses of mangroves and tidal marsh between 1948 and 1988 were 290 acres (36%) and 23 acres (82%), respectively. Also, SBEP (SBEP wetlands web page, 2011) reports that 1,800 acres (38%) of tidal emergent wetlands were lost across the entire Sarasota Bay system between 1950 and 1990.

Evans and Evans (1988) conducted an inventory of shoreline types for the County in 1988. Based on field inspections, they found that between 1948 and 1987 the length of shoreline dominated by mangroves in Sarasota Bay had increased by 9.2 miles (69%). The reason for the increase in mangrove-dominated shoreline between 1978 and 1987 is unknown.

A marine habitat trend analysis that compared the extent of Sarasota County's marine habitat resources in 1948, 1972, and 1988 was conducted by Mangrove Systems (1988) using aerial photograph interpretation. Mangrove Systems (1988) stated that losses of mangroves and tidal marsh between 1948 and 1987 in Sarasota Bay were 289 acres (36%). Comparing the results of the Mangrove Systems study to the reported 2009 SWFWMD land use data, mangrove and saltmarsh coverage in Sarasota Bay increased by 125 acres (+15%) and 0 acre, respectively, between 1948 and 2009. If this represents a real increase in mangrove coverage or is an artifact of different mapping methods and tools is not known. Also, SBEP (SBEP wetlands web page, 2011) reports that 1,800 acres (38%) of tidal emergent wetlands were lost across the entire Sarasota Bay system between 1950 and 1990.

2.5 SEDIMENT AND BENTHOS

2.5.1 The Resource and Its Functions

Sediments are a natural and important part of estuarine processes. The size and type of sediments in an area influence the types of benthic, bottom-dwelling communities present. The following briefly describes how sediments affect the valued natural resources of the Sarasota Bay estuary.

Sedimentation creates shoals and substrate for emergent vegetation in estuaries. Sediment characteristics define the types of benthic organisms that inhabit the sediments. For example, animals that build tubes require particular sizes of sediment particles. Some polychaete worms prefer finer-grained sediments, while mud-sized sediments generally do not support a healthy benthic community. Amphipod crustaceans that consume bacteria and algae from sand grains are generally not found in muddier sediments. Many coastal fishes also prefer specific sediment grain types for shelter, spawning, and foraging. Therefore, sediment characterization is an important part of understanding the estuarine ecosystem functions that occur in the estuary.

Like shoreline alteration, the time scale on which sediment characteristics change in estuarine waters (in the absence of major coastal construction or changes in coastal morphology) makes it unnecessary to monitor this resource as frequently as a more dynamic natural feature such as water quality. Local sediment characteristics should, however, be recognized as a critical element of understanding estuarine dynamics and ecology.

Benthic (bottom-dwelling) organisms live in or on the sediments and other substrates of water bodies and are subsequently fundamentally affected by sediment type and quality. Benthic organisms include worms, snails, clams and other bivalves; numerous small crustaceans; and other invertebrate life forms. Unlike fish and other mobile fauna, most benthic invertebrates are limited in their ability to relocate if environmental conditions become unfavorable. Benthos are an essential component of the diet of many fishes and wading birds and are important because of their generally small size and their abundance.

Benthic organisms obtain food through a variety of mechanisms, including consumption of detritus, suspension feeding, deposit feeding, and other predation. They collectively process organic material and form an essential link in the transfer of energy to secondary consumers such as fish and birds. Tube-building and burrowing benthic organisms are important in bringing subsurface sediments to the top of the sediment layer and thus bring suspended sediments into contact with the water column. Nutrients and pollutants are cycled and the sediments can be better oxygenated (Jones Edmunds, 2010).

Estuarine benthic communities are primarily subject to the influences of two habitat variables (salinity and sediment characteristics) and two environmental stressors (dissolved oxygen [DO] and sediment contaminants). The interactions of salinity regime and sediment type dictate the fauna that can survive and thrive in an area. Low concentrations of DO or high concentrations of sediment contaminants (e.g., metals, pesticides, hydrocarbons) can further restrict the types and numbers of animals that live in the sediments favoring the most tolerant (Jones Edmunds, 2010).

Many benthic species are limited in range by the physiological challenges and stresses associated with variable salinity environments. Osmotic limitations restrict many freshwater species from using habitats in downstream reaches that are tidally influenced. Marine species also face osmotic problems, which restrict access to upstream freshwater habitats. Estuarine species typically tolerate a wide range of salinities, although they may have discrete "preferences" for optimal reproduction and growth. In other words, salinity is less of an acute stressor and more a chronic stressor for estuarine invertebrates.

Salinity affects benthic organisms directly and indirectly. Salinity is largely influenced by the amount of freshwater inflow entering the system. During periods of sustained high-freshwater inflows such as the summer wet season, low-salinity areas may expand, creating new habitats for the more mobile species that are intolerant of elevated salinities. During low-flow periods, higher salinity waters may facilitate habitat expansion for species favoring higher salinity.

Because water quality and sediment chemistry are fundamental factors in promoting a diverse and healthy benthic macroinvertebrate community, the goals of the WQMP with respect to water quality and sediment management should result in conditions favorable to the success of the macroinvertebrate community and the fauna that depend on them in Sarasota Bay. The following section describes existing regulations that protect the benthic community and qualitatively describes the functions of sediments and their value to benthic organism and other biota.

2.5.2 Existing Regulations for Resource Protection

The following regulations address the protection of submerged sediment and benthic habitats. Sediment and benthos can be protected by prohibiting dredging and filling in submerged lands, protecting water quality, providing public education, and requiring mitigation for unavoidable impacts. Local, state, and federal rules are included as appropriate.

Regulations specific to emergent sediment and benthic habitats are presented below. Many laws and policies that protect seagrasses such as County policies and the FDEP ERP program (discussed for other resources) also protect sediment and benthic habitats and are not repeated here.

2.5.2.1 Sarasota County

- Sarasota County Comprehensive Plan Chapter 2 – Environment: Management guidelines for benthic communities:

- Avoid impacts to submerged or inter-tidal marine and estuarine consolidated substrate. Where some impacts may be unavoidable as part of a beach nourishment or renourishment project approved by the Board and considered to be in the public interest, such impacts shall be mitigated in accordance with state regulations. Chapter 54, Article XXIV, of the Sarasota County Code of Ordinances shall be strictly enforced. This Code prohibits the destruction of the Point of Rocks natural rock outcropping and its associated live rock.

❖ County Code of Ordinances, Chapter 54 Environment and Natural Resources

- Article XXIV. – Point of Rocks Protection

  ➢ This article provides for the protection of Point of Rocks in Sarasota Bay. The live rock located at Siesta Key is an important resource that assists in protecting the beach from erosion and provides a habitat for sea life.

2.5.3 Literature Review

This section qualitatively describes the functions of sediments and their value to benthic organism and other biota and briefly summarizes findings from the following reports:

❖ FWCC Inshore Marine Monitoring and Assessment Program (IMAP) benthic sampling data from 2001.
❖ Results of work by Culter and Leverone (1993).
❖ Results of work by Knowles and Davis (1983).
❖ No routine monitoring of benthos is conducted in Sarasota Bay. However, several benthic surveys have been conducted in Sarasota Bay. Benthic surveys by Culter and Leverone (1993) and Knowles and Davis (1983) provided physical descriptions of the types and distribution of sediments in the bay. These surveys describe a general pattern of fine-grained muddy sediment in quiescent areas of the bay, with coarser sandy sediment in higher-energy areas such as near Big Pass.

Culter and Leverone (1993) conducted a qualitative survey of habitats in the Sarasota Bay estuarine system for the SBEP that included observations of benthic habitat and fauna. The variability in their findings demonstrates the diversity of bay bottom habitats as well as the distribution of natural and altered bottoms in Sarasota Bay. During these surveys, numerous *Diopatra* tubes, live *Mercenaria* clams, and *Busycon* whelks were observed in seagrass meadows and clean, fine sands in the bayside portions of the Big Pass area. Seagrass meadow enclosed by Coon Key, St. Armands Key, and City Island were reported to support horseshoe crabs (*Limulus* *polyphemus)*, pen shells (*Pinnidae spp*.), and hard clams (*Mercenaria mercenaria*). An occasional bay scallop, *Argopecten irradians,* was found within grass beds near New Pass.

Numerous *Mercenaria* clams, both dead and alive, were present in Hudson Bayou grassbeds. Sediments were mainly sandy mud, with a soft flocculent surface layer. The Marina Jack boat basin has been dredged to a depth of approximately 12 feet and contains anoxic silt/clays with virtually no benthic infauna. In contrast, some dredged areas without anoxic sediments had numerous worm tubes and sand dollars present. Artificial reef were also observed and were often heavily colonized with barnacles, tunicates, and colonial hydroids, as well as small motile epifauna (Culter and Leverone, 1993).

Benthic samples were also collected through the FWCC IMAP, which was initiated in 2000, and fisheries and benthic data were collected in Sarasota Bay in 2001. Although much data have been collected in many larger estuarine systems across the state, IMAP is the first program capable of reporting on the status of Florida's nearshore marine systems statewide. When fully implemented, IMAP will play a large role in filling the information gap on the health of Florida’s estuaries.

IMAP found the following taxa the most abundant:

- *Caecum pulchellum*, or “beautiful snail,” a gastropod that has been indicated to be an indicator of contaminated sediments (Grizzle, 1984).
- *Parasterope pollex*, or “seed shrimp,” an ostracod crustacean identified as an opportunistic indicator of pollution (Grizzle, 1984).
- Tubifacea, or Naididae, include a variety of tubeworms that can tolerate a wide range of conditions.
- *Haplocytheridea setipunctata*, an ostracod crustacean with a wide geographic distribution.
- *Tellinidae* spp, bivalve mollusks that contribute to the cycling of chemicals through sediments through burrowing, ingestion, and excretion.
- Numerous polychaete worms including *Fabricinuda trilobata*, Mediomastus spp, Spirorbidae spp, and *Capitella capitata*. The latter has a preferred habitat of muddy and fine-grained sediments and is tolerant of pollution.
- *Hargeria rapax*, a widespread small crustacean sometimes found in very high densities in areas with low-quality water.

Table 2-2 shows the number of organisms observed and number of samples for the top 50 taxa.

Table 2-2 Dominant (Most Abundant) Benthic Taxa Collected by the FWCC IMAP Sampling in 2001

Scientific Name	Total Abundance	Number of Samples
Caecum pulchellum	2238	9
Parasterope pollex	1912	17
Tubificidae	916	25
Haplocytheridea setipunctata	834	17
Tellina texana	751	5
Fabricinuda trilobata	458	9
Mediomastus	457	20
Spirorbidae	436	1
Capitella capitata	389	7
Tellinidae	339	3
Hargeria rapax	320	8
Tellina	316	14
Phascolion strombi	280	16
Mysella planulata	223	15
Nucula aegeenis	195	10
Monticellina dorsobranchialis	189	12
Glycinde solitaria	169	15
Notomastus latericeus	150	3
Rhynchocoela	147	21
Olivella dealbata	144	12
Macoma tenta	133	3
Pomatoceros americanus	124	2
Caulleriella cf. alata	121	9
Ampelisca cristata	118	10
Cirriformia grandis	118	5
Mulinia lateralis	116	3
Maldanidae	112	10
Mediomastus ambiseta	111	5
Cirrophorus lyra	110	12
Neaeromya floridana	107	2
Sipuncula	95	4
Aricidea philbinae	88	10
Acteocina canaliculata	85	11
Turbonilla conradi	85	10
Exogone rolani	73	7
Mediomastus californiensis	68	12
Granulina ovuliformis	67	7
Cerapus sp. B	65	7
Marginella apicina	65	10
Listriella barnardi	62	10
Kinbergonuphis simoni	61	7
Ampelisca abdita	57	4
Nereis acuminata	56	8
Olivella	52	2
Turbonilla sp. AE	52	8

Table 2-2 Dominant (Most Abundant) Benthic Taxa Collected by the FWCC IMAP Sampling in 2001

Scientific Name	Total Abundance	Number of Samples
Acteocina candei	51	5
Branchiostoma	50	5
Apoprionospio pygmaea	48	11
Caecum johnsoni	48	2

2.6 OYSTERS

2.6.1 The Resource and Its Function

The Eastern oyster, *Crassostrea virginica*, occupies a range from the north Atlantic coast into the Gulf of Mexico and the Caribbean Sea (Bahr and Lanier, 1981). The oyster's tolerance of low temperatures and widely ranging salinities, turbidity, and DO makes its widespread survival possible (Bahr and Lanier, 1981). Oysters tolerate salinities ranging from 0 to 42 ppt (Shumway, 1996). Oysters are subject to diseases brought on by higher salinities, especially when they occur with high temperatures (e.g., infestation by a protozoan, *Perkinsus marinus*), and to predation by invertebrates (oyster drills, starfish). At lower salinities, diseases are less likely to infect oysters, but growth rates are reduced (Jones Edmunds, 2010).

Oysters are an important indicator of estuarine health, and their status can help identify water-management problems. Oyster reefs serve several valuable ecological functions. They provide habitat for estuarine fauna, including conch, mud crab, fish, and other bivalves (Wells, 1961; Tolley and Volety, 2005) and help improve water quality by filtering as they feed. This section summarizes existing regulations and current oyster monitoring and research activities conducted by the County and others and describes recent findings of the County's oyster monitoring activities.

2.6.2 Existing Regulations for Resource Protection

The following regulations address the protection of oysters, which can be accomplished by prohibiting dredging and filling in submerged lands, protecting water quality, limiting harvests, and providing public education. Local, state, and federal rules are included as appropriate. Non-regulatory activities such as monitoring and colonization also help sustain the local oyster population.

Regulations specific to oysters are presented below. Many laws and policies that protect seagrasses such as County policies and the FDEP ERP and water quality programs (discussed for other resources) also protect oysters and are not repeated here.

2.6.2.1 Sarasota County

❖ Sarasota County Comprehensive Plan Chapter 2 – Environment: Management Guidelines for Oysters

- Improve water quality by limiting or eliminating pollution and its causes.
- Maintain natural freshwater flows entering bays.
- Conserve oyster bars and beds.
- Submit a resource management plan for perpetually protected areas, based on best available technology, for review and approval by the County prior to or concurrent with the preliminary plan or site and development plan development review process.

2.6.2.2 FWCC

❖ Chapter 68, Florida Administrative Code, Section B-27 – Sets harvest season and take limit for oysters.

2.6.2.3 Monitoring Programs and Other Data Sources

2.6.3 Trend Analysis

2.6.3.1 Methods

❖ No maps showing the current or recent extent of oyster bars in all of Sarasota Bay were identified. However, Sarasota County recently sponsored an inventory of oysters within County boundaries (Photo Science, 2010). Also, Sarasota County is currently mapping oyster locations in County waters and expects to finish in 2012. Florida Seagrant (2003) conducted oyster mapping for historical (1883–9 and 1955) and recent (2001) conditions but only for Little Sarasota Bay. Additionally, the following datasets were also reviewed:

- Sarasota County 2006 Comprehensive Oyster Monitoring Program (Jones, 2007).
- GIS coverage of current oyster bar locations by Photo Science, Inc. (2010) for SBEP.
- GIS coverage of historical oyster bar locations by Photo Science, Inc. (2007) for SBEP.

Sarasota County conducts an oyster monitoring program throughout its estuaries with two sites in Sarasota Bay—one in Hudson Bayou off Osprey Avenue and one in the bay south of the mouth of Hudson Bayou—as shown in Figure 2-13. The purpose of the program is to document the viability of existing oyster bars in the County's bays and tidal creeks. The number and percent of live oysters observed at each site using a 0.25-m-square quadrat are documented and compared between sites and over time. These data were also incorporated into this analysis.

Figure 2-13 Sarasota County Oyster Monitoring Sites in Sarasota Bay

2.6.3.2 Results and Discussion

Figure 2-14 presents results from the most recent 6 years of data for the two sites. The percent-live oysters at the in-bay site, HUD1, ranged from a high of 78% in fall 2006 to a low of 62% in spring 2009. These scores were generally higher than percent-live oysters at HUD2, the upstream site, which ranged from a low of 55% in fall 2006 to a high of 81% 6 months later.

Sarasota County contracted with Photo Science, Inc. in 2010 to conduct a photogrammetric survey of all oyster bars within County waters. In the southern half of Sarasota Bay, oysters were most prolific along the shore of Longboat Key and City Island to the west, and in the tidal reaches of Hudson and Whitaker bayous to the east (Figure 2-15). A total of 87 individual oyster bars ranging in size from 0.01 to 0.25 acre, and having a total areal extent of 3.8 acres, were identified.

SBEP contracted Photo Science, Inc. to digitize 1948 aerial photographs to identify oyster bars in Sarasota Bay. Figure 2-16 shows the oyster bars. The largest oyster bar area identified is south of Bird Key.

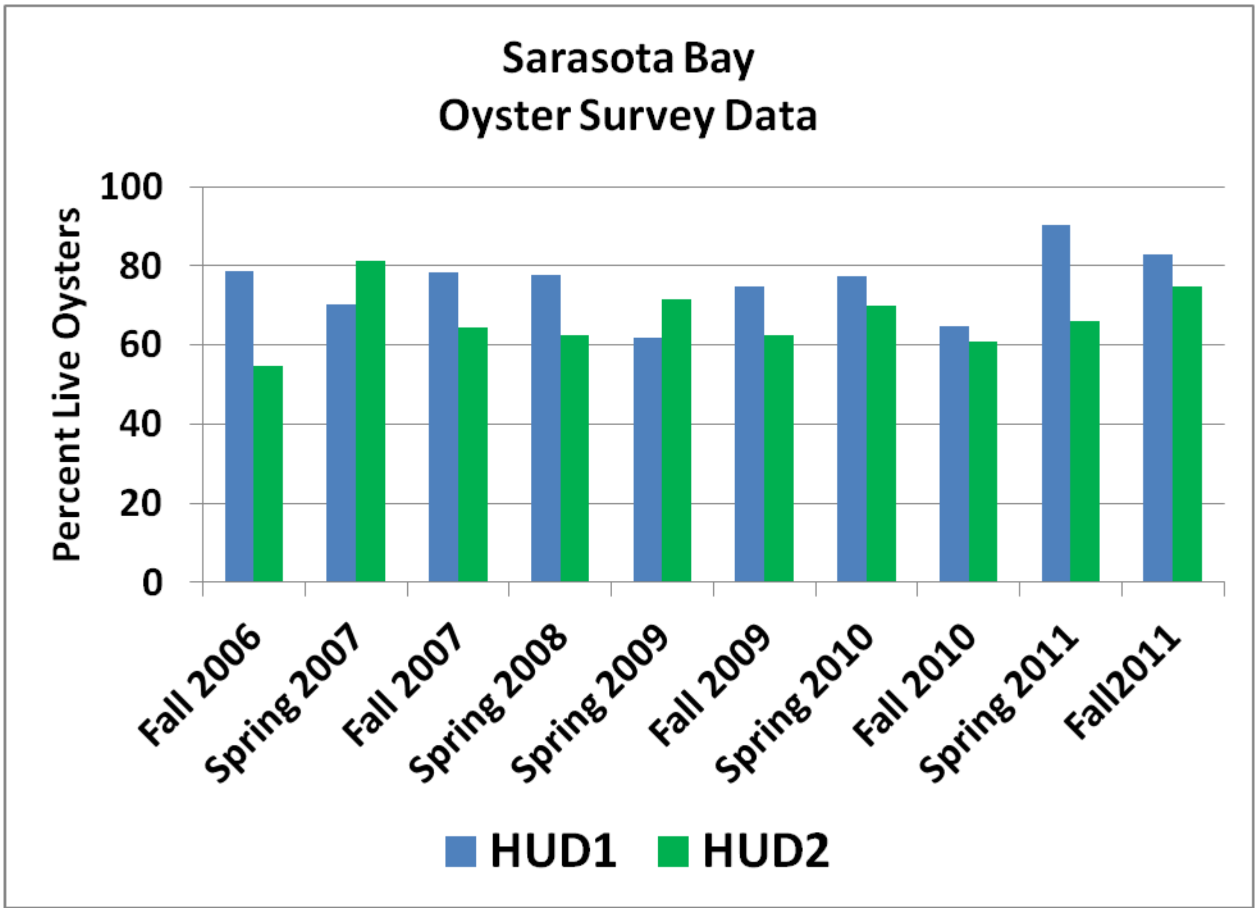


Figure 2-14 Sarasota County Oyster Monitoring Program – Live Oysters from Sarasota Bay Sites – 2006 through 2010

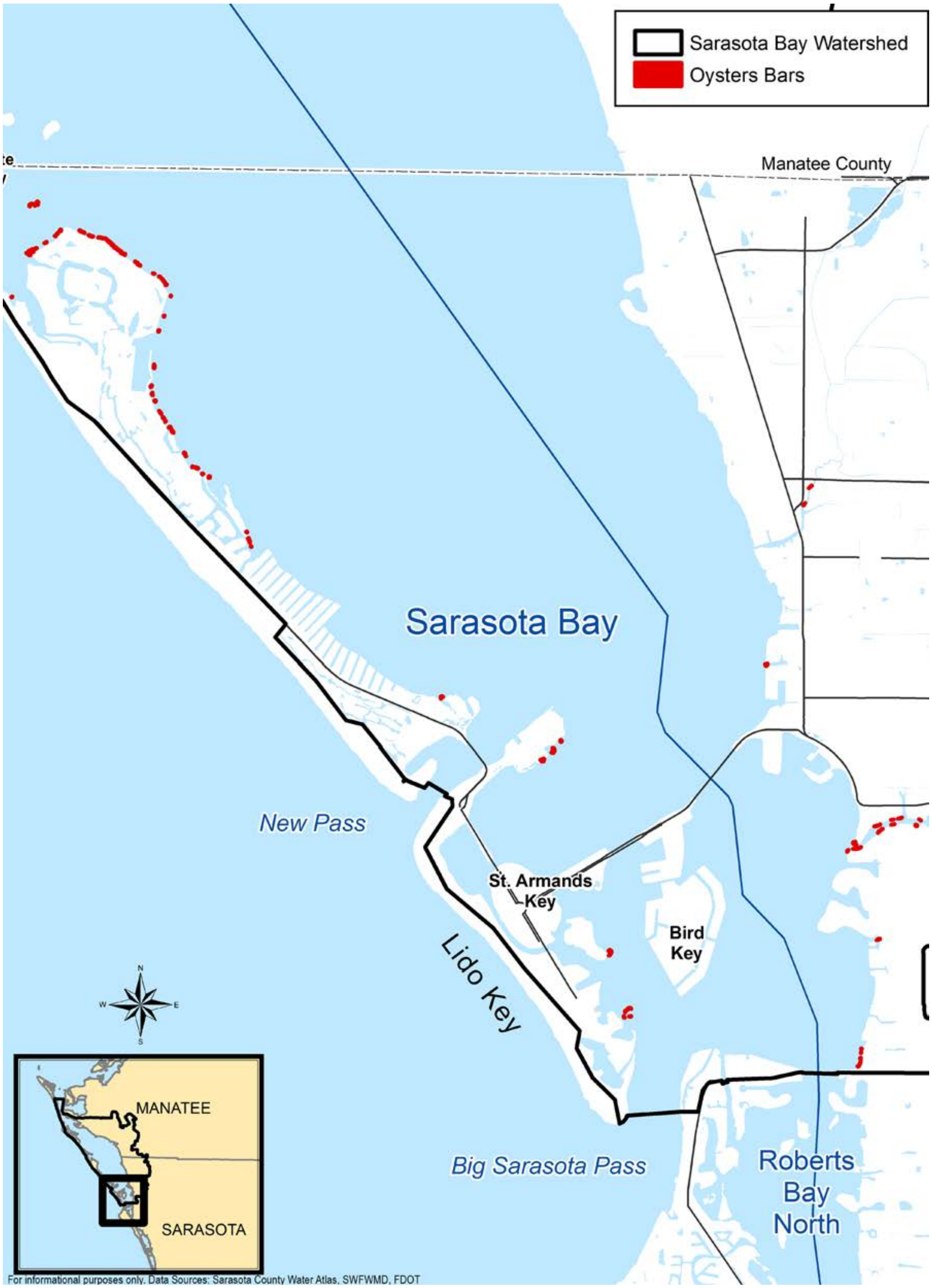


Figure 2-15 Oyster Bars within Sarasota Bay

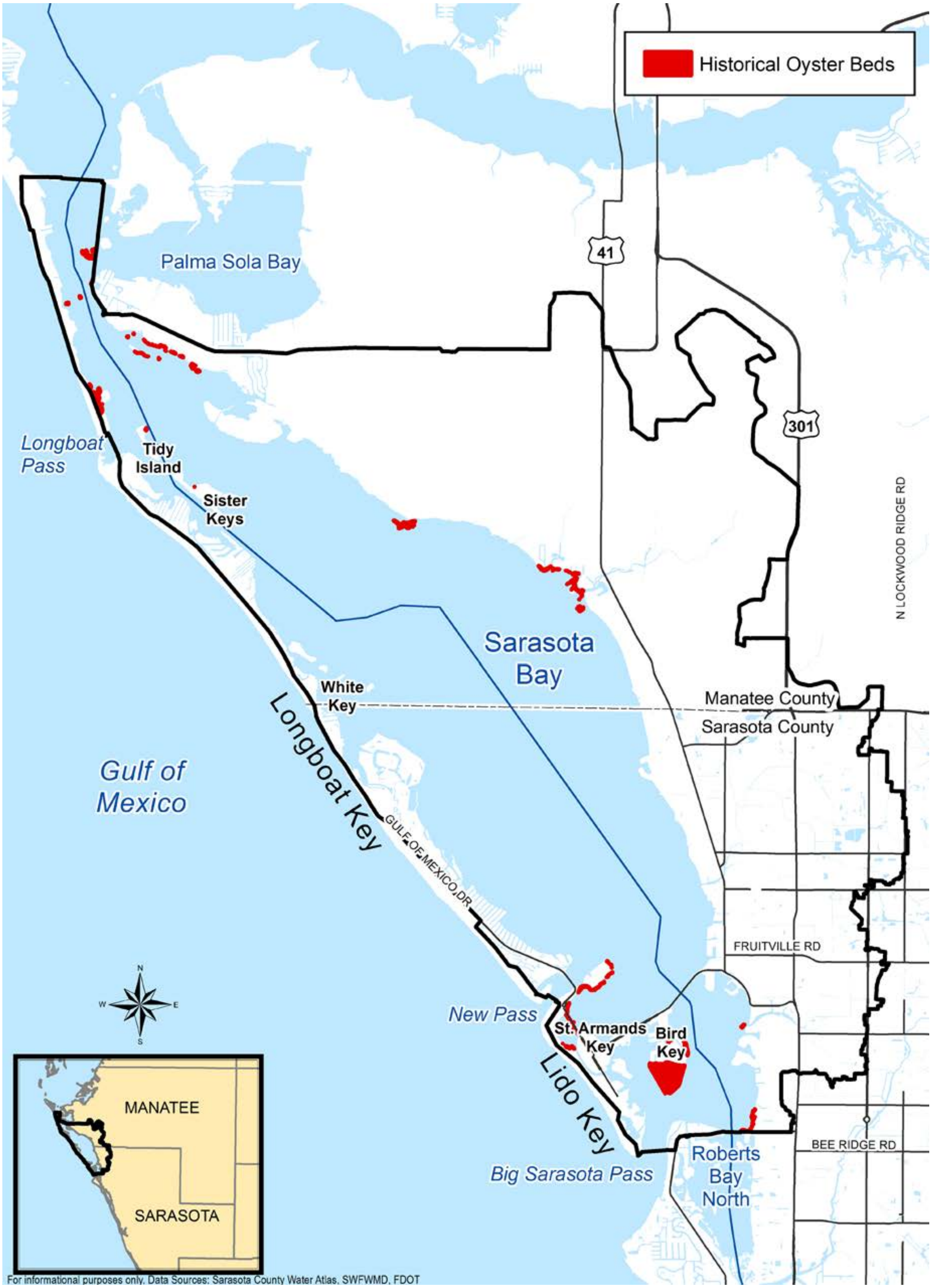


Figure 2-16 Estimated Historical (1948) Oyster Beds in Sarasota Bay (Photo Science, Inc., 2007)

2.7 SCALLOPS

2.7.1 The Resource and Its Functions

Scallops are an important indicator of estuarine health. Once plentiful along Florida's southwest coast, they now exist locally in greatly diminished abundance. Several potential causes of the decline in the scallop population include a decrease in available habitat, changes in water quality, and over-harvesting. This decline led to drastic changes in the way scallops are managed in state waters. In 1994, waters south of the Suwannee River were closed to commercial harvesting while recreational limits were reduced. Through a combination of restoration and management practices, the recreational fishery was re-opened in west-central Florida but still remains closed in Sarasota Bay.

Besides providing a much desired food source for humans, scallops provide other benefits. Like oysters they filter water as they feed, contributing to improved water quality. Scallops are also a food source for rays. This section summarizes current activities conducted by the County and others with respect to monitoring scallop populations in the bay, as well as current research in re-stocking scallops.

2.7.2 Existing Regulations for Resource Protection

The following regulations address the protection of scallops, which can be accomplished by prohibiting dredging and filling in submerged lands, protecting water quality, limiting harvests, and providing public education. Local, state, and federal rules are included as appropriate. Non-regulatory activities such as monitoring and seeding spat also help sustain the local scallop population.

Regulations specific to scallops are found in Chapter 68, FAC, Section B-18, which sets harvest season and take limits. These regulations are enforced by the FWCC. Many laws and policies that protect seagrasses such as County policies and the FDEP ERP and water quality programs (discussed for other resources) also protect scallops and are not repeated here.

2.7.3 Monitoring Efforts and Status

Sarasota County has partnered with Fish and Wildlife Research Institute (FWRI) and Albritton Farms in placing scallop monitoring traps in bays throughout the County. Drifting scallop spat attach themselves to the traps, which are collected every other month and taken to FWRI for laboratory analysis. Sarasota County is also participating with FWRI to place scallop-seeding cages throughout the county. The cages, with live scallops, are set out under docks. Each month, volunteers use provided tools to maintain the cages and collect data.

Sarasota County and Sarasota Bay Watch conduct annual scallop searches in the County's bays. Figure 2-17 shows the results of the 2008 search (Sarasota County, 2008). Based on field notes from the scallop searches, the most scallops were observed either near passes and/or in areas with seagrass meadows, their preferred habitat. The number of scallops observed in recent years has dropped, with 947 found in 2008, 136 scallops in 2009, and only 12 in 2010. However, as this is a volunteer effort, the number of scallops found may reflect the number of participants in the searches or may be caused by natural variability. Sarasota Bay had by far the most scallops found in any SBEP bay segment during the 2008 search.

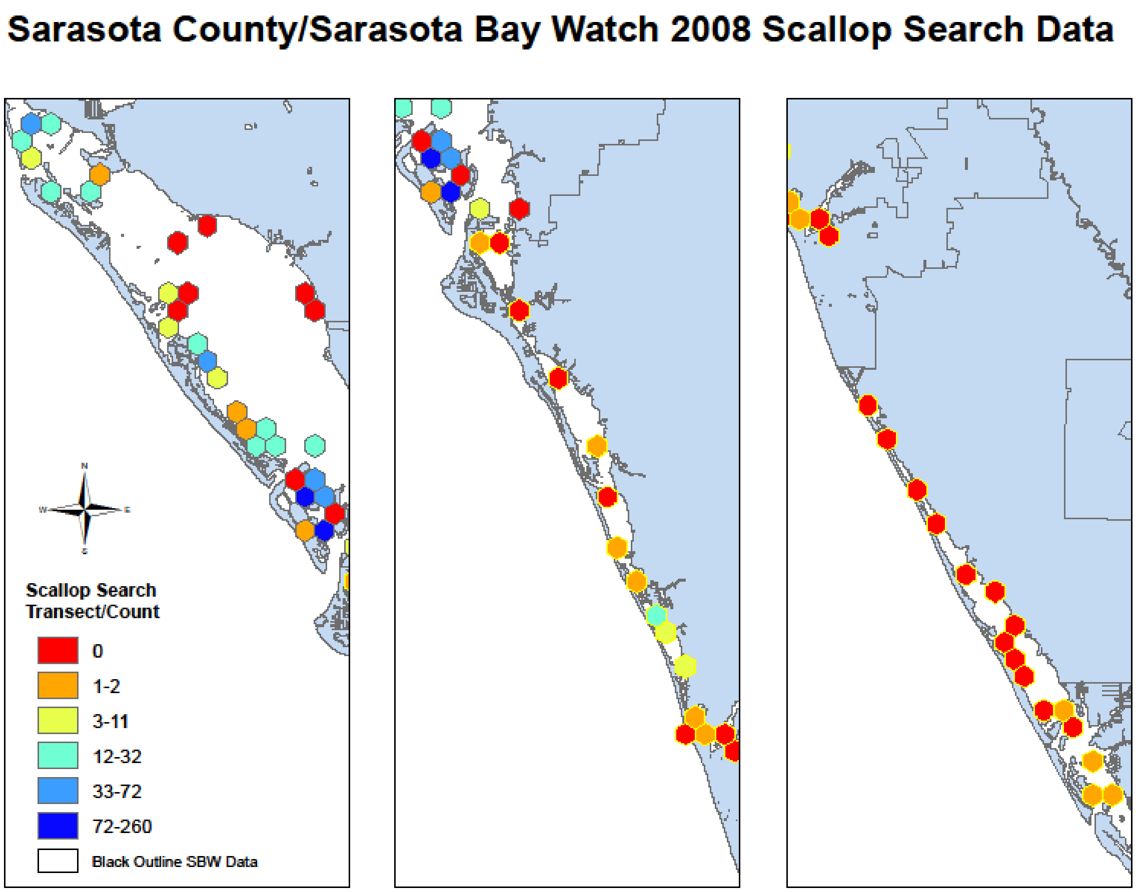


Figure 2-17 Results of 2008 Sarasota County/Sarasota Bay Watch Scallop Search

2.8 FISHES

2.8.1 The Resource and Its Function

Fisheries in Florida and other coastal areas depend on estuaries for their survival. The delivery of nutrients from freshwater inflows to the estuary is an import driver for primary production and facilitates the transfer of energy up the trophic food web.

Fish form an important part of the food web in saltwater and freshwater ecosystems and can be top predators, intermediate herbivores, or plankton eaters. A variety of birds and other animals depend on fish as their primary food source. The presence or absence of individual species and overall fish numbers can be an indicator of ecosystem health and can affect water clarity and water quality. Fisheries form an important resource for food and recreation for humans as well. In fact, angling is the most popular recreational activity on many Florida waters.

Sarasota County is bracketed by two of the other ecologically significant estuaries of Florida, Tampa Bay and Charlotte Harbor. Sarasota Bay is a lagoonal system with few inlets, less freshwater input, and longer residence times for areas of similar salinity than either Tampa Bay or Charlotte Harbor. Therefore, while the overall species composition of fishes in Sarasota Bay likely resembles that of Tampa Bay and Charlotte Harbor, fish community structure likely differs among the estuaries due to the different hydrologic regimes.

This section describes the results of fish-sampling activities in Sarasota Bay. Important commercial, recreational, and other species are identified. No comparison of the fish communities of the three estuaries was made for this report.

2.8.2 Existing Regulations for Resource Protection

The following regulations address the protection of fishes, which can be accomplished by prohibiting dredging and filling in submerged lands, protecting water quality, limiting harvests, and providing public education. Local, state, and federal rules are included as appropriate.

Regulations specific to fishes are presented below. Many laws and policies that provide protection to seagrasses such as County policies and the FDEP ERP and water quality programs (discussed for other resources) also protect fishes and are not repeated here.

2.8.2.1 FDEP

- Threatened and Endangered Species Program

  - Chapter 372.072 Florida Statutes (Florida Endangered and Threatened Species Act of 2005) provides for research and management to conserve and protect threatened and endangered species as a natural resource. This act was established to provide the conservation and management of these resources, with particular attention to those species designated by FWCC, FDEP, or the U.S. Department of the Interior U.S. Fish & Wildlife Service or successor agencies, as endangered or threatened. The federal Endangered Species Act was promulgated in 1973.

- At this time, no fish species identified in any sampling in the estuary is on the state or federal threatened and endangered species list.

2.8.2.2 FWCC

- Chapter 68, Florida Administrative Code
  - Section 68B – Marine Fisheries: Recreational and Commercial Saltwater Fisheries Regulations
  - Section 68E – Regulations for other Marine Resources

2.8.3 Fish Taxa and Abundance Analysis

- Finfish are monitored state-wide under the FWCC Fisheries Independent Monitoring (FIM) Program. Sampling in Sarasota Bay occurred only recently as a special project funded by SBEP. Results of 2009–2010 monitoring are published in MacDonald et al. (2010). Additionally, the FWCC IMAP generated fisheries sampling data from 2001 as well as Serviss and Sauers (2003).

2.8.3.1 Methods

Data from FIM sampling in 2009–2010 and IMAP sampling in 2001 were analyzed to identify the most commonly observed species collected using a variety of gear, as described below. Results were corroborated by reviewing the abundance and diversity of fish identified by Serviss and Sauers (2003).

The FIM program is a system-wide approach and evaluates marine communities and the populations of fish and invertebrate species that comprise them. FIM also investigates habitat conditions to learn more about system-wide trends. Researchers in the program monitor the status and relative abundance of recreational and commercial fishes from estuaries around the state. In 2009 Sarasota Bay was included in the list of estuaries to be sampled.

To ensure the sampling of a wide range of fish sizes and ages during a survey, FIM uses a variety of techniques and fishing gear to collect fish population data. Smaller fishes are usually collected with a 21-m seine or a 6.1-m otter trawl. FIM uses the 21-m seine in water depths of 1.8 m or less; the trawl is used in water of greater depths. Larger subadult and adult fishes are collected using 183-m purse seines. Program biologists use the seines along shoreline habitats and the otter trawl for open-bay sampling. Figure 2-18 shows the sampling locations.

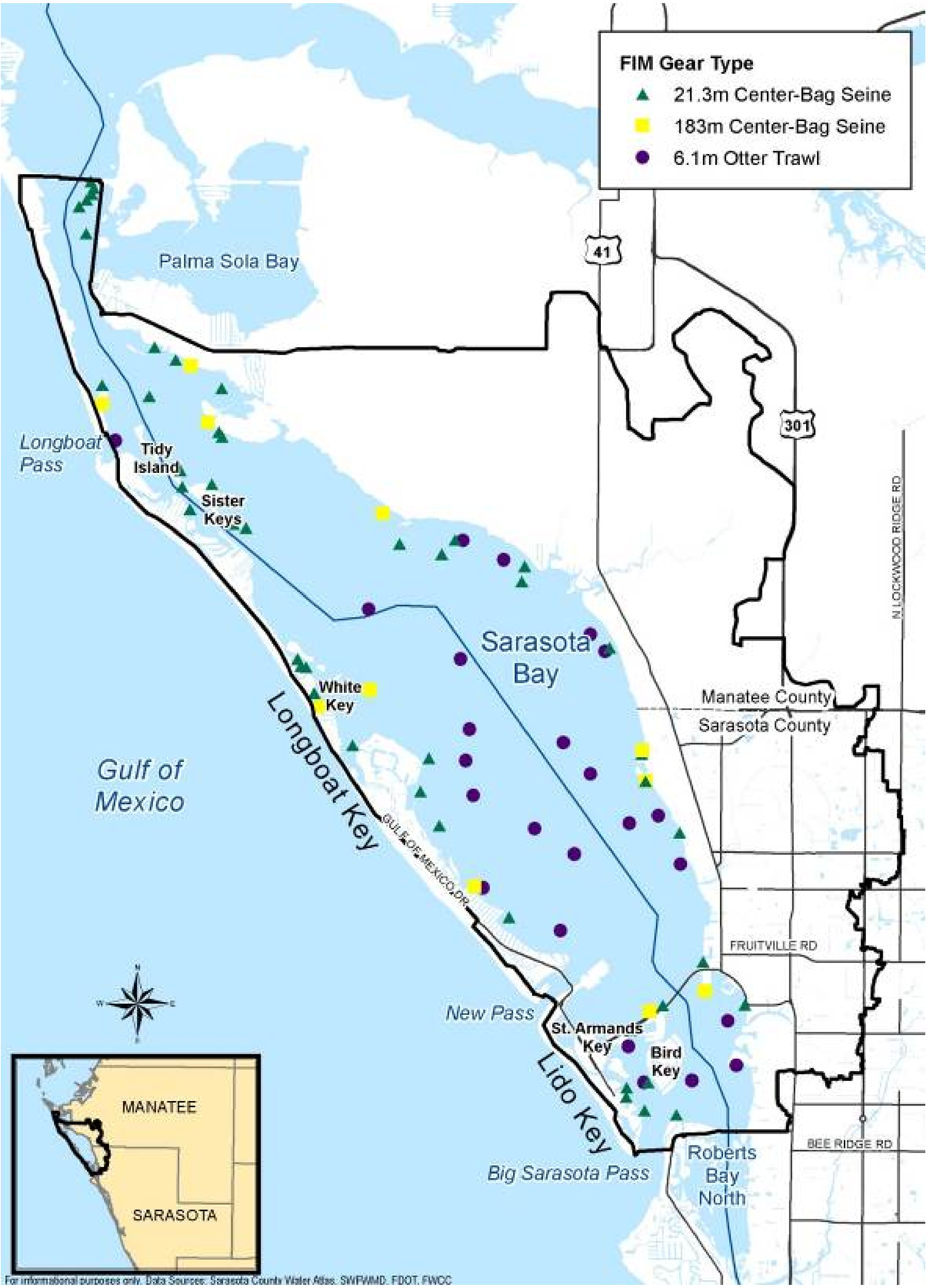


Figure 2-18 FWCC FIM Fish Sampling Sites Shown by Collection Gear Used

Fish samples were also collected through the FWCC IMAP. Although much data have been collected in many larger estuarine systems across the state, IMAP is the first program capable of reporting on the status of Florida's nearshore marine systems statewide. When fully implemented, IMAP will play a large role in filling the information gap on the health of Florida’s estuaries. IMAP was initiated in 2000, and fisheries and benthic data were collected in Sarasota Bay in 2001. Like the FIMS sampling, both seines (21.3 m only) and trawls were used to sample coastal and open water sites, respectively.

As reported in the 2002 IMAP annual report (McRae, 2002), trawls averaged significantly more number of species per set than seines statewide. Gear-based differences were most apparent in the Sarasota/Lemon Bay sampling unit where seines caught an average of nine species per set and trawls caught an average of 17 species per set.

2.8.3.2 Results and Discussion

Table 2-3, Table 2-4, and Table 2-5 present the results of the FWCC FIM sampling for Sarasota Bay as a whole. Each table shows the number of fish caught by a particular gear and the rank of each fish taxon in terms of numbers observed. The ubiquitous pinfish was the most numerous and was ranked first or second for all three gear types used to sample in a variety of habitats. Bay anchovy was ranked first in large seine samples and second in trawl samples.

Spot, mullet, snappers, and seatrout were among the most frequently observed recreationally or commercially important species taken with the 21.3-m bay seine. The 183-m haul seine yielded relatively abundant snapper, snook, spot, and mullet. Snapper, flounder, and seatrout were the highest ranked recreational/commercial species taken with the 6.1-m trawl.

Table 2-6 shows IMAP sampling results. As with the FIM data, the pinfish is most frequently observed with the bay anchovy ranked third. Seatrout, flounder, and snapper are higher ranked recreational/commercial species. One notable difference of the IMAP data from FIM is the lack of spot in the IMAP because spot come inshore only during the winter and were in deeper water during the IMAP sampling in July 2001.

Table 2-3 Dominant Fish Taxa Collected by the FWCC FIM Sampling in Sarasota Bay Using 21.3-m Bay Seine During 2009–2010

Scientific name	Common name	Number Collected	Rank
Anchoa mitchilli	Bay anchovy	20397	1
Lagodon rhomboides	Pinfish	9400	2
Eucinostomus spp.	Eucinostomus mojarras	3468	3
Leiostomus xanthurus	Spot	2485	4
Lucania parva	Rainwater killifish	1224	5
Harengula jaguana	Scaled sardine	638	6
Eucinostomus gula	Silver jenny	383	7
Farfantepenaeus duorarum	Pink shrimp	288	8
Menidia spp.	Menidia silversides	276	9
Eucinostomus harengulus	Tidewater mojarra	134	10
Bairdiella chrysoura	Silver perch	122	11
Anchoa cubana	Cuban anchovy	100	12
Stephanolepis hispidus	Planehead filefish	82	13
Syngnathus scovelli	Gulf pipefish	67	14
Mugil cephalus	Striped mullet	43	15
Lutjanus synagris	Lane snapper	40	16
Strongylura notata	Redfin needlefish	37	17
Gobiosoma robustum	Code goby	36	18
Lutjanus griseus	Gray snapper	29	19
Fundulus similis	Longnose killifish	28	20
Cynoscion nebulosus	Spotted seatrout	27	21
Orthopristis chrysoptera	Pigfish	26	22
Oligoplites saurus	Leatherjack	24	23
Floridichthys carpio	Goldspotted killifish	21	24
Microgobius gulosus	Clown goby	20	25
Sciaenops ocellatus	Red drum	19	26
Synodus foetens	Inshore lizardfish	19	27
Chasmodes saburrae	Florida blenny	17	28
Cyprinodon variegatus	Sheepshead minnow	16	29
Gobiosoma spp.	Gobiosoma gobies	13	30
Sphoeroides nephelus	Southern puffer	13	31
Strongylura marina	Atlantic needlefish	13	32
Callinectes sapidus	Blue crab	9	33
Hyporhamphus meeki	False silverstripe halfbeak	9	34
Ctenogobius boleosoma	Darter goby	7	35
Fundulus grandis	Gulf killifish	7	36
Haemulon plumierii	White grunt	7	37
Hippocampus zosterae	Dwarf seahorse	7	38
Syngnathus floridae	Dusky pipefish	7	39
Syngnathus louisianae	Chain pipefish	7	40
Paralichthys albigutta	Gulf flounder	6	41
Chilomycterus schoepfii	Striped burrfish	5	42
Monacanthus ciliatus	Fringed filefish	5	43
Nicholsina usta	Emerald parrotfish	5	44

Table 2-3 Dominant Fish Taxa Collected by the FWCC FIM Sampling in Sarasota Bay Using 21.3-m Bay Seine During 2009–2010

Scientific name	Common name	Number Collected	Rank
Achirus lineatus	Lined sole	4	45
Membras martinica	Rough silverside	4	46
Portunus spp.	Portunus crabs	4	47
Urophycis floridana	Southern hake	4	48
Opisthonema oglinum	Atlantic thread herring	3	49
Prionotus scitulus	Leopard searobin	3	50

Table 2-4 Dominant Fish Taxa Collected by the FWCC FIM Sampling in Sarasota Bay Using 183-m Haul Seine During 2009–2010

Scientific name	Common name	Number Collected	Rank
Lagodon rhomboides	Pinfish	2464	1
Bairdiella chrysoura	Silver perch	587	2
Harengula jaguana	Scaled sardine	517	3
Opisthonema oglinum	Atlantic thread herring	271	4
Orthopristis chrysoptera	Pigfish	178	5
Eucinostomus gula	Silver jenny	91	6
Lutjanus griseus	Gray snapper	54	7
Centropomus undecimalis	Common snook	42	8
Leiostomus xanthurus	Spot	37	9
Diplodus holbrookii	Spottail pinfish	36	10
Ariopsis felis	Hardhead catfish	34	11
Mycteroperca microlepis	Gag	34	12
Archosargus probatocephalus	Sheepshead	23	13
Elops saurus	Ladyfish	21	14
Mugil cephalus	Striped mullet	20	15
Mugil curema	White mullet	20	16
Selene vomer	Lookdown	19	17
Lutjanus synagris	Lane snapper	18	18
Sphyraena barracuda	Great barracuda	13	19
Stephanolepis hispidus	Planehead filefish	10	20
Nicholsina usta	Emerald parrotfish	9	21
Paralichthys albigutta	Gulf flounder	9	22
Sphoeroides nephelus	Southern puffer	8	23
Mugil gyrans	Whirligig mullet	7	24
Strongylura notata	Redfin needlefish	6	25
Chilomycterus schoepfii	Striped burrfish	5	26
Haemulon plumierii	White grunt	5	27
Ogcocephalus cubifrons	Polka-dot batfish	5	28
Callinectes sapidus	Blue crab	4	29
Cynoscion nebulosus	Spotted seatrout	4	30
Sphyrna tiburo	Bonnethead	4	31
Trachinotus falcatus	Permit	4	32

Table 2-4 Dominant Fish Taxa Collected by the FWCC FIM Sampling in Sarasota Bay Using 183-m Haul Seine During 2009–2010

Scientific name	Common name	Number Collected	Rank
Acanthostracion quadricornis	Scrawled cowfish	3	33
Scomberomorus maculatus	Spanish mackerel	3	34
Caranx hippos	Crevalle jack	2	35
Eucinostomus harengulus	Tidewater mojarra	2	36
Oligoplites saurus	Leatherjack	2	37
Sciaenops ocellatus	Red drum	2	38
Synodus foetens	Inshore lizardfish	2	39
Centropristis striata	Black sea bass	1	40
Dasyatis americana	Southern stingray	1	41
Eugerres plumieri	Striped mojarra	1	42
Fundulus grandis	Gulf killifish	1	43
Fundulus similis	Longnose killifish	1	44
Limulus polyphemus	Horseshoe crab	1	45
Monacanthus ciliatus	Fringed filefish	1	46
Opsanus beta	Gulf toadfish	1	47
Sarotherodon melanotheron	Blackchin tilapia	1	48
Strongylura marina	Atlantic needlefish	1	49

Table 2-5 Dominant Fish Taxa Collected by the FWCC FIM Sampling in Sarasota Bay Using 6.1-m Trawl During 2009–2010

Scientific name	Common name	Number Collected	Rank
Lagodon rhomboides	Pinfish	346	1
Anchoa mitchilli	Bay anchovy	330	2
Menippe spp.		197	3
Eucinostomus gula	Silver jenny	169	4
Orthopristis chrysoptera	Pigfish	83	5
Eucinostomus spp.	Eucinostomus mojarras	74	6
Chilomycterus schoepfii	Striped burrfish	31	7
Portunus spp.	Portunus crabs	31	8
Prionotus scitulus	Leopard searobin	30	9
Gobiosoma spp.	Gobiosoma gobies	22	10
Acanthostracion quadricornis	Scrawled cowfish	18	11
Lutjanus synagris	Lane snapper	15	12
Gobiosoma robustum	Code goby	14	13
Eucinostomus harengulus	Tidewater mojarra	13	14
Urophycis floridana	Southern hake	13	15
Farfantepenaeus duorarum	Pink shrimp	12	16
Stephanolepis hispidus	Planehead filefish	11	17
Ogcocephalus cubifrons	Polka-dot batfish	10	18
Synodus foetens	Inshore lizardfish	9	19
Hippocampus erectus	Lined seahorse	8	20
Opsanus beta	Gulf toadfish	6	21

Table 2-5 Dominant Fish Taxa Collected by the FWCC FIM Sampling in Sarasota Bay Using 6.1-m Trawl During 2009–2010

Scientific name	Common name	Number Collected	Rank
Paralichthys albigutta	Gulf flounder	6	22
Archosargus probatocephalus	Sheepshead	5	23
Etropus crossotus	Fringed flounder	5	24
Hypleurochilus caudovittatus	Zebratail blenny	4	25
Achirus lineatus	Lined sole	3	26
Ancylopsetta quadrocellata	Ocellated flounder	3	27
Ariopsis felis	Hardhead catfish	3	28
Cynoscion arenarius	Sand seatrout	3	29
Diplectrum formosum	Sand perch	3	30
Gobiosoma longipala	Twoscale goby	3	31
Lutjanus griseus	Gray snapper	3	32
Prionotus tribulus	Bighead searobin	3	33
Scorpaena brasiliensis	Barbfish	3	34
Serranus subligarius	Belted sandfish	3	35
Callinectes sapidus	Blue crab	2	36
Haemulon plumierii	White grunt	2	37
Sphoeroides nephelus	Southern puffer	2	38
Syngnathus louisianae	Chain pipefish	2	39
Anchoa cubana	Cuban anchovy	1	40
Chasmodes saburrae	Florida blenny	1	41
Chloroscombrus chrysurus	Atlantic bumper	1	42
Cynoscion nebulosus	Spotted seatrout	1	43
Dasyatis americana	Southern stingray	1	44
Lucania parva	Rainwater killifish	1	45
Menticirrhus americanus	Southern kingfish	1	46
Monacanthus ciliatus	Fringed filefish	1	47
Opisthonema oglinum	Atlantic thread herring	1	48
Sciaenops ocellatus	Red drum	1	49
Serraniculus pumilio	Pygmy sea bass	1	50

Table 2-6 Dominant Fish Taxa Collected by the FWCC IMAP Sampling in Sarasota Bay During July 2001 Using All Gear

Scientific Name	Common Name	Total Abundance	Number of Samples
Eucinostomus spp.		3381	36
Lagodon rhomboides	Pinfish	1425	24
Harengula jaguana	Scaled sardine	672	2
Anchoa mitchilli	Bay anchovy	651	13
Lucania parva	Rainwater killifish	648	7
Orthopristis chrysoptera	Pigfish	330	24
Bairdiella chrysoura	Silver perch	304	16
Eucinostomus gula	Silver jenny	267	23
Gobiosoma spp.		250	19

Table 2-6 Dominant Fish Taxa Collected by the FWCC IMAP Sampling in Sarasota Bay During July 2001 Using All Gear

Scientific Name	Common Name	Total Abundance	Number of Samples
Farfantepenaeus duorarum	Pink shrimp	162	21
Floridichthys carpio	Goldspotted killifish	156	6
Microgobius gulosus	Clown goby	137	11
Eucinostomus harengulus	Tidewater mojarra	104	11
Callinectes sapidus	Blue crab	74	20
Cynoscion nebulosus	Spotted seatrout	60	14
Synodus foetens	Inshore lizardfish	54	21
Chilomycterus schoepfi	Striped burrfish	43	16
Prionotus scitulus	Leopard searobin	35	12
Syngnathus scovelli	Gulf pipefish	28	6
Menidia spp.		27	2
Paralichthys albigutta	Gulf flounder	27	13
Archosargus probatocephalus	Sheepshead	26	11
Lutjanus synagris	Lane snapper	25	7
Arius felis	Hardhead catfish	21	8
Leiostomus xanthurus	Spot	21	6
Gobiosoma robustum	Code goby	20	10
Lutjanus griseus	Gray snapper	20	6
Strongylura notata	Redfin needlefish	18	3
Menippe spp.		15	7
Dasyatis sabina	Atlantic stingray	13	10
Lactophrys quadricornis	Scrawled cowfish	12	8
Opsanus beta	Gulf toadfish	11	5
Monacanthus hispidus	Planehead filefish	10	7
Syngnathus louisianae	Chain pipefish	10	7
Menticirrhus americanus	Southern kingfish	9	5
Achirus lineatus	Lined sole	8	5
Ancylopsetta quadrocellata	Ocellated flounder	8	7
Limulus polyphemus	Horseshoe crab	8	5
Symphurus plagiusa	Blackcheek tonguefish	8	5
Microgobius thalassinus	Green goby	6	3
Cynoscion arenarius	Sand seatrout	5	4
Etropus crossotus	Fringed flounder	5	2
Ogcocephalus radiatus	Polka-dot batfish	5	1
Oligoplites saurus	Leatherjacket	5	3
Sphoeroides nephelus	Southern puffer	5	3
Syngnathus floridae	Dusky pipefish	5	3
Calamus arctifrons	Grass porgy	4	2
Chasmodes saburrae	Florida blenny	4	2
Serraniculus pumilio	Pygmy sea bass	4	1

Other fisheries data were available from a study completed by Serviss and Sauers (2003), who performed a synoptic inventory of juvenile fisheries habitat for the SBEP study area. This study area included all of Sarasota Bay, Roberts Bay North, and south through Blackburn Bay. Several sampling sites were in Sarasota Bay and were generally clustered around Leffis Key near southern Anna Maria Island, Tidy Island, Durante Park almost 3 miles south of Longboat Pass, Bowlees Creek, between Whitaker and Hudson Bayous, and near New Pass and Big Pass. Results are generally compatible with the FIM data, showing spot and mullet as among the most frequently observed species of recreational or commercial interest. Table 2-7 shows the results of the Serviss and Sauers (2003) sampling. Results are reported for all sampling gear for the entire Sarasota Bay estuary system.

Table 2-7 Dominant Fish Taxa Collected by Serviss and Saures (2003) Sampling in the Sarasota Bay Estuarine System Using 21.3-m and 6.1-m Boat Seines

Scientific Name	Common Name	Number Caught	Rank
Anchoa mitchilli	Bay anchovy	116,208	1
Lucania parva	Rainwater killifish	63,313	2
Leiostomus xanthurus	Spot	23,237	3
Menidia spp.	Assorted silverside	18,962	4
Eucinostomus spp.	Assorted mojarra	16,679	5
Lagodon rhomboids	Pinfish	15,890	6
Harengul jaguana	Scaled sardine	15,174	7
Gambusia holbrooki	Eastern mosquitofish	14,430	8
Poecilia atipinna	Sailfin molly	7,707	9
Mugil spp.	Assorted mullet	3,788	10
Mugil cephalus	Striped mullet	3,335	11
Cyprinodon variegatus	Sheepshead minnow	2,973	12
Floridichthys carpio	Goldspotted killifish	2,035	13
Anchoa cubana	Cuban anchovy	1,568	14
Fundulus grandis	Gulf killifish	1,348	15
Eucinostomus harengulus	Tidewater mojarra	1,308	16
Clupeidae spp.	Assorted herring	1,293	17
Fundulu majalis	Striped killifish	1,148	18
Microgobius gulosus	Clown goby	1,014	19
Eucinostomus gula	Silver jenny	724	20
Brevoortia spp.	Assorted menhaden	677	21
Anchoa hepsetus	Striped anchovy	433	22
Farfantepenaeus duorarum	Pink shrimp	336	23
Sphoeroides nephelus	Southern puffer	220	24
Strongylura notata	Red finneedlefish	146	25
Scomberomorus maculatus	Spanish mackerel	136	26
Lophogobius cyprinoides	Crested goby	110	27
Syngnathus scovelli	Gulf pipefish	110	28
Bairdiella chrysoura	Silver perch	100	29
Oligoplites saurus	Leatherjacket	94	30

Table 2-7 Dominant Fish Taxa Collected by Serviss and Saures (2003) Sampling in the Sarasota Bay Estuarine System Using 21.3-m and 6.1-m Boat Seines

Scientific Name	Common Name	Number Caught	Rank
Callinectes sapidus	Blue crab	86	31
Cynoscion nebulosus	Spotted seatrout	55	32
Gobiosoma spp.	Assorted goby	52	33
Orthopristis chrysoptera	Pigfish	51	34
Chilomycterus schoepfi	Striped burrfish	37	35
Opsanus beta	Gulf toadfish	35	36
Sciaenops ocellatus	Red drum	34	37
Heterandria formosa	Least killifish	31	38
Mugil curema	White mullet	26	39
Synodus foetens	Inshore lizardfish	23	40
Lucania goodei	Bluefin killifish	22	41
Gobiosoma robustum	Code goby	21	42
Strongylura timucu	Timucu	19	43
Syngnathus floridae	Dusky pipefish	18	44
Diplodus holbrooki	Spottail pinfish	16	45
Hippocampu zosterae	Dwarf seahorse	16	46
Gobiosoma bosc	Naked goby	13	47
Strongylura marina	Atlantic needlefish	13	48
Achirus lineatus	Lined sole	12	49
Centropomu undecimalis	Snook	12	50
Bathygobius soporator	Frillfin goby	12	51
Archosargu probatocephalus	Sheeps head	10	52
Mycteroperca microlepis	Gag	10	53
Fundulus spp.	Assorted killifish	10	54
Megalops atlanticus	Tarpon	7	55
Syngnathus louisianae	Chain pipefish	6	56
Micropterus salmoides	Largemouth bass	6	57
Lutjanus griseus	Gray snapper	5	58
Diapterus plumieri	Striped mojarra	5	59
Strongylura spp.	Assorted needlefish	5	60
Mugil gyrans	Fantail mullet	4	61
Pogonias cromis	Black drum	4	62
Fundulus confluentus	Marsh killifish	4	63
Trinectes maculatus	Hogchoker	4	64
Limulus polyphemus	Horseshoe crab	4	65
Chaetodipterus faber	Atlantic spadefish	3	66
Adinia xenica	Diamond killifish	3	67
Hyporhamphus spp.	Halfbeak (juv)	2	68
Sphyraena barracuda	Great barracuda	2	69
Aluterus schoepfi	Orange filefish	2	70
Calamus arctifrons	Grass porgy	2	71
Monacanthus hispidus	Planehead filefish	2	72

Table 2-7 Dominant Fish Taxa Collected by Serviss and Saures (2003) Sampling in the Sarasota Bay Estuarine System Using 21.3-m and 6.1-m Boat Seines

Scientific Name	Common Name	Number Caught	Rank
Lutjanus synagris	Lane snapper	1	73
Menticirrhu saxatilis	Northern kingfish	1	74
Paralichthys albigutta	Gulf flounder	1	75
Dasyatis say	Bluntnose stingray	1	76
Haemulon parrai	Sailors choice	1	77
Lepomis spp.	Bluegill	1	78
Selene vomer	Lookdown	1	79
Urophyci floridana	Southern hake	1	80

2.9 TIDAL CREEKS

2.9.1 The Resource and Its Functions

Tidal creeks are relatively small coastal tributaries that link between freshwater terrestrial and estuarine systems. Because of their close connection to the marine and freshwater systems, tidal creeks play a unique and integral role in the ecological function of coastal estuaries as:

- A source of high primary and secondary production.
- A site of nutrient cycling.
- A source of food for small-bodied fishes and crustaceans, as well as a foraging area for larger piscivorous fishes, wading birds, snakes and alligators.
- Nursery habitat for juvenile fishes and crustaceans of economic value, including oysters and the common snook.

Tidal creeks possess water quality characteristics that differ from freshwater systems and the open estuary. Because of their direct connection to watershed-based sources of nutrients and their smaller volumes and shallower depths relative to the open estuary, tidal creeks generally have relatively high nutrient and chlorophyll concentrations and low dissolved oxygen (DO) levels compared to the estuaries. DO levels from 2–4 mg/L are commonly observed in tidal creeks in the region, including relatively undisturbed systems. Higher nutrient concentrations and lower DO levels in tidal creeks relative to the estuary may be required to support the higher levels of primary and secondary production in these systems. Nutrient inputs from the watershed supply much of the energy that facilitates primary production in tidal creeks in the form of benthic microalgal communities and phytoplankton. The algal washes into the estuary to support upper trophic levels and drive secondary production by benthic macroinvertebrates, fishes, and crustaceans (Janicki Environmental, Inc., 2011).

Despite possessing water-quality conditions that would be considered impaired in many freshwater and estuarine systems, tidal creeks have been shown to support higher densities of many species of small-bodied fishes and other biota compared to the adjacent estuary and tidal river. Small-bodied fishes such the gulf killifish, sailfin molly, mosquitofish, and rainwater killifish spend their entire life cycle within tidal creeks. Oyster bars are often found at the mouths of tidal creeks. These species have adapted to the physio-chemical conditions of the creeks, which often have much higher variability than the open water estuary (Janicki Environmental, Inc., 2011).

Shoreline vegetation in many of tidal reaches of creeks in the Sarasota Bay system typically consists largely of red mangrove (*Rhizophora mangle*) or white mangrove (*Laguncularia racemosa*), especially in the more mesohaline to polyhaline reaches and transitions. Black needlerush (*Juncus roemerianus*) and cordgrass (*Spartina* spp.) are also found along the banks in the higher salinity reaches but are not nearly as common as mangroves. In the larger tidal tributaries with large watersheds, freshwater-tolerant and upland vegetation such as cattails (*Typha* spp.), leather fern (*Acrostichum danaeifolium*), buttonwood (*Conocarpus erectus*), and oak (*Quercus* spp.) occur as the tributary moves farther into the upland areas.

Unlike shallow embayments and open estuarine areas, submerged aquatic vegetation is often absent from tidal reaches of coastal creeks, perhaps due to the proximity to freshwater pulses and the resulting lower salinities found in tidal creeks. Occasionally, ephemeral beds of widgeon grass (*Ruppia maritima*) have been observed in the bays' tidal creeks, but seagrass beds consisting of turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*) are not typically found (Janicki Environmental, Inc., 2011).

Two tidal creeks are tributaries to Sarasota Bay—Whitaker Bayou and Hudson Bayou. The physiography and history of these creeks have been documented in Appendix A – Project Background and Physical Setting, Section 1.3. As reported, most of the tidal creeks and their watersheds have been developed for urban land uses, with little remaining natural wetlands and floodplain.

Sarasota County has collected water quality samples in these creeks monthly since 2006. Summaries of those data are provided in the Tributaries Water Quality Status and Trends section of this report, which also reports tidal creeks listed as "impaired" by the State's TMDL program. Sarasota Bay coastal creeks remain tidal, as defined by salinity data analysis, only a short distance upstream from the mouth, acquiring freshwater characteristics at or just upstream of US-41/Tamiami Trail, as shown in Figure 2-19 (Janicki Environmental, Inc., 2011). Despite the County's efforts, until recently most of the Sarasota Bay tidal creeks are in largely unstudied with respect to water quality (SBEP, 2011). Sarasota County is also conducting ecological monitoring and assessment in coastal creeks for the Sarasota County Tidal Creek Condition Index (TCCI). This section summarizes existing regulations that protect tidal creek functions and results of Sarasota County's TCCI for tidal creeks that are tributaries of Sarasota Bay.

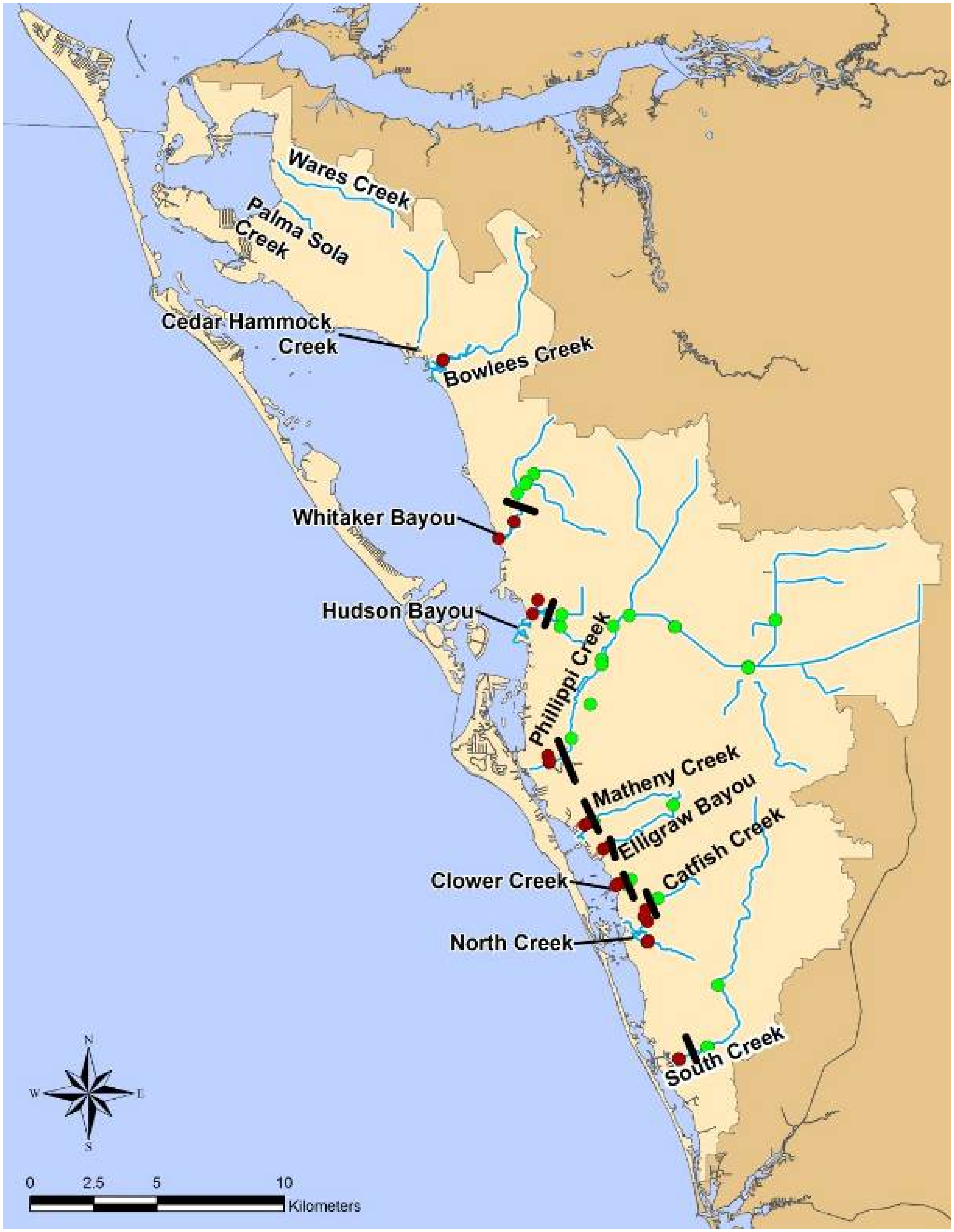


Figure 2-19 Approximate Location of the Upstream Limit of Tidal Reaches of Coastal Creeks in the Sarasota Bay Estuary System as Defined by Empirical Salinity Data Analysis

2.9.2 Existing Regulations for Resource Protection

The following regulations address the protection of tidal creeks, which can be accomplished by prohibiting dredging and filling in submerged lands, protecting water quality, limiting harvests, and providing public education. Local, state, and federal rules are included as appropriate.

Regulations specific to tidal creeks are presented below. Many laws and policies that protect seagrasses such as County policies and the FDEP ERP and water quality programs (discussed for other resources) also protect tidal creeks and are not repeated here.

2.9.2.1 Sarasota County

- Sarasota County Comprehensive Plan Chapter 2 – Environment: Management Guidelines for Tidal Creeks:

  - Prohibit dredging except to maintain existing previously permitted or grandfathered drainage canals, man-made canals and basins, and navigation channels as authorized by County Codes. Dredging shall be done in an environmentally sound manner as determined by the County, and impacts must be mitigated through a County-approved mitigation plan consistent with applicable regulations. The dredging of new navigation channels other than those just described shall be prohibited.

  - Reduce pollution entering coastal streams.

  - Prohibit filling.

  - Discourage shoreline hardening of bay shorelines and promote shoreline softening through vegetation projects.

  - Stormwater runoff from new development shall comply with governing regulations. The Sarasota County Stormwater Environmental Utility shall use best management practices to protect water quality of stormwater runoff to receiving waters. For wetland habitats, stormwater runoff from impervious surfaces must be pretreated before being discharged. Such facilities shall be designed and constructed in accordance with applicable regulations so that the discharge does not violate applicable local, state, or federal water quality standards or degrade the quality of the receiving waterbody. Water discharges into natural wetlands must be done by overflow and spreader swales to avoid degrading the ecosystem.

- Where appropriate, manage the volume, timing, and duration of stormwater discharge from new development in a manner to mimic as closely as possible the historical unaltered hydrologic conditions.

- If fill is stockpiled near a coastal stream, employ appropriate sediment control measures (e.g., hay bales, silt screens, etc.) to prevent sedimentation into the coastal stream. When building sites adjacent to coastal streams are elevated by filling, the same erosion control requirements apply and the fill must be stabilized to prevent entry of sediment into the stream.

Unless superseded by the watercourse buffer requirements contained within the County's Land Development Regulations, buffers of existing upland vegetation or planted upland vegetation that are sufficient in each case to protect the values and functions of coastal streams shall be required for a development, including new single-family residential structures, along all or portions of the coastal stream to protect these systems from adverse impacts. The required buffer width is 15 feet; however, in constrained situations, an average 15-foot-wide buffer may be allowed. In such averaging situations, the minimum buffer width shall be 5 feet.

2.9.3 Trend Analysis

2.9.3.1 Methods

Several datasets and technical documents were compiled and reviewed for this analysis:

- ❖ Annual data from Sarasota County TCCI monitoring program, 2008–2010.
- ❖ Sarasota Bay Numeric Nutrient Criteria: Tidal Creeks Letter Memorandum. 2011. Prepared by Janicki Environmental, Inc. Prepared for Sarasota Bay Estuary Program. Sarasota, Florida.
- ❖ SBEP. 2011. Sarasota Bay Tidal Creek Workshops Sampling & Measurement Program(s) for Sarasota Bay Tidal Creek. SBEP Technical Advisory Committee. Sarasota, FL.
- ❖ Tidal Creek Condition Index for Coastal Streams in Sarasota County, Florida (Estevez, 2007).

Sarasota County's Environmental Services Business Center sought to develop an easily understood and ecologically valid TCCI to compare the ecological conditions of tidal creeks within the County's watersheds and to track changes in tidal creek health over time (Estevez, 2007). Creeks are scored on a variety of ecological measures including selected benthos abundance and diversity, oyster survival and size, and filamentous algae and periphyton coverage. Data obtained for the County's tidal creeks for 2008 through 2010 were assessed, and all creeks in the County were ranked according to TCCI scores.

2.9.3.2 Results and Discussion

Sixteen tidal creeks in Sarasota County are assessed annually. Two tidal creeks, Whitaker Bayou and Hudson Bayou, are in Sarasota Bay. Based on the scoring criteria used by Estevez (2007), Whitaker Bayou was ranked lowest of the creeks scored and Hudson Bayou was scored mid-range.

The TCCI scoring criteria were developed in 2008. Median TCCI scores for each creek were averaged for 2008 through 2010 data. Creeks are scored on a variety of features, with higher scores more desirable. Of the 16 tidal creeks that were scored, Whitaker Bayou ranked 16th and Hudson Bayou ranked 12th. The low scores suggest that these are significantly altered creek systems with ecological stresses caused by their urbanized watersheds. Whitaker Bayou scored high in percent-live oysters and filamentous algae cover, as did many other creeks, but scored low on the other eight criteria. Hudson Bayou also scored high in percent-live oysters and filamentous algae cover, as well as periphyton cover, but scored moderate to low on the other criteria. Figure 2-20 shows the results of the 2008 through 2010 scoring with Sarasota Bay creeks indicated by the arrows .

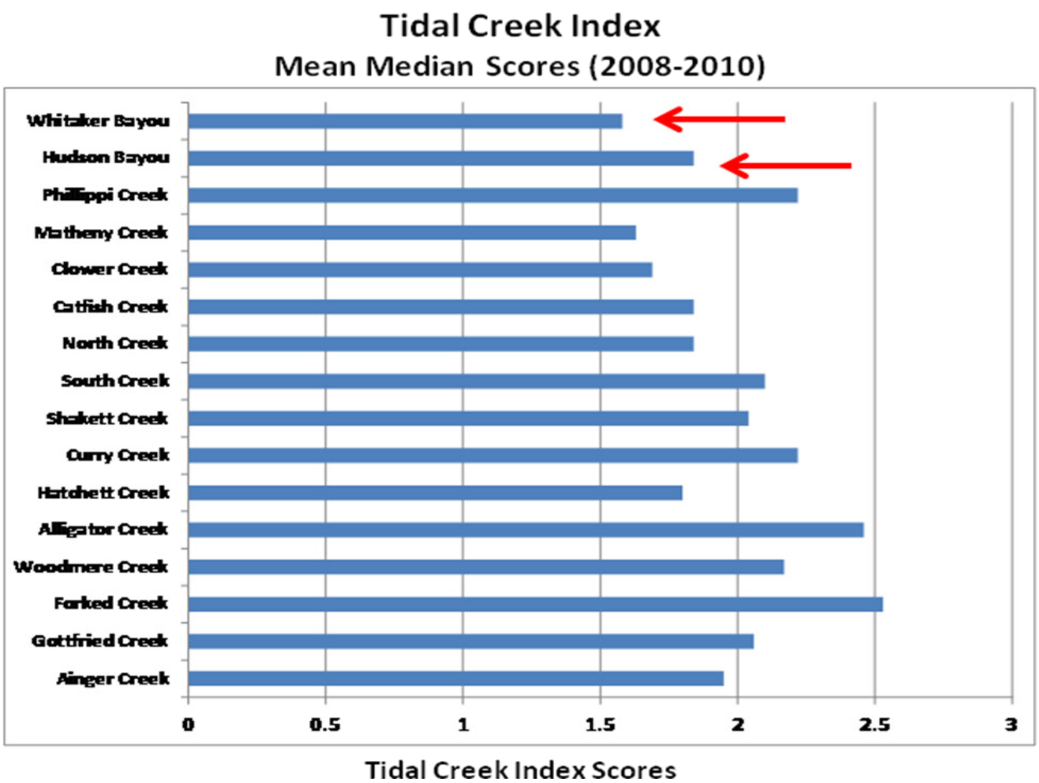
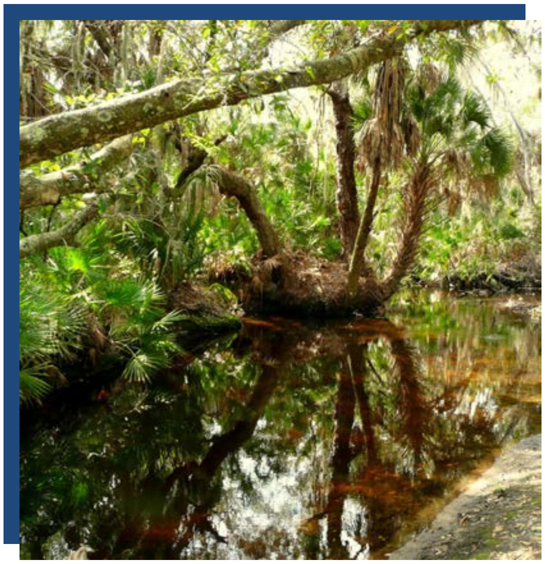


Figure 2-20 Tidal Creek Condition Index Scores (2008–2010)
Creeks in the Sarasota Bay watershed are shown with arrows.

As part of the WQMP, the TCCI is intended to be used as a watershed management tool to document the relative health of tidal creeks within the County. The index scores will provide a valuable component of the overall assessment Sarasota Bay to ensure its proper stewardship.

3.0 FRESHWATER NATURAL SYSTEMS

3.1 STREAMS

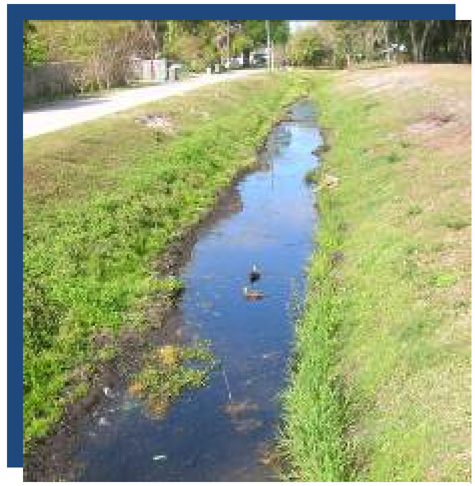


Small streams and wetlands provide crucial linkages between aquatic and terrestrial ecosystems and between upstream watersheds and tributaries and the downstream rivers and lakes. Scientists often refer to the benefits humans receive from the natural functioning of ecosystems as ecosystem services. The special physical and biological characteristics of intact small streams provide natural flood control, recharge groundwater, trap sediments and pollution from fertilizers, recycle nutrients, create and maintain biological diversity, and sustain the biological productivity of downstream rivers, lakes, and estuaries. These ecosystem services are provided by seasonal as well as perennial streams and wetlands. Even when such systems have no visible overland connections to the stream network, small streams and wetlands are usually linked to the larger network through groundwater.

Small streams offer an enormous array of habitats for plant, animal, and microbial life. These systems provide shelter, food, protection from predators, spawning sites and nursery areas, and travel corridors through the landscape. Many species depend on small streams and wetlands at some point in their lives. Materials that wash into streams include everything from soil, leaves, and dead insects to runoff from agricultural fields and animal pastures. One of the key ecosystem services that stream networks provide is filtering and processing such materials. Healthy aquatic ecosystems can transform natural materials like animal waste and chemicals such as fertilizers into less harmful substances. Small streams and their associated wetlands play a key role in storing and modifying potential pollutants, such as chemical fertilizers, in ways that maintain downstream water quality. Recycling organic carbon contained in the bodies of dead plants and animals is an additional very important ecosystem service. Ecological processes that transform inorganic carbon into organic carbon and recycle organic carbon are the basis for every food web on the planet. In freshwater ecosystems, much of the recycling happens in small streams and wetlands, where microorganisms transform everything from leaf litter and downed logs into food for other organisms in the aquatic food web, including macroinvertebrates, frogs, and fish. Like nitrogen and phosphorus, carbon is essential to life but can be harmful to freshwater ecosystems if present in excess or in the wrong chemical form. If all organic material received by headwater streams and wetlands went directly downstream, the glut of decomposing material could deplete oxygen in the downstream estuary, thereby damaging and even killing fish and other aquatic life.

The ability of headwater streams to transform organic matter into more usable forms helps maintain healthy downstream ecosystems.

The health of Sarasota Bay's small streams is critical to the ultimate health of Whitaker Bayou, Hudson Bayou, and Sarasota Bay. The health of streams is often linked to changes that occur to the stream channel such as dredging, straightening, and removing the bank and adjacent vegetation. Where channel morphology is modified or structural features are added, stream dynamics and energy dissipation can change significantly. Channelization of naturally meandering creeks results in increased stream velocities and bank erosion, which can produce large pulses of freshwater that can decrease the salinity in the bay.



Channelized Whitaker Bayou Tributary in North Water Tower Park

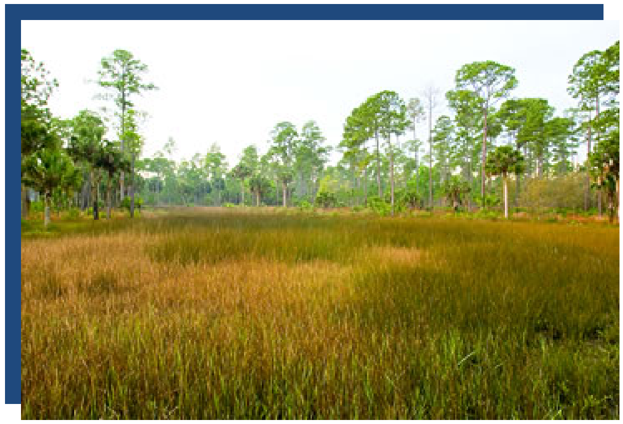
Due to the extensive residential and commercial development that has occurred in Sarasota Bay, a majority of the Whitaker and Hudson Bayous' freshwater tributaries have been dredged and channelized and are referred to as canals. To prevent further degradation of water quality and habitat, emergent vegetation and vegetated banks must be maintained so that the canals can enhance rather than degrade downstream water quality. However, because the canals are a primary component in the surface water management system, adequate conveyance capacity must be maintained in the canals to minimize upstream or downstream flooding. Jones Edmunds investigated opportunities to enhance freshwater stream/canal systems on public lands. Potential stream enhancement projects are presented in this WQMP.

3.2 WETLANDS

A wetland is an area that is inundated (flooded) or saturated (soaked) by ground or surface water frequently or for prolonged periods, often and long enough to support vegetation typically adapted for life in saturated soils. Wetlands are habitats that have both hydric (wet) soils and vegetation. Wetlands types found in Florida include bayheads, cypress wetlands, deep marshes, hardwood swamps, hydric hammocks, shallow marshes, and wet prairies.

3.2.1 Value and Function

Through the years public perception of wetlands has varied, with wetlands mostly seen as breeding grounds for mosquitoes and other pests or as nuisances that needed to be drained so the land could be used. Wetlands were believed to be useful only to produce peat and fossil fuels or to be drained as sites for agriculture.



Wetlands serve valuable functions that benefit everyone including:

- Cleaning, or filtering, pollutants from surface waters.
- Storing water, e.g., from storms or runoff with reduces flood risk and promotes infiltration.
- Providing natural stormwater conveyances to reduce the risk of flood damage to developed lands.
- Recharging groundwater.
- Serving as nurseries for saltwater and freshwater fish and shellfish that have commercial, recreational, and ecological value.
- Serving as the natural habitat for a variety of fish, wildlife, and plants, including rare, threatened, endangered, and endemic (native) species.

Wetlands are often referred to as the 'kidneys' of the landscape and are a significant factor in the health and existence of other natural resources of the watershed, such as rivers, streams, lakes, groundwater, wildlife, and estuaries. Wetlands play a key role in storing and modifying potential pollutants, such as chemical fertilizers, in ways that maintain downstream water quality. They also export organic carbon to streams and other downstream water bodies. In limited amounts, organic carbon is essential to maintaining a healthy aquatic ecosystem.

3.2.2 Historical Trends

Based on 1940s aerial imagery, the Sarasota Bay watershed contained approximately 11,463 acres of freshwater wetlands with herbaceous depressional marshes comprising 78% of the total wetland acreage (Figure 3-1). In 2008, Sarasota Bay had 1,384 acres of freshwater wetlands; 571 acres are herbaceous and 813 acres are forested (Figure 3-2). This is an 88% loss in wetland acreage for this 60-year period. Wetland losses are primarily due to filling to convert land to residential and commercial use or dredging to make water features (Figure 3-1 and Figure 3-2).

An important component of any WQMP is to identify locations and develop subsequent projects on public lands that enhance the natural systems within the watershed. These enhancements can result in a diversity of results such as increasing wildlife habitat quality, attenuating stormwater flows, enhancing downstream water quality, and reducing erosion and sediment loading. Additionally, these projects can offer important public education opportunities by using kiosks or serving as demonstration sites.

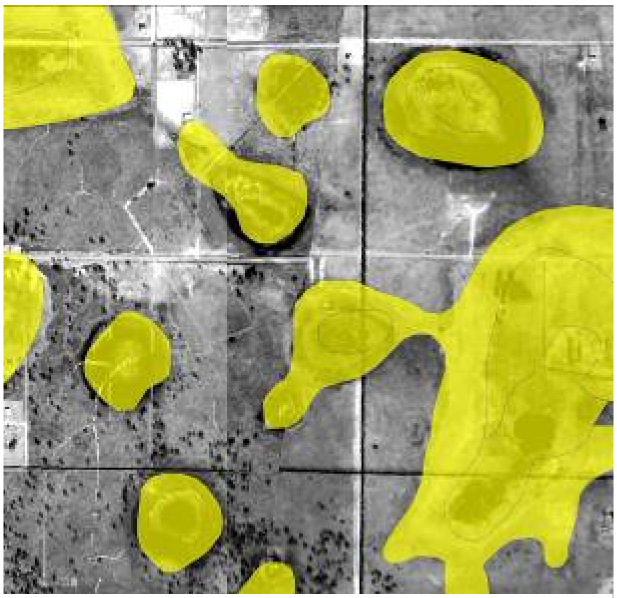


Figure 3-1 Pre-Development Aerial Depicting Numerous Freshwater Wetlands

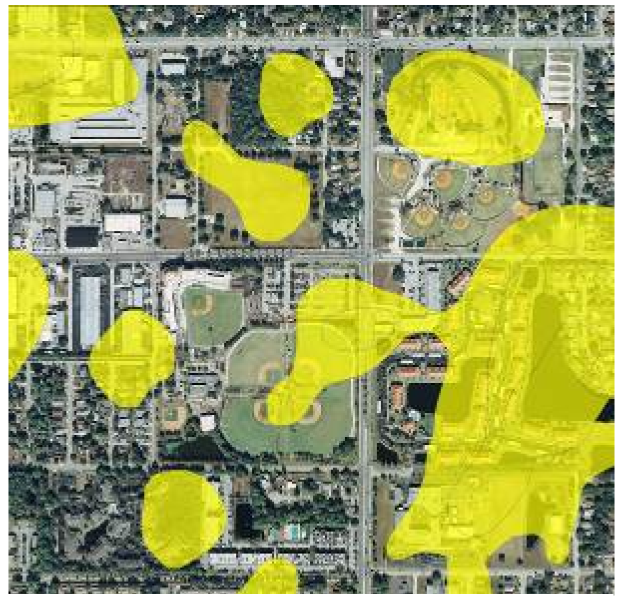


Figure 3-2 2011 Aerial Depicting Historical Wetlands Now Residential and Commercial Land Uses

4.0 NATURAL SYSTEM HABITAT ASSESSMENT AND POTENTIAL IMPROVEMENTS STRATEGY

4.1 INTRODUCTION

Jones Edmunds completed a desktop GIS analysis and identified potential habitat-improvement opportunities on public lands in the Sarasota Bay watershed with a focus on enhancing, restoring, or creating wetlands to improve the watershed's hydrologic, hydraulic, or water quality functions. As a result, an emphasis was placed on public lands that contained wetlands due to their importance and influence on on-site or downstream water quality and quantity. Jones Edmunds identified potential sites based on a GIS desktop assessment using available digital datasets. These sites were compiled into a table and distributed to the County project manager and stakeholders to review. Jones Edmunds also coordinated extensively with County staff and SBEP and its consultants (Scheda Environmental, Inc. and Wilson Miller) to determine if the sites identified by Jones Edmunds were being reviewed and conceptual designs were being developed under their contract with SBEP or if known encumbrances (easements, County/City proposes infrastructure projects, etc.) were on selected sites.

Data collected at the identified sites during preliminary field assessments and subsequent analysis were used to develop conceptual designs with an emphasis on improving natural systems habitat within publicly owned properties. The intent of these improvements is to enhance on-site natural systems and water quality or downstream receiving waters. Any observations of listed wildlife species were recorded, but listed wildlife-species-specific surveys were not part of the preliminary field assessments.

4.2 HABITAT IMPROVEMENT OPPORTUNITIES

Jones Edmunds identified potential habitat-improvement opportunities in the Sarasota Bay watershed. Project and site-selection methodology are provided in the following subsections. Analysis and project and programmatic recommendations to improve habitat in Sarasota Bay and its tributaries can be found in Appendix G.

4.2.1 Methodology

4.2.1.1 Data Compilation and Analysis

Jones Edmunds used GIS to compile and review numerous public lands shapefiles obtained from the Sarasota County GIS library, the Sarasota County Environmentally Sensitive Lands Program (ESLPP), SBEP, and SWFWMD:

- ESLPP parcels
- Neighborhood parklands

- Public- and agency-owned lands
- SWFWMD
- Airport Authority
- Hospital
- School Board
- Federal
- State
- City

Jones Edmunds selected all public lands greater than 1 acre that contained or were adjacent to native wetland communities (FLUCCS_ID = 6XXX) and reviewed them in GIS. One-foot topography and County hydrography datasets were then used to review each potential site for connectivity to downstream receiving waterbodies. In addition, an emphasis was placed on those sites that were hydrologically connected to off-site wetlands or surface waters. Digital historical aerial photographs were also compiled for some sites from the Florida Department of Transportation and the University of Florida Map Library.

4.2.1.2 Field Investigations

Jones Edmunds identified 13 potential habitat improvement sites during the GIS analysis. Jones Edmunds visited all 13 sites in March 2011 to characterize the vegetation communities, identify any listed wildlife species using the site, determine if the wetlands were hydrologically impacted, and identify habitat or water quality improvement opportunities. At each site, habitat or water quality improvement opportunities and existing land use were documented. Unique features, the limits of existing communities, and the limits of proposed activities were located with a handheld global positioning system (GPS). Additionally, the on-site vegetative communities were categorized according to the 1999 FLUCCS developed by the Florida Department of Transportation.

4.2.1.3 Results and Discussion

The County and local stakeholders (City of Sarasota, SBEP, etc.) have implemented or are developing conceptual designs for numerous habitat and water quality improvement projects in the Sarasota Bay watershed. Table 4-1 documents these projects.

Jones Edmunds reviewed and discussed the potential opportunities on the 13 sites that were field-assessed with County staff and stakeholders and are summarized in Table 4-2. After this review, the County and Jones Edmunds recommended the following six sites for conceptual design and presentation in this section of the WQMP:

1. Arlington Park
2. Bayfront Park and Marina
3. Longboat Key Bayfront Park

4. North Water Tower Park
5. Payne Park
6. Hudson Bayou Oak Street Canal

The locations of these six sites are shown on Figure 4-1. The following presents vegetation community descriptions and proposed habitat improvement activities. Including proposed projects does not confer any special status, approval, permitting, standing, or funding from SWFWMD. All proposed projects are subject to regulatory review and permitting. Requests for funding assistance will have to meet the requirements of funding programs and be subject to the SWFWMD's Governing Board appropriating funds.

Table 4-1 Summary of Completed Habitat Improvement or LID Projects Completed or in Design in Sarasota Bay

Site ID*	Site Name	Project Location	Project Status	Responsible Agency	Project Activities
1	Airport/Crosley Connection	8374 North Tamiami Trail	Conceptual Design Complete		Update stormwater.
2	Alderman/Brother Geenen	West end of Brother Geenen Way	In Conceptual Design		Install LID elements and kayak launch.
3	Anna Maria/Holmes Beach Stormwater	Holmes Beach	Conceptual Design Complete		Retrofit existing stormwater outfalls, install bioswales, create wetland treatment areas, and improve shoreline. Further investigation into the feasibility and exact locations for improvement projects should be conducted to determine the overall treatment benefits relative to the costs.
4	Bayfront Drive North	Bayfront Drive	In Conceptual Design		Construct bioswale system and detention pond, divert low flows into area, and install curb cuts on the east side of Tamiami Trail to allow runoff into the area.
5	Bayfront Drive South	Bayfront Drive	In Conceptual Design		Construct bioswale and detention pond, divert low flows into area, and install curb cuts on the east side of Tamiami Trail to allow runoff into the area.
6	Sarasota BayWalk	City Island, Sarasota	Complete		Excavated six lagoons, planted with native upland species in spoil upland, and installed more than 20,000 shoreline plantings.
7	BayWalk Creek	Sarasota	Underway		Conduct extensive exotic plant removal and native plantings and conceptual design of pedestrian bridge over the creek.
RBNS06	Beekman Place	the Village at Beekman Place and Hidden Forest neighborhoods	Conceptual Design Complete		Enhance wetland and wetland buffer and remove exotic plants.
RBNS01	Circus Hammock	17th street near Bobby Jones Golf Course	Conceptual Design Complete		Increase hydroperiod of wetland, remove exotic plants, and enhance wetland buffer and wetland.
8	Edwards Islands	Roberts Bay	Conceptual Design Complete		Primarily remove exotic plant proposed (opposition from residents), create native coastal hammock, stabilize shoreline, and enhance to reduce erosion.
9	FISH Preserve	Cortez Road	Phase I Complete		Create intertidal wetland and restore upland (exotic removal and planting).
10	Gladiola Fields Oyster Restoration	West of 75th Street West and 53rd Street West	Conceptual Design Complete		Construct a pilot oyster habitat restoration project (SBEP in conjunction with Manatee County).
11	Grassy Point Preserve	3401 East Bay Drive	Conceptual Design Complete		City of Holmes Beach and SBEP designed and permitted initial habitat restoration project in 2007, which included removing exotic vegetation, enhancing upland with native coastal hammock plantings, creating saltmarsh, enhancing wetland, and installing boardwalk. Current phase includes removing additional exotic vegetation and retrofitting stormwater. Upland restoration planting completed in March 2012.
12	Hudson Bayou	Sarasota High School, School Avenue	Unknown		Remove exotic plants, plant native plants along eroded bank, construct treatment wetland pockets, enhance wetland enhancement, and construct vegetated bioswale.
13	Indian Beach/Sapphire Shores	5015 Sun Circle	Conceptual Design Complete		Install bioswales, retrofit three relatively large stormwater outfalls, install gross-pollutant-removal structures, install rip rap at the toe of existing seawall, and restore oysters.
14	Indian Beach/Sapphire Shores	5015 Sun Circle	Conceptual Design Complete		40th Street Project – Remove existing pipe, replace with gross-pollutant-removal structure, and create bioswale with stabilization at pipe end. Marlin Site – Re-contour existing bioretention area, plant native plants in wetland, and create bioswale.

Table 4-1 Summary of Completed Habitat Improvement or LID Projects Completed or in Design in Sarasota Bay					
Site ID*	Site Name	Project Location	Project Status	Responsible Agency	Project Activities
15	Ken Thompson	Ken Thompson Park	Complete		Re-establish 2 acres of mangrove tidal wetlands.
RBS01	Main A Channel & Celery Fields Confluence	Main A Channel & Celery Fields Confluence	Conceptual Design Complete		Create wetland and stabilize slope with native plantings.
RBS02	Main A channel and Celery Fields	I-75/Fruitville Road	Conceptual Design Complete		Stabilize banks with soil amendment and native vegetation and remove exotic vegetation.
RBS07	Main B Channel	Beneva Rd Carwash	Conceptual Design Complete		Stabilize bank, construct treatment wetland, and plant native vegetation.
16	Matheny Creek	Gulf Gate Subdivision	Unknown		Stabilize bank, install gross-pollutant-removal structures, create more sinuous creek signature, and create treatment wetland.
17	Neal Preserve	12301 Manatee Avenue	Partially Complete		Install recreational features (trails, observation towers, etc.) and restore wetland and upland (complete).
18	New Pass	1700 Ken Thompson Pkwy	Complete		Manage vegetation.
19	North Lido Beach Park	Benjamin Franklin Drive	Phase I Complete		Habitat improvement and enhancement project designed and permitted in 2009 including removing large Australian pine and Brazilian pepper, creating a tidal creek that will connect to the Pansy Bayou, creating high and low marsh wetland, and restoring upland coastal hammock. Phase II consists of removing remaining Australian pine, maintaining Brazilian pepper removal area, and supplemental plantings in the dune system and coastal hammock.
20	Perico Bayou	11700 Manatee Avenue	Conceptual Design Complete		Remove exotic plants and plant native vegetation.
21	Phillippi Estates Park	5500 US-41	Conceptual Design		Remove exotic vegetation, fill mosquito ditch, create bioswale, and install gross-pollutant-removal structures.
22	Pinecraft Park	1420 Gilbert Avenue	In Conceptual Design		Regrade and stabilize shoreline, enhance ditch, and removed exotic plants. Scheda is developing the plans.
RBWQ03	Proctor Road at Phillippi Creek	Proctor Road	Conceptual Design Complete		Create wetland and wetland buffer.
23	Quick Point Nature Preserve	100 Gulf of Mexico Drive	Complete		Remove exotic vegetation, enhance shoreline, and create saltmarsh and mangrove swamp. This joint habitat improvement project was completed in 1999 by SBEP, Town of Longboat Key, and Sarasota County.
24	Rattlesnake Island	Lyons Bay	Conceptual Design Complete; Partial Project Completion		Remove Australian pine in 2010, remove and maintain exotic vegetation, install a living shoreline on the east side, and create a tidal creek and associated saltmarsh.
25	Red Bug Slough	5200 Beneva Road	Complete		Stabilize channel stabilization, restore stream, remove exotic vegetation, and create wetland (treatment and habitat).
RBNS04	River Ridge Oxbow	Phillippi Creek, S. of Hyde Park to N. of Webber	Conceptual Design Complete		Enhance wetland and dredge to elevation that will result in 1 to 2 feet of standing water during the wet season to create an emergent marsh.
26	Skiers Island	Roberts Bay	Conceptual Design Complete		Remove exotic vegetation and create native coastal hammock and plant with oaks, myrsine, seagrape, and green buttonwood. Future work may stabilize shoreline and enhance to reduce wave erosion.

Table 4-1 Summary of Completed Habitat Improvement or LID Projects Completed or in Design in Sarasota Bay

Site ID*	Site Name	Project Location	Project Status	Responsible Agency	Project Activities
27	South Lido Beach park	400 Benjamin Franklin Drive	Phase I Complete		Several habitat restoration, enhancement, and creation projects have been completed since 2001 including high and low marsh creation, tidal creek creation, exotic removal, and dune restoration. Current phase removes spoil mound and exotic vegetation. SBEP applied in March 2011 for funds under the NOAA Estuary Habitat Restoration Program to support large-scale habitat restoration at South Lido.
RBWQ01	The Landings to Phillippi Shores Park	The Landings	Conceptual Design Complete		Construct biofiltration swale and create treatment wetland.
RBS12	Tuttle Avenue Bridge to America Drive	Turtle Avenue	Conceptual Design Complete		Plant mangroves, install gross-solids and sediment-removal baffle box, construct stormwater treatment and bioretention swale, and monitor the site.
28	Ungerelli Property	4000 Palma Sola Boulevard	Conceptual Design Complete		Remove exotic vegetation (underway), restore saltmarsh, fill mosquito ditch, and create bioswale.
RBNS03	Urfer Family Park	Bee Ridge/Honore	Conceptual Design Complete		Restore cattle pond to emergent marsh wetland, remove exotic species, plant native vegetation, and enhance wetland buffer.
29	Whitaker Bayou (MLK Park)	2524 Coconut Avenue	In Design		Remove compromised vertical seawall and rip-rap, re-stabilize bank, plant native vegetation, create treatment wetland, and install bioswales and gross-pollutant-removal structures.
30	Whitaker Bayou 32nd Street Greenway Park	Greenway Park	Conceptual Design Complete		Reduce sediment and nutrient load, create and enhance habitat, intercept ditch into bioretention area planted with wetland vegetation, stabilize bank, and construct treatment wetland.

*Sites assigned a "RB" Site ID are projects proposed by Jones Edmunds in the 2010 Roberts Bay North Water Management Plan.

Table 4-2 Summary of Sarasota Bay Field Investigated Potential Habitat Improvement Sites					
Site Name*	Owner	Potential Activity	Watershed Tour Site	Acres	Comments
Arlington Park	**City of Sarasota**	**Stormwater treatment wetland**	**No**	**17.2**	**Hudson Bayou headwaters**
Bayfront Park and Marina	**City of Sarasota**	**Living shoreline**	**Yes**	**1.4**	
Longboat Key Bayfront Park	**City of Longboat Key**	**Stormwater Treatment Wetland; Bioretention**	**No**		
North Water Tower Park	**City of Sarasota**	**Stormwater treatment wetland; Wetland enhancement**	**No**	**21.4**	**Hydrologically isolated; Near Wilson Miller "hot spots"**
Payne Park	**City of Sarasota**	**Stormwater treatment wetland**	**No**	**39.5**	
Hudson Bayou Oak Street Canal	**City of Sarasota**	**In-stream enhancement**	**No**		**Recommended by KWestover**
Hatton Street Ditch	School Board	Stormwater treatment wetland	No	34.2	Very limited space for treatment
Luke Wood Park	City of Sarasota	Riparian Habitat Enhancement (Kayak/Canoe Launch)	Yes	13.5	Lift station to be built and project proceeding with FDEP
North Lido Public Beach	City of Sarasota	Exotic removal	No	23.2	SBEP and Scheda working on portion of site. Other work to be done per Jay Leverone of SBEP.
Pioneer Park	City of Sarasota	Exotic removal / Create riparian habitat	Yes	6.9	
Ringling School of Art / MLK Park	Ringling School of Art & Design, Inc.	Shoreline Restoration / Habitat Enhancement (Kayak/Canoe Launch)	Yes	1.2	Wilson Miller working with SBEP for conceptual design per Molly Williams on 02/28/11.
South Lido County Park	Sarasota County	Exotic removal	Yes	145.6	SBEP and Scheda working on portion of site. Other work to be done per Jay Leverone of SBEP.
Whitaker Gateway Park	City of Sarasota	Stormwater treatment wetland / Bioretention areas	No	8.4	Several stormwater ponds installed

*Sites in **bold** were selected for conceptual designs. The other sites were assessed in the field but not selected due to various reasons.

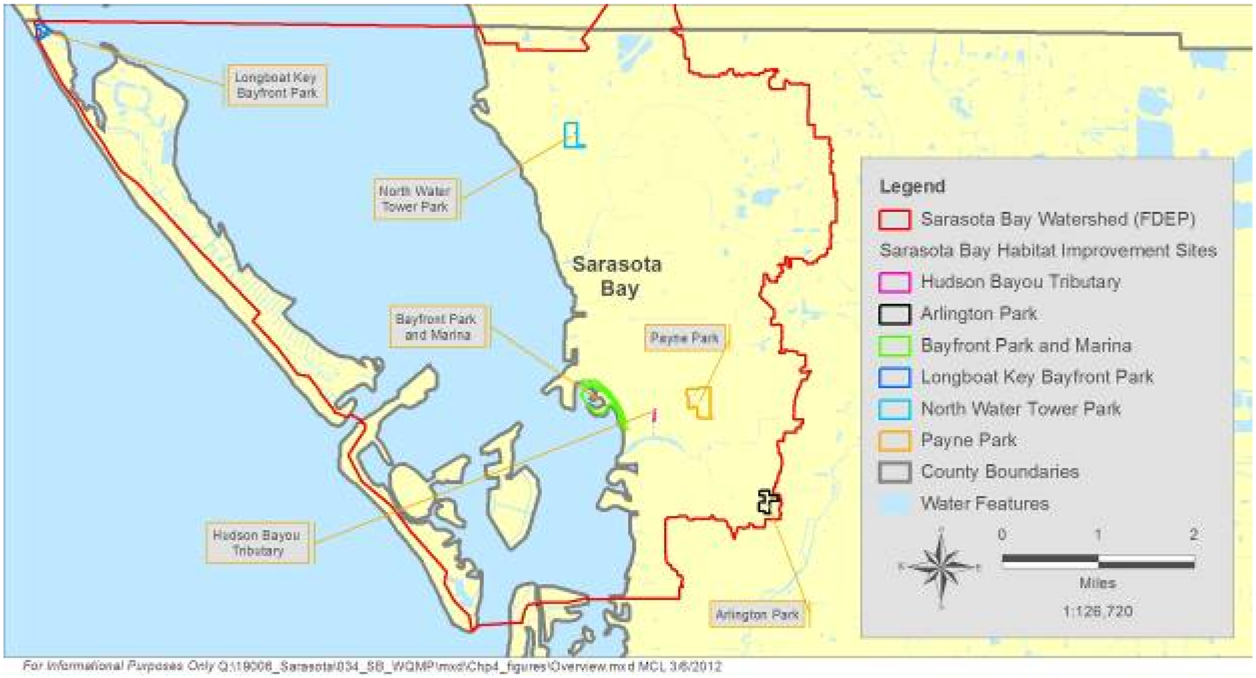


Figure 4-1 Site Overview Map

4.3 ANALYSIS\RECOMMENDATIONS

The following sections provide investigation summaries and recommendations for the selected project sites to help improve habitats in the Sarasota Bay watershed.

4.3.1 Arlington Park

Arlington Park is an approximately 17-acre County park west of the Arlington Street and South Tuttle Avenue intersection (Figure 4-2 and Figure 4-3).

Figure 4-2 Arlington Park Location Map

Figure 4-3 Existing Land Use for Arlington Park

4.3.1.1 Site Description

This site contains an isolated Mixed Hardwood Wetland (FLUCCS Code 6170) in the southwest corner of the park dominated by red maple (*Acer rubrum*), laurel oak (*Quercus laurifolia*), bulrush (*Scirpus* sp.), spadderdock (*Nuphar luteum*), buttonbush (*Cephalanthus occidentalis*), red maple (*Acer rubrum)*, and popash (*Fraxinus caroliniana)* along the banks (Photograph 1). A wetland buffer of approximately 15 to 40 feet is present around this wetland, which is dominated by live oak (*Quercus virginiana)*, laurel oak, wax myrtle (*Myrica cerifera)*, salt bush (*Baccharis halimifolia*), and scattered Brazilian pepper (*Schinus terebinthifolia)*. (Photograph 1).

Photograph 1 On-site Isolated Wetland in Northwest Region of Park

A ditch west and south of the wetland connects to the park's water feature and is dominated by pickerelweed (*Pontederia cordata)*, bog hemp (*Boehmeria cylindrical)*, marsh pennywort (*Hydrocotyle umbellata)*, panicgrass (*Panicum* sp.*)*, smooth beggarticks (*Bidens laevis*), and creeping primrosewillow (*Ludwigia repens)* (Photographs 2 and 3). A large weir impounds the pond at the connection of this ditch (Photograph 4). A larger Mixed Hardwood Wetland (FLUCCS Code 6170) is in the central portion of the park and is dominated by live oak, sweetbay (*Magnolia virginiana)*, sweetgum (*Liquidambar styraciflua)*, cabbage palm (*Sabal palmetto)*, and Brazilian pepper, with an understory of Boston fern (*Nephrolepis exaltata)* and air potato vine (*Dioscorea bulbifera*) (Photograph 5). This wetland is directly connected to the on-site pond via a drainage ditch. A third wetland dominated by exotic palms, Brazilian pepper, taro (*Colocassia esculenta)*, cinnamon fern (*Osmunda cinnamomea*), Boston fern, red maple, and laurel oak is in the northeast corner of the site. This wetland connects to the larger central wetland via a shallow swale. Adjacent uplands are primarily Temperate Hardwood Hammock (FLUCCS Code 4250) dominated by laurel oak, live oak, sabal palm, red maple, and greenbrier (*Smilax* sp.).

A large pond in the center of Arlington Park has little or no littoral vegetation (Photograph 6) and appears to have very poor water quality based on clarity and the suspended algae observed. The pond is regularly mowed to the edge of the water and evidence of bank erosion occurring in several locations exists (Photograph 7).

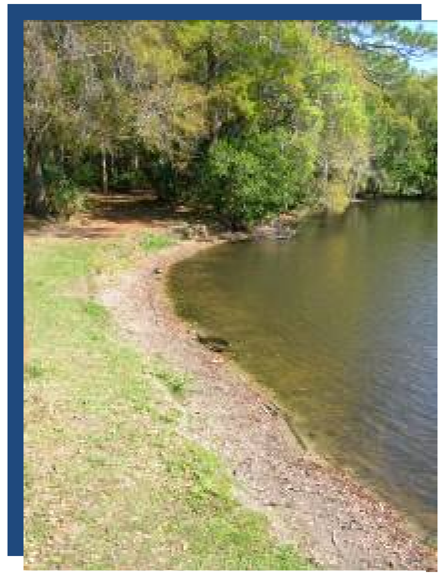
Photograph 2 Looking North of Ditch that Runs along Northwest Boundary of Park

Photograph 3 Looking East of Ditch

Photograph 4 Weir at South End of Pond

Photograph 5 Wetland North of Pond

Photograph 6 Facing Southwest of the Pond in the Center of Site



Photograph 7 West Bank of the Pond

4.3.1.2 Proposed Habitat Improvement

Wetland Enhancement—Jones Edmunds proposes to enhance the central Mixed Wetland Hardwood system by removing Brazilian pepper, Boston fern, air potato, and any other invasive exotic vegetation that is observed (Figure 4-4). This enhancement will help restore a native understory and midstory strata in this wetland and improve wildlife utilization. Exotic removal could be accomplished by soliciting the assistance of neighborhood associations or youth organizations. Bay Guardians have "air potato round-ups," at North Water Tower Park and other parks that are very successful and could greatly assist City/County staff in removing exotics and provide an educational experience for residents. Additionally, such removals must be conducted routinely (bi-annually) for at least 2 years to ensure that the species are no longer present.

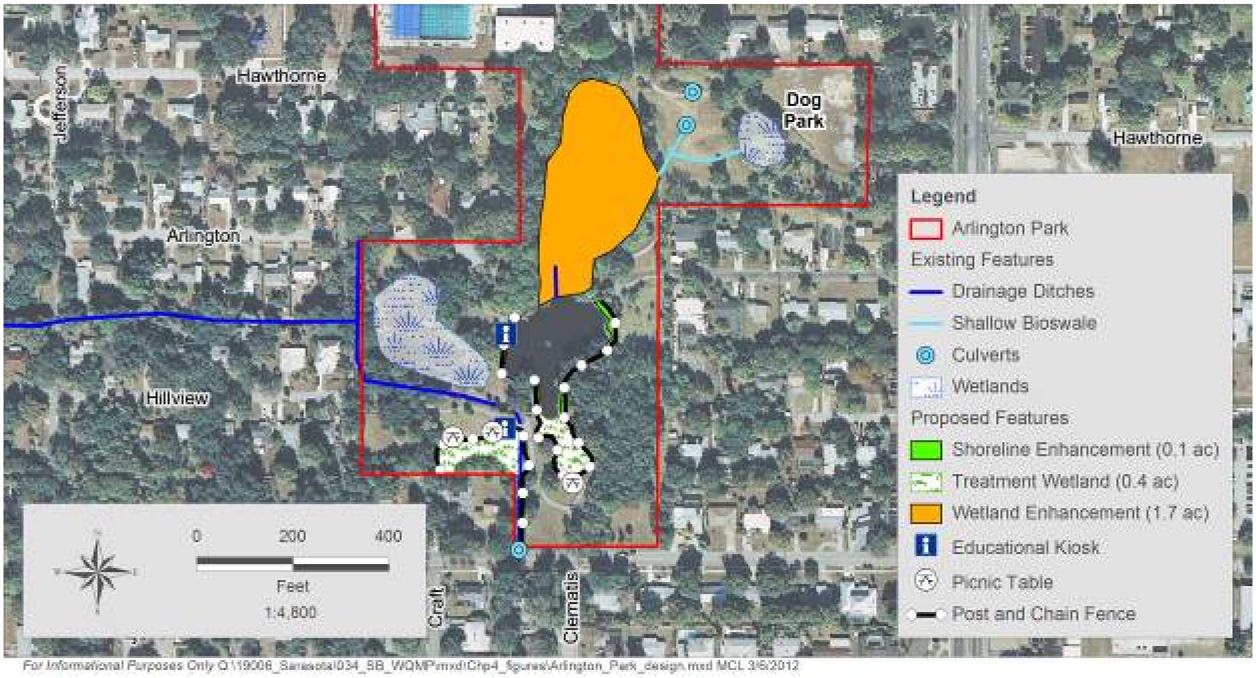


Figure 4-4 Arlington Park Habitat Improvement Conceptual Plan

Treatment Wetland Creation—Jones Edmunds recommends excavating the two existing turf grass areas at the south end of the park to create shallow depressional treatment wetlands totaling 0.4 acre (Figure 4-4). For the west treatment wetland, an existing swale flows north, draining residential areas to the south (Photograph 8). This swale currently flows directly into the pond with little or no treatment. Jones Edmunds proposes to create the treatment wetland adjacent (west) to this swale to detain and provide additional treatment before it discharges into the pond (Photograph 9). Stormwater flows will be diverted into this area using a diversion weir set in the existing swale. A drop structure will discharge flow from the treatment wetland to the water feature via a pipe.

Picnic benches and a kiosk area are also proposed to provide viewing and education opportunities for park visitors. Table 4-3 lists potential native species that would be appropriate to install in the west treatment wetland. These species were selected assuming that the wetland will be a flashy system due to intermittent stormwater flows and thus only inundated for brief periods.

Photograph 8 Ditch at South End of Site Flowing North

Photograph 9 Area West of South Swale That Will Be Excavated to Create Second Treatment Wetland

Table 4-3 Proposed Plant Species for Arlington Park Treatment Wetland Adjacent to Swale

Common Name	Scientific Name	Location
Sand cordgrass	*Spartina bakerii*	Upper slope
Blue iris	*Iris hexagona*	Basin
Soft rush	*Juncus effusus*	Basin
Florida coreopsis	*Coreopsis floridana*	Basin
Skyflower	*Hydrolea corymbosa*	Basin
Narrow-leaf sunflower	*Helianthus angustifolius*	Basin

The second proposed treatment wetland area is on the south side of the central pond. The existing south shore has no vegetation and is experiencing erosion (Photograph 10). Jones Edmunds proposes to expand this water feature to the south and create a shallow emergent marsh to provide more beneficial wildlife habitat and assist in enhancing water quality in the pond. The treatment wetland will be created in an existing maintained bahia/turf grass area south of the pond to a depth that supports emergent vegetation. Jones Edmunds recommends planting a diversity of emergent marsh species on 3-foot centers such as pickerelweed (*Pontedaria cordata*), duck potato (*Sagittaria* spp.), spikerush (*Eleocharis* sp.), iris (*Iris hexagona*), bulrush (*Scirpus* sp.), and sawgrass (*Cladium jamaicense*) (Table 4-4).

Photograph 10 South Shore of Pond To Be Expanded

Table 4-4 Conceptual Planting Plan for Arlington Park Treatment Wetland Adjacent to Pond

Type	Scientific Name	Common Name	% of Plant Species
ZONE 1 (Side Slopes)			
Herb	*Spartina bakerii*	Sand cordgrass	35
	Iris hexagona	Blue iris	35
	Juncus effusus	Soft rush	30
		Total	*100*
ZONE 2 (Basin)			
Herb	*Cladium jamaicense*	Sawgrass	10
	Eleocharis sp.	Spikerush	20
	Thalia geniculata	Fire flag	20
	Scirpus californicus	Bulrush	10
	Sagittaria latifolia	Duck potato	20
	Pontedaria cordata	Pickerelweed	20
		Total	*100*

Shoreline Enhancement—Based on the site assessments conducted by Jones Edmunds and Kelly Westover of Sarasota County, we recommend pulling back the banks of the pond to create littoral shelves that can be planted with desirable native emergent vegetation species (Figure 4-4). The creation of this littoral shelf will help assimilate additional nutrients, provide a source of detritus for invertebrates, and provide forage and refugia for urban vertebrate and invertebrate wildlife species.

Along the southwest side of the pond, the narrow width of uplands between pedestrian path and the pond may only allow slopes to be pulled back at a 4 or 3:1 slope. Jones Edmunds proposes to pull back slopes as gradual as possible based on available uplands while still allowing a 6- to 12-foot-wide strip that will be mowed for pedestrian access along this water feature. Jones Edmunds also proposes a post-and-chain fence along the top of the bank to protect against mowing and damage to vegetation by neighborhood residents.

Table 4-5 lists potential native species that would be appropriate to install within the littoral shelf. Plants would be installed on 3-foot centers but could vary in size from bare root to 1 gallon depending on funding. These species will provide relatively dense groundcover, uptake nutrients, and improve aesthetics as blue iris, pickerelweed, and water lily have showy flowers.

Table 4-5 Proposed Plant Species for Littoral Shelf Creation at Arlington Park

Common Name	Scientific Name	Location
Sand cordgrass	*Spartina bakerii*	Upper slope
Blue iris	*Iris hexagona*	Lower slope
Soft rush	*Juncus effusus*	Lower slope
Spikerush	*Eleocharis* sp.	Toe of slope
Pickerelweed	*Pontedaria cordata*	Toe of slope
Water lily	*Nymphae odorata*	Below toe of slope

4.3.2 Bayfront Park and Marina

Bayfront Park and Marina is an approximately 50-acre City of Sarasota park south of the intersection of North Tamiami Trail (US-41) and North Gulf Stream Avenue (SR-789) (Figure 4-1, Figure 4-2, Figure 4-3, Figure 4-4, and Figure 4-5).

4.3.2.1 Site Description

The marina directly fronts Sarasota Bay and consists of several restaurants, numerous boat slips, and a developed seawall with walking path (Figure 4-6). The south portion of the park contains a stabilized shoreline with a concrete walking path, benches, grass, and large trees. Several very small areas of mangroves are along this shoreline. Much of the shoreline is armored with stone of various sizes because the considerable fetch within Sarasota Bay can direct waves to this shore (Photographs 11 and 12). This park offers beautiful views of Sarasota Bay and experiences significant tourist and local resident pedestrian traffic due to the marina, restaurants, children's water park, and proximity to downtown. As such, it offers a unique opportunity for an educational 'living shoreline' project that will have extensive exposure due to the popularity of this park. The City used the public restrooms at this park as a water conservation showcase project that incorporated a greenroof, cisterns, and other water conservation practices. Additionally, a local City of Sarasota resident has provided the City with a donation to create a

Sustainability Walk through a portion of this park. This walk will entail constructing a new path and incorporating a rain garden and LID/sustainable practices into the walk.

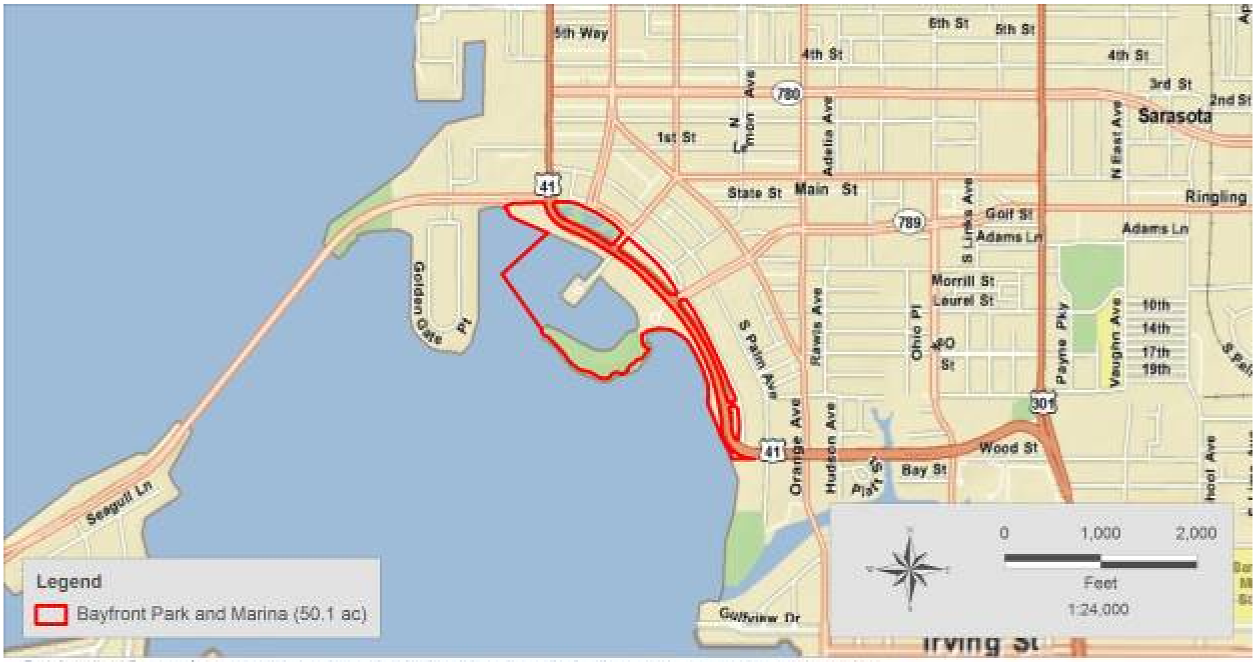


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Figure 4-5 Bayfront Park and Marina Location Map

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Figure 4-6 Bayfront Park and Marina Existing Land Use Map

Photograph 11 Shoreline Rock Armor along West Tip of Park

Photograph 12 Rock Armor along East Shoreline

Large mature red and black mangroves are well-established near the City's restrooms (Photograph 13) as well as along a headwall that turns south in the southeast portion of this park (Photograph 14). These mangroves grow amid large rocks that were placed to armor the shoreline.

Photograph 13 Red Mangroves Dominating Shoreline near County Restroom

Photograph 14 Red and Black Mangroves Established in Front of Headwall along East Side of Park

4.3.2.2 Proposed Habitat Improvement

<u>Living Shoreline Enhancement</u>—Based on the site assessments conducted by Jones Edmunds biologists, we recommend enhancement along the south shoreline of the marina. This enhancement includes several small planting areas in strategically placed locations to minimize

impacts to the current landscape and viewing opportunities of Sarasota Bay from the park perimeter pedestrian trail. Jones Edmunds captured the locations of all waterfront park benches using GPS. The mangrove plantings are proposed in locations that do not obscure the view from these benches. However, these locations are conceptual and could be moved based on park staff recommendations in a final design.

Jones Edmunds proposes planting groupings of red (waterward) and black mangroves (upslope of red mangroves) along the shoreline in several locations. Additionally, groupings of saltmarsh cordgrass (*Spartina alterniflora*) are proposed as this species will not block views of the bay (Figure 4-7). Two kiosks that describe the living shoreline restoration effort and its benefits are also proposed. We recommend that the kiosk in the northwest corner of the park present a discussion of seagrass as there are some patches immediately in front of the bulkhead for viewing. Due to the very high use of this park, we expect that this could be a very successful public education opportunity.

Figure 4-7 Bayfront Park and Marina Habitat Improvement Conceptual Design

4.3.3 Longboat Key Bayfront Park

Longboat Key Bayfront Park is an approximately 7-acre County park fronting the Gulf of Mexico side of Sarasota Bay that consists of recreational facilities, converted commercial and residential property, a concrete seawall, and two mangrove fingers (Figure 4-8).

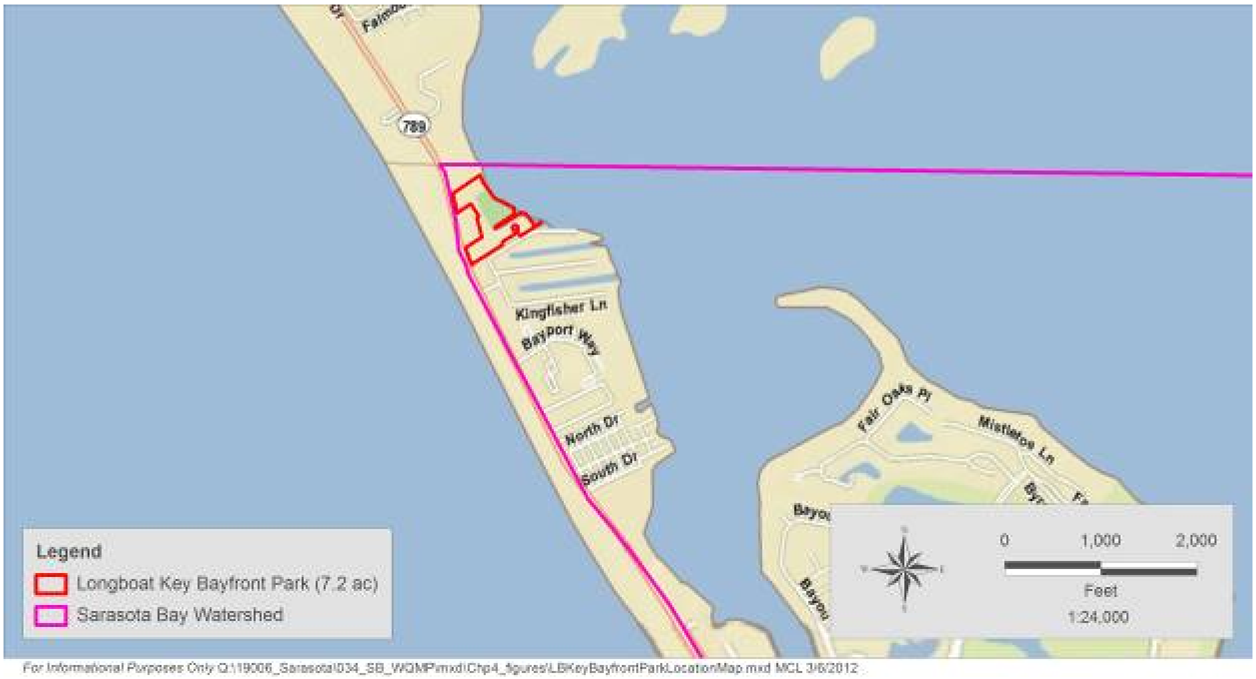

Figure 4-8 Longboat Key Bayfront Park Location Map

4.3.3.1 Site Description

The majority of the site consists of established facilities with maintained landscaping. An approximately 300-foot-by-80-foot area immediately north of the tennis courts is a maintained field and appears to have been an equipment staging area in the mid-1990s. However, two mangrove (FLUCCS Code 6120) fingers enter the southeast portion of the site and connect directly to Sarasota Bay (Figure 4-9). These fingers have a concrete seawall at their connection with the bay and up a portion of the finger. The southernmost finger transitions from mangroves to a shallow upland cut swale approximately midway through the property. These fingers are dominated by red mangrove (*Rhizophora mangle)*, white mangrove (*Laguncularia racemosa)*, and Brazilian pepper and appear to have been dredged between 1948 and 1951 (Photographs 15 and 16).

Figure 4-9 Bayfront Park Longboat Key Existing Land Use Map

Photograph 15 1948 Photograph of Project Site

Photograph 16 1951 Photograph of Project Site

4.3.3.2 Proposed Habitat Improvement

Bioretention Area Creation—Due to the absence of stormwater treatment in this neighborhood and basin, Jones Edmunds proposes constructing two small bioretention treatment wetlands: one in the north end of the site that would discharge to Sarasota Bay (Photograph 17) and one in the southwest portion of the site (Photograph 18) that would hydrologically connect to the adjacent mangrove wetland ([Figure 4-10](#)). These created wetlands would capture stormwater runoff from the adjacent commercial properties, SR-789, and the impervious parking lot on the west side of the site, which all slope down to the site from the west. ICPR modeling of the basin to determine peak stormwater stages will be necessary to confirm that the bioretention area will not cause unacceptable flood impacts. These bioretention areas will provide stormwater quality enhancement and attenuation for Sarasota Bay as runoff will enter these treatment areas rather than directly entering Sarasota Bay. However, the north bioretention area will require an outfall structure in the bioretention area and an outfall pipe into Sarasota Bay as this area is elevated and bound by a large headwall along Sarasota Bay.

Photograph 17 Looking East of North Bioretention Area

Photograph 18 Looking Northeast Across Proposed South Bioretention Area Toward Mangrove Finger

Figure 4-10 Longboat Key Bayfront Park Site Habitat Improvement Conceptual Plan

We expect that these systems will be flashy due to intermittent inflows of stormwater from rain but will dry quickly due to underlying well-drained sands. An engineered soil is proposed for the upper 6 to 18 inches of the bioretention areas based on the elevation of the water table. This soil will facilitate nutrient and water retention. Table 4-6 lists species suited for this hydroperiod that could be planted on 3-foot centers in the bioretention creation area. Jones Edmunds also proposes a post-and chain-fence along the top of the bank to protect against mowing and damage to vegetation.

Table 4-6 Conceptual Planting Plan for Bayfront Park Longboat Key Bioretention Areas

Common Name	Scientific Name	Location
Blanket flower	*Gallardia pulchella*	Side Slope
Sand cordgrass	*Spartina bakerii*	Side Slope and Basin
Sea oxeye daisy	*Borrichia frutescens*	Basin
Soft rush	*Juncus effusus*	Basin
Florida coreopsis	*Coreopsis floridana*	Basin
Skyflower	*Hydrolea corymbosa*	Basin
Narrow-leaf sunflower	*Helianthus angustifolius*	Basin

Wetland Buffer Enhancement—Currently, the upland portions of this site are mowed right to the edge of the mangroves (Photographs 19 and 20). Jones Edmunds proposes to enhance approximately 10 to 15 feet along the two mangrove fingers to create a vegetated wetland buffer. Enhancement will include removing Brazilian pepper and planting native upland salt-tolerant plant species along the edge of the mangroves. Table 4-7 lists proposed plant species. Jones Edmunds also proposes a post-and-chain fence along the top of the bank to protect against mowing and pedestrian damage to vegetation.

Photograph 19 Looking East of South Mangrove Finger

Photograph 20 Looking West along Edge of North Mangrove Finger

Table 4-7 Conceptual Planting Plan for Bayfront Park Longboat Key Wetland Buffer Areas

Common Name	Scientific Name	Location
Sand cordgrass	*Spartina bakerii*	Upper slope
Muhly grass	*Muhlenbergia capillaries*	Basin

4.3.4 North Water Tower Park

The North Water Tower Park site is an approximately 21-acre park east of US-41 between 42nd and 47th Street in a residential neighborhood (Figure 4-11).

4.3.4.1 Site Description

A playground, disc golf course, picnic benches, and parking lot are the main park amenities and the park appears to be heavily used. The majority of the park consists of a mature Temperate Hardwood (FLUCCS Code 4250) community dominated by live oak, cabbage palm, and saw palmetto (*Serenoa repens)* (Photograph 21). Numerous paved sidewalks traverse much of this community (Figure 4-12). An isolated Mixed Hardwood Wetland (FLUCCS Code 6170) on the northwest portion of the site (Figure 4-12) is dominated by red maple, Carolina willow (*Salix caroliniana)*, Peruvian primrosewillow (*Ludwigia peruviana)*, lizard's tail (*Saururus cernuus)*, smartweed (*Polygonum* sp.), and Brazilian pepper (Photograph 22). A shallow swale has been excavated and connects this wetland to the east/west ditch at the south end of the park. This swale has been excavated to the approximate wetland grade and thus dewaters the wetland during the wet season. Laurel oak and other transitional species appear to be encroaching in this wetland due to reduced hydroperiod.

Figure 4-11 North Water Tower Park Location Map

Photograph 21 Upland Community in Center of Park

Photograph 22 Mixed Wetland Hardwood Community in Northwest Corner of Park

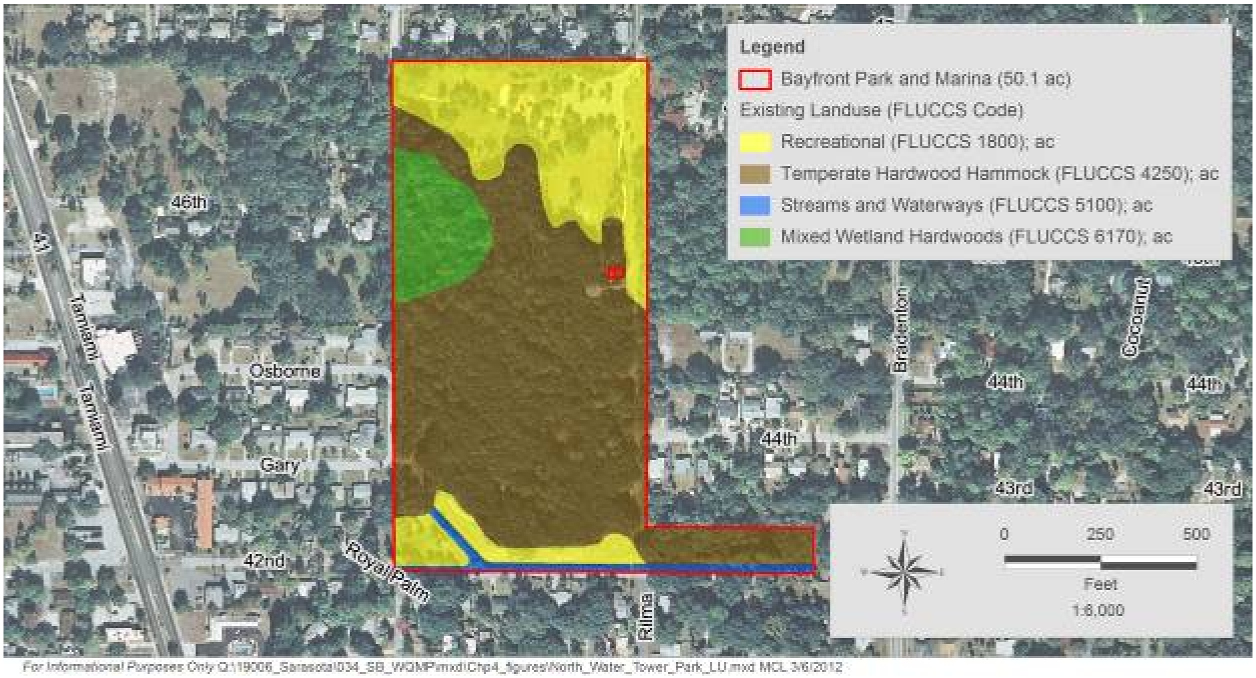

Figure 4-12 North Water Tower Park Existing Land Use Map

An upland cut ditch enters the park via a 48-inch concrete pipe from the intersection of Gary Street and Royal Palm Avenue along the west side of the site (Photograph 23). This ditch then flows southeast to the south park boundary and continues east until it goes under a residential area via extremely large concrete culvert (Photographs 24 and 25). A shallow upland cut swale draining residential areas in the southwest corner and a second shallow ditch that drains the center of the park intercept the ditch referenced above (Photograph 26). The southeast corner of the site consists primarily of a Brazilian-pepper-dominated upland area with several large live oaks and cabbage palms immediately north of the large ditch flowing east away from the park (Photograph 27). The other dominant species in this upland area are air potato, Boston fern, raintree, night shade (*Solanum* sp.), and citrus trees.

Photograph 23 Culvert and Ditch on West Side of Park Draining Gary Street and Royal Areas to the West Palm Avenue

Photograph 24 Facing East of Ditch at South End of Park Flowing East

Photograph 25 South Ditch Facing East Where It Exits Park

Photograph 26 Upland Area and Shallow Ditch in Southwest Corner of Park Where Treatment Wetland is Proposed and Cypress Trees to Remain

Photograph 27 South Ditch and Uplands (on left) Where Treatment Wetland Flow-Way is Proposed

4.3.4.2 Proposed Habitat Improvement

Wetland Enhancement—Jones Edmunds proposes to enhance the on-site wetland in the northwest corner of the park by treating and removing species such as Brazilian pepper and primrose willow. As discussed for the proposed Arlington Park wetland enhancement, exotic removal could be accomplished with the assistance of local youth groups, neighborhood associations, or schools.

Additionally, a ditch block is proposed to slow flows leaving this wetland via a shallow swale that flows south to the main east/west ditch at the south end of the park. This shallow swale dewaters this wetland (Figure 4-13). Restricting this flow will increase the depth and duration of inundation, which should reduce encroaching transitional species, promote additional coverage of desirable herbaceous wetland species, and reduce stormwater flows to the downstream ditches. However, the adjacent disc golf hole will likely be flooded more frequently as portions of it are actually in the wetland. Additional detailed topographic information in and around the wetland will be needed, and hydraulic and hydrologic (H&H) modeling will be required to determine potential flooding impacts if this ditch block is to be designed and permitted.

Ditch Bank Enhancement—Jones Edmunds proposes to enhance the upland cut ditch in the south portion of the site. The first ditch enters the site at the intersection of Royal Palm Avenue and Gary Street. Jones Edmunds proposes to pull back the north side slopes of this ditch approximately 15 feet and grade it back to a 4:1 slope (Photographs 28 and 29) east to the pedestrian bridge in the southeast corner of the site. Slopes will be pulled back to the greatest extent possible without having to reconfigure the disc golf fairway. The newly graded slopes will be stabilized with a geotextile fabric stapled in place and planted with native upland and wetland herbaceous vegetation. This vegetation will help stabilize the eroding side slopes, intercept overland flow, trap sediments being transported downstream, and improve aesthetics. Table 4-8 lists some plant species proposed for the stream enhancement area.

Figure 4-13 North Water Tower Park Habitat Improvement Conceptual Plan

Photograph 28 Facing Southeast along Ditch Coming from Royal Palm Avenue Where Side Slopes Will Be Pulled Back and Planted

Photograph 29 Ditch Running along Southern Boundary of Park Where Side Slopes Will Be Pulled Back and Planted

Table 4-8 Conceptual Planting Plan for North Water Tower Park Ditch Enhancement Area		
Common Name	Scientific Name	Location
Pickerelweed	*Pontedaria cordata*	Toe of slope
Soft rush	*Juncus effusus*	Lower slope
Blue iris	*Iris hexagona*	Lower slope
Sand cordgrass	*Spartina bakerii*	Mid-slope
Muhly grass	*Muhlenbergia capillaries*	Upper slope
Purple lovegrass	*Eragrostis spectabilis*	Upper slope

Bioretention Creation Area A—In the southwest corner of the site, Jones Edmunds proposes to excavate a small portion of a maintained turf grass area adjacent to existing cypress trees to create an herbaceous bioretention system. This area will be excavated to a higher depth than the adjacent main ditch to maximize basin width. This wetland will detain and treat untreated stormwater flowing into this system during storm events from residential areas to the west and south. As a result, we expect that this creation area will experience a flashy hydroperiod. The creation area will rely on infiltration and evapotranspiration for small storm flows and pop off to the adjacent ditch during large storm events. The area will provide additional habitat for avian and herpetofauna species. Two picnic benches and a kiosk are also proposed to provide viewing and education opportunities for park visitors (Figure 4-13). Table 4-6 lists potential native species that would be appropriate to install in the treatment wetland.

Treatment Wetland Creation Area A—Jones Edmunds proposes to create a treatment wetland along the southeast corner of the site (Figure 4-13). This wetland will intercept flow in the large ditch that flows east along the park's south boundary. Flow will be directed through an emergent marsh flow-way that will reenter the ditch near the culvert that diverts flow under a residential area (Photograph 25). This emergent marsh creation area will be excavated in disturbed uplands dominated by Brazilian pepper. A portion of these uplands will remain as a tree island and two other small areas as they contain several large live oaks and sabal palms. The creation area will be planted with a diversity of native emergent marsh and wet prairie species to provide treatment and additional wildlife habitat in the park (Table 4-4).

Treatment Wetland Creation Area B and Pond—Untreated stormwater from a large contributing area drains from the Tamiami Trail (US-41) stormwater pipe network into a ditch adjacent to 42nd Street that leads to a channel that discharges to Whitaker Bayou. Stakeholders have expressed concern about the quality of the stormwater that flows through the 42nd Street ditch and eventually into the bayou.

The stormwater inventory shows a north-to-south 42-inch stormwater pipe that crosses Tamiami Trail south of 47th Street and north of 46th Street (Figure 4-14). The parcels between 46th Street and 47th Street and the east portion of 46th Street are privately owned. The County owns 47th Street and Royal Palm Avenue.

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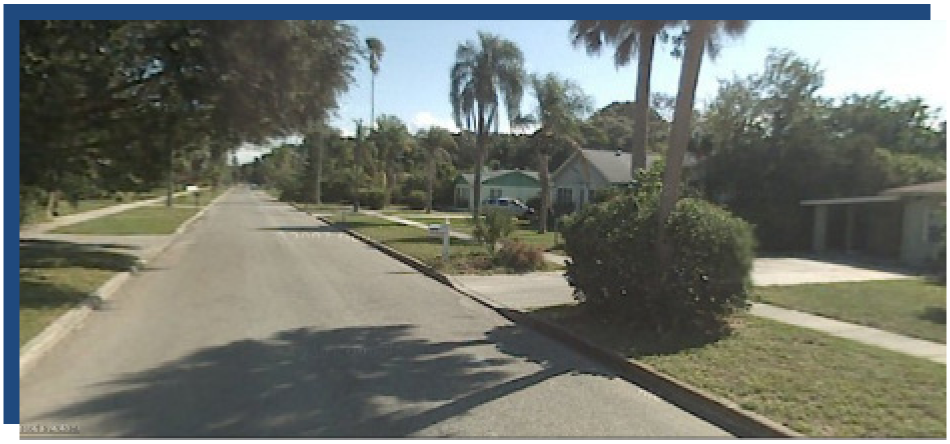
Figure 4-14 Aerial View of Site 4 (SWFWMD, 2010) with Sarasota County Stormwater Inventory

A storm sewer system carries untreated runoff along US-41 at this location. A connection to the system is midway between 46th Street and 47th Street on the east side of US-41 (Figure 4-15). The sidewalk along the east side of US-41 between these two streets is cracked and in disrepair. No public stormwater conveyance infrastructure is on or adjacent to 47th Street or 46th Street (Photograph 30). The east portion of 46th Street is privately owned. There is also a lift station where 46th Street meets the west side of North Water Tower Park (Figure 4-15).

Figure 4-15 Site 4 Storm Sewer System



A

B

Photograph 30 47th Street (Source: Google Maps) (A) and 46th Street (B)

A 47th Street homeowner indicated that in the 1960s a ditch was behind her property. She pointed out that the ditch had been "over her child's head" but has filled in over the years. Neighbors have since dug the trench to alleviate flooding (Photograph 31). The homeowner also said that water backs up in this trench at the park entrance during heavy rain. No easement parallels the backyards of the homes along the south side of 47th Street.

Photograph 31 Ditch Adjacent to Private Properties on the South Side of 47th Street

An open area is at the Water Tower Park Royal Palm Avenue entrance. To the east is a parking lot with more open area on the south side of the lot. To provide treatment, Jones Edmunds recommends diverting flow from the US-41 storm sewer system to a treatment wetland and wet pond treatment system in the north grassed areas of the park (Figure 4-14). The fringing created wetland would be planted on 3-foot centers with a diversity of emergent marsh species (Table 4-4). This pond/wetland system would likely discharge via an underground pipe to the ditch immediately south (Figure 4-13). Replacing the sidewalks along 47th Street and between 46th and 47th Street with pervious concrete or pervious pavers is also recommended.

Wetland Buffer Enhancement—Brazilian pepper, air potato, Boston fern, raintree, and any other exotic invasive plants will be treated and/or removed from uplands adjacent to wetland creation Area B and the main forested area of the park. Removing these species will increase the habitat value of these uplands and decrease the spread of these species. Supplemental planting of native upland species may be required in isolated locations where exotic invasive species are dense.

4.3.5 Payne Park

Payne Park is an approximately 40-acre developed park one block east of US 301 and north of Wood Street (Figure 4-16).

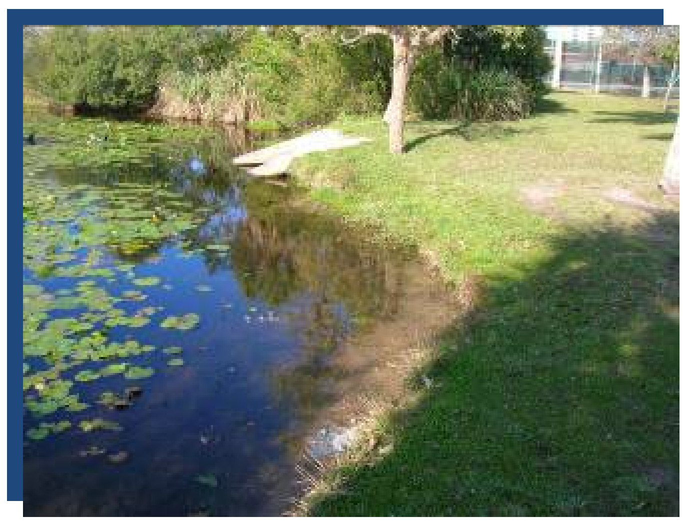
Figure 4-16 Payne Park Site Location Map

4.3.5.1 Site Description

The majority of this park consists of developed facilities including recreational facilities, walking pathways, skate park, amphitheater, and open grassy areas. Several ponds, or water features, are in the northwest and south portions of the park (Figure 4-17). The northwest pond receives untreated stormwater from roads to the north, and the pond discharges via two drop structures to another park to the south. The pond bank is mowed to the water's edge in many locations except where some bunch grasses have been placed (Photographs 32 and 33). This park experiences very high public use with a large number of residents walking dogs around this pond and other portions of the park.

Figure 4-17 Payne Park Site Existing Land Use

Photograph 32 South Shore of Northwest Pond



Photograph 33 North Shore of Northwest Pond

The two ponds in the south portion of the site are mowed to the water's edge. A few herbaceous, wax myrtle, and bald cypress tree plantings are around the perimeter of the ponds but no littoral emergent vegetation (Photograph 34). The easternmost pond has a large area of bulrush in the center but nothing along the margins. The easternmost pond also appears to discharge to a ditch to the south that runs east/west near the park boundary (Photograph 35). The westernmost pond does not appear to receive stormwater or discharge as no structures were observed.

Photograph 34 South Side of East Pond at South End of Park

Photograph 35 North Side of West Pond at South End of Park

The south east/west ditch receives inflow from a large culvert on South School Avenue, the easternmost pond, and a large apartment complex immediately south (Photographs 36 and 37). The ditch has a small brick outfall on the west end (Photograph 38).

Photograph 36 Facing East of Ditch at South End of Park

Photograph 37 Inlet Pipes from East Pond (Left) and Apartment Complex (Right)

Photograph 38 Drop Inlet Structure at West End of Ditch

4.3.5.2 Proposed Habitat Improvement

Treatment Wetland Creation—A treatment wetland is proposed on the south portion of the site around the observed east/west drainage ditch due to the absence of stormwater treatment in this neighborhood and basin (Figure 4-18). Upland areas north and south of the existing east/west swale will be excavated to create an approximately 0.8-acre treatment wetland. A large group of native trees in the center will remain, while Jones Edmunds recommends that the large Australian pines at the east end of the swale be removed. The enhancement of an approximately 15- to 20-foot-wide upland buffer is also included in this recommended project to provide a vegetated buffer between the treatment wetland and the heavily used park area (Figure 4-18).

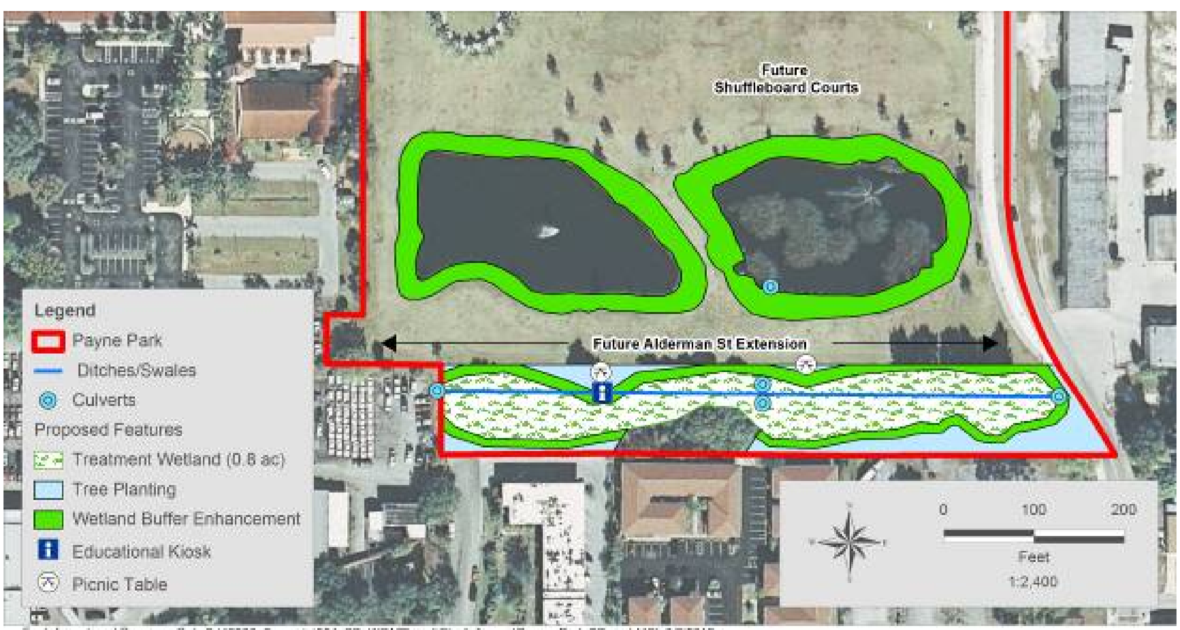


Figure 4-18 Payne Park Southeast Habitat Improvement Conceptual Plan

This wetland will detain and treat flows received from the apartment complex to the south and untreated stormwater inflowing from the pipe at the east end of the swale. Table 4-8 lists of potential native species that would be appropriate to install in the treatment wetland.

Two picnic benches and a kiosk are proposed to provide viewing and education opportunities for park visitors (Figure 4-18). Jones Edmunds also proposes a post-and-chain fence along the top of the bank to protect against mowing and damage to vegetation by neighborhood residents.

Wetland Enhancement—Based on the site assessments, Jones Edmunds recommends that the banks and a portion of the adjacent uplands of the northwest pond be planted with desirable native emergent vegetation and transitional wetland species (Figure 4-19). The planting of this pond edge will create an important buffer to protect the water quality of the pond from dog waste and overland flow that carries nutrients. This vegetated strip will help trap and assimilate nutrients, provide a source of detritus for invertebrates, and provide forage and refugia for urban vertebrate and invertebrate wildlife species.

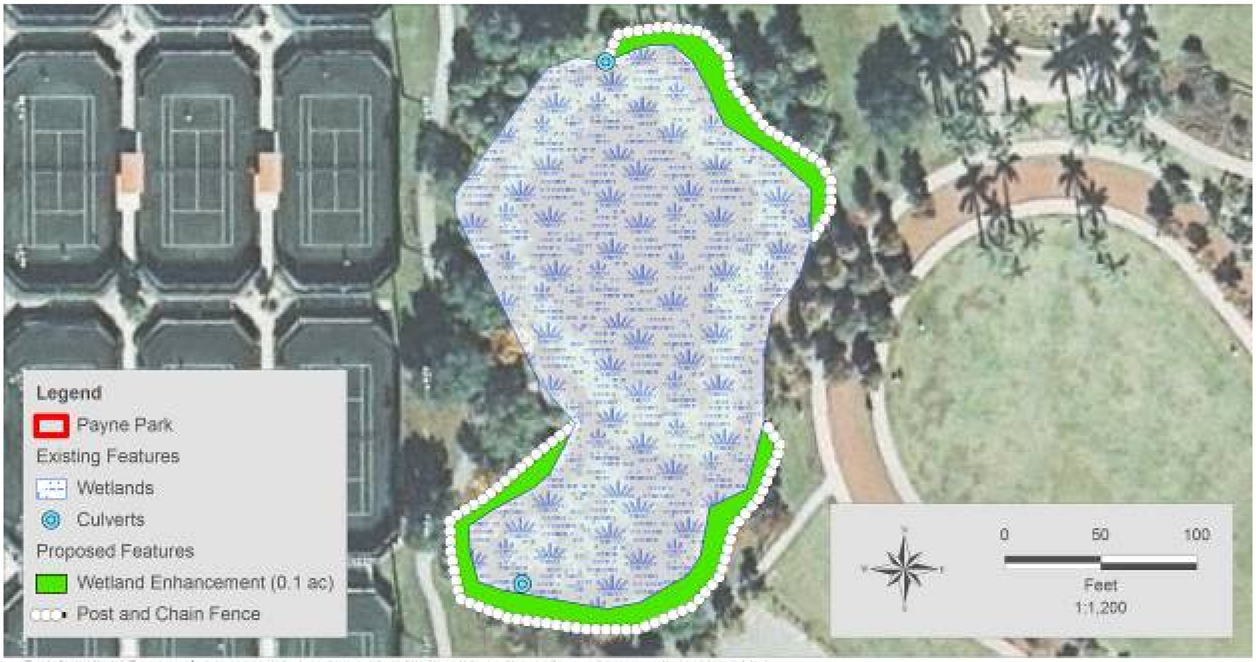


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Figure 4-19 Payne Park West Habitat Improvement Conceptual Plan

Table 4-9 lists of potential native species that would be appropriate to install within the littoral shelf and side slopes. Plants would be planted on 3-foot centers but could vary in size from bare root to 1 gallon depending on funding. These species will provide relatively dense groundcover, uptake nutrients, and improve aesthetics. Jones Edmunds also proposes a post-and-chain fence along the top of the bank to protect against mowing and damage to vegetation by neighborhood residents.

Table 4-9 Proposed Plant Species for Northwest Pond at Payne Park		
Common Name	Scientific Name	Location
Pickerelweed	*Pontedaria cordata*	At or below toe of slope
Soft rush	*Juncus effusus*	Toe of slope
Blue iris	*Iris hexagona*	Side slope
Sand cordgrass	*Spartina bakerii*	Side slope
Purple lovegrass	*Eragrostis spectabilis*	Upland
Muhly grass	*Muhlenbergia capillaries*	Upland
Beautyberry	*Callicarpa americana*	Upland

Upland Enhancement—Jones Edmunds proposes to plant shade trees and understory shrub and herbaceous species at Payne Park adjacent to the proposed east/west ditch that will be enlarged as well as around the two south ponds to enhance the ecology of this property and provide a small area of canopy for avian wildlife species (Figure 4-19). Table 4-10 lists proposed tree, shrub, and herbaceous species. Additionally, Jones Edmunds proposes to remove Australian pine from the east/west ditch. Two picnic benches and an educational kiosk that provides the public with an explanation of the enhancement and treatment wetland creation area function and benefits are also proposed.

Table 4-10 Proposed Plant Species for Adjacent Upland Areas at Payne Park	
Common Name	Scientific Name
Live oak	*Quercus virginiana*
Laurel oak	*Quercus laurifolia*
Sabal palm	*Sabal palmetto*
Longleaf pine	*Pinus palustris*
American beautyberry	*Callicarpa Americana*
Saw palmetto	*Serenoa repens*
Muhly grass	*Muhlenbergia capillaris*

4.3.6 Hudson Bayou Oak Street Canal

This project site is in the southeast region of the Sarasota Bay watershed between Orange and Osprey Avenues (Figure 4-20).

4.3.6.1 Site Description

This site is a channelized tributary of Hudson Bayou characterized as Streams and Waterways (FLUCCS Code 5100) that starts at Oak Street and flows south within a narrow 12- to 15-foot-wide drainage easement between single- and multi-family residential properties (Figure 4-20 and Figure 4-21). This tributary was a dredged narrow channel at least since 1948 (Photograph 39). Currently, almost the entire reach of this channelized tributary is armored or has vertical or near vertical side slopes, and many of the homes or fences are within several feet of the channel bank (Photographs 40 and 41). Much of the bank is dominated by exotic palms, Brazilian pepper, cogon grass, and ornamental ground covers (Photographs 40, 41, and 42). However, red mangrove is fairly well established in the south reaches of the channel, particularly south of Devonshire Lane at the terminus of Alderman Street (Photograph 43).

At the time of our site visit, water in this system had low visibility and sedimentation was observed. This system receives untreated stormwater that discharges directly to the creek via pipes (Devonshire Lane) or ditches (Alderman Street).

Figure 4-20 Hudson Bayou Tributary Site Location Map

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Figure 4-21 Hudson Bayou Tributary Site Existing Land Use Map

Photograph 39 1948 Aerial of Hudson Bayou Tributary

Photograph 40 West Bank of Tributary at Terminus of Alderman Street

Photograph 41 East Bank from Oak Street

Photograph 42 Oak Street Facing South of Hudson Bayou Tributary

Photograph 43 Red Mangroves at Terminus of Alderman Street

4.3.6.2 Proposed Habitat Improvement

Stream Enhancement—Based on the site assessments conducted by Jones Edmunds, we recommend that portions of the banks be enhanced by removing exotic invasive vegetation such as Brazilian pepper and planting desirable native species such as red or black mangrove at or just above the toe of slope. Enhancement of the side slope will be challenging in several locations due to the vertical bank and the potential for bank failure if large exotic invasive trees and shrubs are removed. Thus, Jones Edmunds proposes to selectively remove the vegetation and plant in phases so that long stretches of the bank are not exposed at one time. Additionally, in some cases the bank has been armored with rocks, and removing this material would likely result in more harm than benefit. Table 4-11 lists several shade-tolerant species that could be planted on side slopes where exotic invasive vegetation is removed.

Table 4-11 Proposed Plant Species for Side Slopes at Hudson Bayou Tributary Site

Common Name	Scientific Name
Wax myrtle	*Myrica cerifera*
Yaupon holly	*Ilex vomitoria*
Wild coffee	*Psychotria nervosa*
Leatherfern	*Acrostichum danaeifolium*
Swamp fern	*Blechnum serrulatum*

Jones Edmunds proposes in-stream enhancement by installing several logs and thick-diameter (6 inches or greater) branches in two or three locations of this stream reach to trap sediments, provide additional structure diversity for the benthic community, and provide foraging and refugia for fish species. Large woody material provides valuable ecological services to stream health in Florida such as habitat diversity, shaping stream morphology, erosion control, and flood attenuation (Ray, 1999; Shields et al., 2004; and Diehl, 1994). In addition, the County should encourage LID practices if the adjacent Devonshire property is to be developed. This would help treat and detain stormwater before it enters this Hudson Bayou tributary. Permitting and H&H modeling through FDEP may be required for the placement of snags.

Jones Edmunds also investigated the potential to improve the roadside swale that runs east-west on the north side of Alderman Street. This ditch conveys large flows during the wet season and has scour at the toe of slope, particularly in the east portion of the ditch (Photographs 44 and 45). Based on our review of the County parcel dataset, the south portions of this ditch could be widened in two locations. However, even in the widest location only approximately 20 feet of right-of-way are available. Thus, any improvements would be creating 3:1 or 4:1 side slopes along this approximately 180-foot-long area (Figure 4-22). Jones Edmunds believes that this improvement would result in little water quality enhancement and thus does not propose it as an additional enhancement at this project site.

Photograph 44 Alderman Roadside Ditch in Central Region Facing West

Photograph 45 East End of Ditch Facing West at Terminus of Alderman Street

Figure 4-22 East-West Tributary Ditch to Hudson Bayou Where Improvements were Investigated

4.4 CONCLUSION

Six potential habitat improvement project sites were identified within Sarasota Bay watershed that create or enhance existing wetland, surface water, or upland natural systems habitat. Implementing these projects will help treat stormwater flows and improve water quality in the

Sarasota Bay watershed. In addition, several proposed designs have incorporated passive recreational (trails) and educational opportunities (kiosks) for local residents.

Jones Edmunds will calculate ecological lift using the Uniform Mitigation Assessment Methodology, develop conceptual cost estimates, calculate downstream water quality benefits, and provide project rankings for these sites in Appendix G – Project and Program Recommendations.

5.0 LEVEL OF SERVICE

5.1 OBJECTIVE

Setting resource protection level of service (LOS) targets is one of the most important elements of an effective water quality management plan. An overall approach to protecting the resources of Sarasota Bay has recently been established by the SBEP, SWFWMD, Sarasota County and other local governments, FDEP, and other interested parties. The targets adopted by SBEP were primarily water-quality-based and were intended to be protective of seagrasses, an extremely important natural resource for Sarasota Bay as well as many other estuarine systems. Developing and implementing LOS targets for other natural resources are another critical element of effective resource management and are addressed in this document.

LOS criteria are readily developed for infrastructure such as roads, wastewater management, or evacuation routes using objective criteria. Natural systems LOS criteria are more difficult to develop, particularly for terrestrial ecosystems, due to the current state of critical habitats, which have suffered significant loss. In other words, achieving a desirable LOS may not be practical. However, setting resource protection LOS targets is an important element of an effective watershed management plan. Achieving or exceeding these LOS targets is desirable outcome for any community as it builds a strong local economy, provides Sarasota Bay residents a better quality of life, and has been supported by citizens. Sarasota Bay's seagrasses, oysters, and mangroves provide invaluable functions and can serve as indicators of water quality and/or bay health. As a result, setting an LOS target for these natural systems and implementing a monitoring program can help managers track changes to these natural systems and infer watershed health.

This section presents natural systems LOS and/or trend analysis for seagrass, oysters, and mangroves as well as watercourse buffers and shorelines in Sarasota Bay. The information summarized in this section presents the methods, results, and discussion for historical trends; natural systems LOS targets when feasible; and recommendations and potential management actions to increase or maintain existing LOS.

5.2 METHODS

5.2.1 Seagrass

Seagrass targets for Sarasota Bay have previously been established by participants in SBEP. The SBEP Management and Policy Boards unanimously approved chlorophyll *a* and seagrass LOS targets (presented below) at their January 15, 2010 meeting. At the June 4, 2010 meeting, both boards delegated authority to the SBEP Technical Advisory Committee for submission of draft numeric nutrient criteria, which are based on meeting seagrass targets, to FDEP and the US Environmental Protection Agency (EPA).

The LOS target-setting process was based on comparing historical seagrass coverage developed through photo-interpretation of historical (ca. 1950) aerial photographs to recent seagrass surveys conducted by SWFWMD (1988, 1994, 1999, 2001, 2004, and 2006). Since the seagrass target-setting process was completed, additional seagrass inventories have been completed (2008 and 2010). SBEP defined the seagrass target as the larger areal extent of seagrass coverage under either historical (1950 coverage, less areas that have since been filled or dredged and are deemed unrestorable) or current (average of 2004 and 2006, the most current data available at the time) conditions.

Data that were compiled and used for this analysis include seagrass survey data for Sarasota Bay (1950, 1988, 1994, 1999, 2001, 2004, 2006, 2008, and 2010) provided by SWFWMD.

5.2.2 Oysters

Bay-wide targets for oyster survival in Sarasota Bay have not previously been developed. However, since 2006 the County has conducted periodic monitoring for oysters at sites within Hudson Bayou, a tributary to Sarasota Bay (Figure 5-1), and other bay segments. Oyster reefs at the monitoring sites are inspected, and percent-live oysters and other data are collected and reported (Jones, 2007).

The County is also completing an inventory of all oyster reefs within County waters with an expected completion date of 2012. The goals of the inventory are to identify oyster habitats in both natural and altered estuarine and tidal creek settings, develop baseline maps of existing oysters, document the upstream extent of oyster habitat in tidal creeks, and assess the information obtained to identify potential restoration opportunities (Meaux, 2011). Figure 5-2 is a sample map from the inventory. A single oyster reef attached to a seawall near the mouth of Whitaker Bayou is shown as an orange dot. For the bay-wide mapping effort, only the areal extent of the oysters is reported, but percent-live data are not. Additionally, the inventory is limited to the portion of Sarasota Bay within the County's jurisdiction. Both monitoring programs are summarized in Section 2.6.

Figure 5-1 Sarasota County Oyster Monitoring Sites in Sarasota Bay

Figure 5-2 Example Map from County Oyster Inventory Program
Oyster reef location is shown as an orange dot.

As with the water quality LOS targets, a target is not the lowest value that may be acceptable but rather is a desirable level. Thus, because 75% live oysters is the mid-point of the "On Target" range of the County's oyster monitoring program, an LOS target of 75% live oysters at all sites examined is a reasonable target. Oysters provide a keystone habitat within southwest Florida creeks and should be protected and where necessary restored. Because of the uncertainty associated with the historical oyster mapping, setting an acreage target based on historical coverage is not feasible. A reasonable target is to protect oyster bars and suitable habitat and to undertake restoration projects as funding becomes available.

Results from the following monitoring efforts were reviewed to help identify a meaningful LOS target for oysters:

❖ Sarasota County 2006 Comprehensive Oyster Monitoring Program (Jones, 2007).

❖ Mapping Oyster Habitat in Sarasota County Waters (Sarasota County Water Resources, 2011). Presentation by Kathryn Meaux to Charlotte Harbor National Estuary Program Technical Advisory Committee July 14, 2011).

5.2.3 Mangroves

In Section 2.4, mangrove acreage for Sarasota Bay, including portions in Manatee County and excluding Roberts Bay North, was presented as a component of an analysis of emergent vegetation. These data do not allow a comparison between previously completed or future WQMPs in Sarasota County. As a result, a 1948, 1972 to 1973, and 2010 mangrove (red, black, and white) GIS polygon feature class was developed using existing digital black-and-white 1948, SWFWMD, 1972 black-and-white aerial imagery, and SWFWMD 2010 true-color infrared digital aerial imagery. Digital copies of Mangrove Systems (1988) 1948, 1972, or 1987 mangrove datasets were not obtainable for use.

For the 1948 and 1972 datasets, all mangroves that are clearly discernible from upland or aquatic habitats were digitized over historical digital aerial imagery (Figure 5-3). The mangrove feature class represents mangrove forest present only in the Sarasota County portions of the Sarasota Bay watershed and includes Roberts Bay North. To develop a 2010 dataset, a combination of several data sources were used. For the base dataset, mangrove swamps were extracted from the County's 2007 Native Habitat dataset. Then using the FWRI Marine Resources GIS 2004 mangrove dataset, many small mangrove polygons not present in the 2007 Native Habitat dataset were added. Finally, the County's mangrove point shapefile from the 2009 mangrove study were used to review the dataset and add mangrove areas not captured by the previous two datasets with a minimum mapping unit of 0.001 acre. Environmental Services and Natural Resources (2009) mangrove data were particularly useful in confirming/identifying narrow mangrove strips along interior tidal streams (Hudson Bayou, Whitaker Bayou, etc.). Polygons in the 2007 or 2004 FWCC dataset that were inaccurate (missing mangrove) by greater than 25% of the polygon in question were redigitized.

Figure 5-3 Example of Digitized Mangroves at Terminus of Phillippi Creek in 1948

5.2.4 Watercourse Setback

In 1995, Sarasota County passed a 50-foot vegetated buffer requirement for properties on watercourses. However, many subdivisions that front major watercourses were platted before 1995 and thus do not need to comply with the 50-foot buffer. Additionally, the City of Sarasota and Longboat Key, which make up 48% of the waterfront property, did not require such a watercourse buffer or setback. Despite this, existing setback distances from homes/buildings to the edge of watercourses were investigated for Sarasota Bay using GIS analysis at the parcel level. The composition of the setback was also investigated as to whether it was naturally vegetated or dominated by turf grass. Major watercourses are defined as bays or surface waters discharging directly to a bay. Features classified as “Bay” or “River” in the County’s “Watercourse” GIS shapefile were selected and represented the major watercourses. Thus, small swales that may be mapped in the County’s “Water Features” that are tributaries of tributaries will not be analyzed.

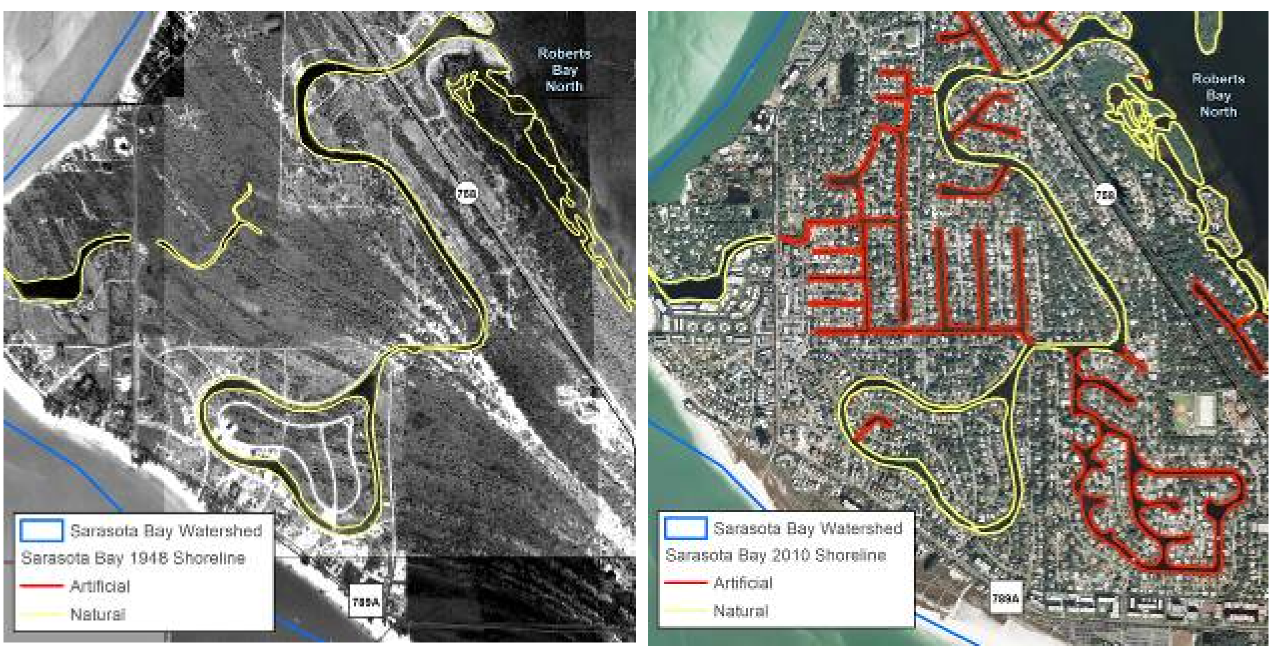
A 50-foot setback polygon of the water features dataset was merged with the County's 2010 parcel dataset to create individual parcel polygons within the larger watercourse buffer polygons. The 50-foot buffer within each parcel was then reviewed using 2010 aerial imagery and attributed "Natural" or "Developed." The natural category was defined as a portion of the 50-foot setback contained within a single parcel that had >50% natural vegetation, which excluded turf grass. "Developed" was defined as a setback that contained >50% turf grass, structures, or impervious surface. If a structure was within the 50 foot setback, this was noted in the DESCRIP field. However, if the 50-foot setback was not developed but contained >50% turf grass, this was noted in the attribute table.

A second GIS analysis was conducted to quantify the range of setbacks present since many parcels in Sarasota were platted before 1995. Sarasota County has digitized building and home footprints for the entire County. This analysis used the 'Near' tool that calculated the linear distance (in feet) from the closest point of the building/home footprint to the watercourse). Pools were not part of the building/home footprint and are allowable within the 50-foot buffer. However, in many cases, the homes wrap around one side of the pool and end up being the closest edge to the watercourse (Figure 5-4). Thus, the distance returned from the edge of the home to the watercourse reflects the true setback present in a majority of cases. Setback distances were grouped into five distance categories (0 to 15 feet, 15 to 30 feet, 30 to 50 feet, 50 to 100 feet, and 100+ feet) and by municipality (City of Sarasota, City of Longboat Key, and Sarasota County).

5.2.5 Shorelines

In Section 2.3, 1948 and 2008 shoreline datasets for Sarasota Bay were created. Details regarding the methodology creating these datasets can be found in the Section 2.3. Jones Edmunds used these data as the base layer to refine these data by differentiating whether the shoreline is artificial/man-made or a historically occurring shoreline. Jones Edmunds added a field titled "TYPE" and attributed each record with "Historic" or "Artificial" to identify shorelines that result from dredging channels through uplands to provide residential water access. For example, shorelines associated with the Grand Canal will be attributed "Artificial" and not used in comparisons of historical to current modified shoreline (Figure 5-5).

Figure 5-4 Digitized Home Footprints and Swimming Pools Which Are Not Included in Building Footprint
(Note: Number in black denotes distance [feet] from edge of structure to watercourse.)



(a) (b)

Figure 5-5 Grand Canal Area 1948 (a) and 2010 (b) Aerial Photographs Depicting "Artificial" Dredged Channels

5.3 RESULTS AND DISCUSSION

5.3.1 Seagrass

Seagrasses are a fundamental component of the ecological structure of most Florida estuaries. Seagrasses provide numerous benefits including stabilizing sediments, providing refuge for juvenile fishes and invertebrates, and serving as a food source for manatee and sea turtles. In addition, microscopic algae (epiphytes) that grow on seagrass blades support a diverse community of grazing organisms. Decaying seagrasses contribute organic material to the food web that plays an important role in the transfer of energy in the various strata of estuarine and coastal biological communities. Seagrasses support a diverse and productive macroinvertebrate community that lives in and around seagrass meadows and in the surrounding sediments. These organisms are an important food resource for higher trophic levels.

Seagrasses are also important and accurate indicators of the ecological health of an estuary. The spatial extent of seagrass growth is limited by light penetration in the water column. Like other plants, seagrasses need a minimum level of light to survive. High nutrient levels in water can cause increases in algal growth that can decrease light penetration in the water column. Maps showing the historical and current extent of seagrass are included in the characterization section.

The LOS target shown in Figure 5-6 is 7,269 acres, which is based on the 1950 coverage, minus the unrestorable areas (dredged or filled lands, etc.). During the target-setting process, data from 2004 to 2006 were used to represent recent conditions. The 2008 and 2010 surveys indicate that seagrass coverage has been significantly above the LOS target acreage since 2008. This equates to approximately 1,700 acres of seagrass in excess of the LOS target acreage. While the trends in seagrass coverage in Sarasota Bay are certainly very promising, the ongoing identification and implementation of water quality and quantity improvement projects in the watershed is still critical to ensure that this trend continues.

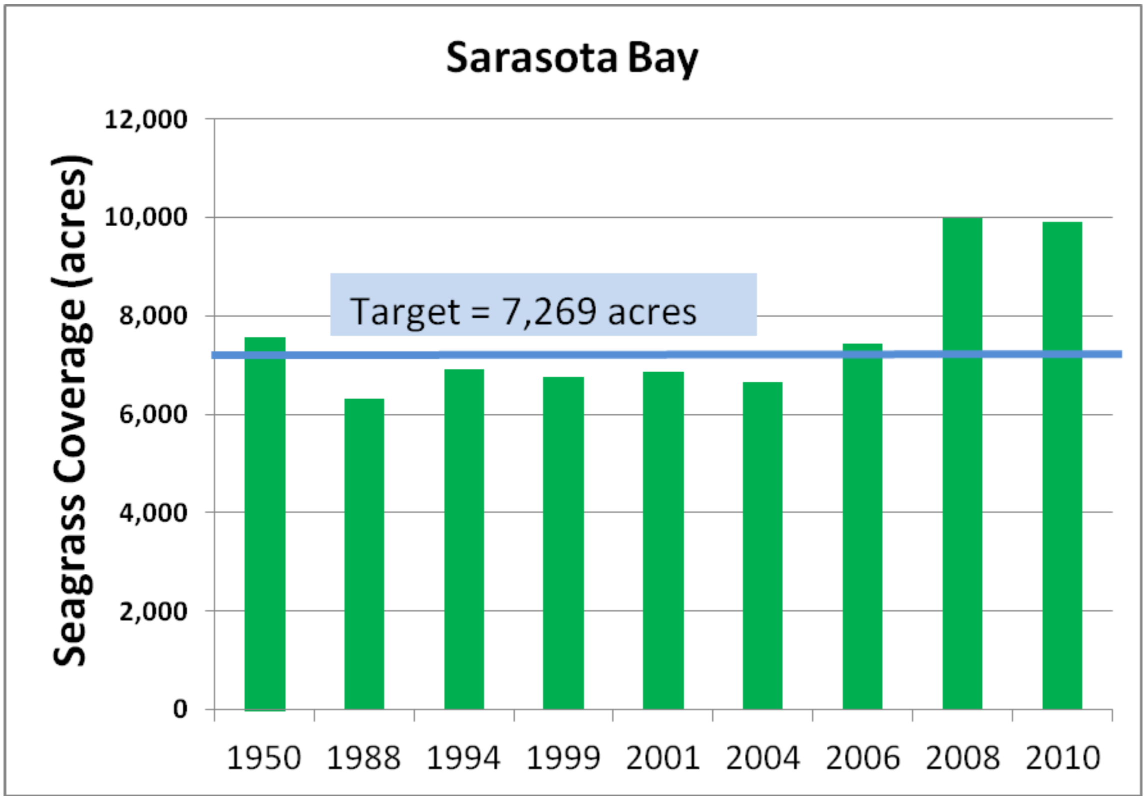


Figure 5-6 Comparison of Seagrass Coverage (acres) from Historical and Recent Surveys in Sarasota Bay with the Seagrass Target Established by SBEP shown.

5.3.2 Oysters

The importance of the Eastern oyster, *Crassostrea virginica*, to the Sarasota Bay system has been discussed in Section 2.6 - *Critical Estuarine and Lotic Natural Resources*. The oyster's tolerance of widely ranging salinities, turbidity, and dissolved oxygen makes its widespread survival possible. Oysters tolerate salinities ranging from 0 to 42 ppt. Oysters are subject to diseases brought on by higher salinities, especially when they occur with high temperatures (e.g., infestation by a protozoan, *Perkinsus marinus*), and to predation by invertebrates (oyster drills, starfish). Oysters are an important indicator of estuarine health, and their status can help identify water-management problems. Oyster reefs serve several valuable ecological functions, providing habitat for estuarine fauna including conch, mud crab, fish, and other bivalves and helping improve water quality through filtering as they feed.

Because the bay-wide areal extent of oysters is not known and the historical mapping data are not of comparable accuracy to modern mapping, establishing an LOS target expressed as acres of oyster bars is not feasible at this time. A target based on acres could be established when the Sarasota County mapping is completed and a similar inventory is made of Manatee County oyster habitats.

The oyster monitoring program provides a method of scoring the health of the individual bars based on percent-live oysters in the bar at the time of a field visit. A score of 70 to 80% live is considered "On Target." Scores below 70% are "Fair" (50 to 69.9%), "Poor (20 to 49.9%), or "Very Poor" (0 to 19.9%). Scores above 80% are "Excellent." Because 75% live oysters is the mid-point of the "On Target" range of the County's existing oyster monitoring program, an LOS target of 75% live oysters in all sites that are examined is deemed to be a reasonable target.

Table 5-1 and Figure 5-7 present the results of the oyster monitoring program. Percent-live oysters for the two Hudson Bayou sites (the only Sarasota Bay sites) are shown for the 2006 through 2011 period of record. The downstream site HUD1 meets or exceeds the target of 75% live in six of the 10 samples with an average score of 75.6%. HUD 2 meets or exceeds the target in two (rounded up) samples and has an average score of 66.9% live. All samples had over 50% live so no "Poor" or Very Poor" results were reported. A comparison with Little Sarasota Bay and Blackburn Bay oyster data (overall average of five sites is 58.9%) indicates that the health of oysters at the two Sarasota Bay sites is better than the average of the five Little Sarasota Bay and Blackburn Bay sites.

Table 5-1 Percent-Live Oysters at Sarasota Bay Sites, 2006–2011

Sample Date	HUD 1	HUD 2
Fall 2006	78.6	54.8
Spring 2007	70.2	81.4
Fall 2007	78.2	64.3
Spring 2008	77.6	62.5
Spring 2009	61.9	71.4
Fall 2009	74.6	62.6
Spring 2010	77.4	69.9
Fall 2010	64.8	60.8
Spring 2011	90.3	66.1
Fall 2011	82.7	74.8
Mean	75.6	66.9

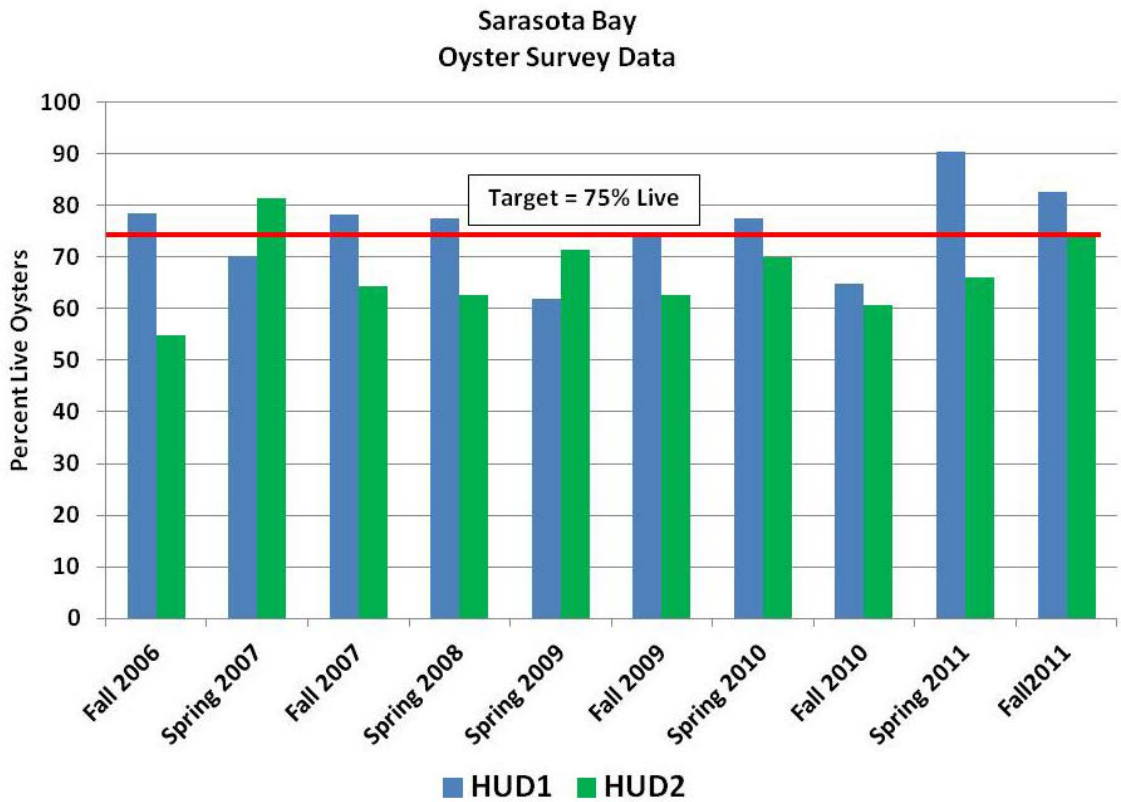


Figure 5-7 Sarasota County Oyster Monitoring Program – Live Oysters from Sarasota Bay (Hudson Bayou) Sites – 2006 through 2011 with Target (75%) Shown

5.3.3 Mangroves

Setting LOS target for mangroves will help protect this vital habitat that supports a diversity of aquatic species and is critical foraging and nursery areas during the life stages of many aquatic vertebrate and invertebrate species. Most fish and shellfish that humans like to catch and eat spend part of their lives among the roots in the mangrove forests that line the estuaries of Southwest Florida. Mangroves are also the first line of defense against tropical storms and hurricanes as they dampen wind and wave energy along the coast. Like seagrasses, mangroves play an important role in stabilizing the benthic environment by trapping and holding fine-grained particles and sediment in their root systems and removing dissolved nutrients from the water column.

Human activities have adversely affected mangroves by clearing and filling mangrove forests for development or to create water views. Excessive trimming of mangroves can kill these trees. Mangroves have also been negatively affected by shoreline hardening. As discussed in Section 2.4, SWFWMD's 2009 land-use estimates of the areal extent of mangroves based on the FLUCCS coverage indicate that 937 acres of mangroves were in Sarasota Bay including the Manatee County portions of the bay. The majority of mangrove growth associated with Sarasota

Bay is north in Manatee County, near Tidy Island, along central and north Longboat Key, and on Anna Maria Island.

Based on 1948 imagery, approximately 589 acres of mangroves were historically in the Sarasota County portions of Sarasota Bay including Roberts Bay (Figure 5-8). Mangrove acreage increased significantly to 756 acres between 1948 and 1972, primarily due to the creation of an extensive canal network between 1948 and 1957 in a large area of Longboat Key where the Longboat Key Club Moorings Marina, Corey's Landing, and Bay Isles are located (Figure 5-9 and Figure 5-10). Delineating mangroves on the 1972 imagery was challenging as determining if the shrub/tree vegetation throughout the area is mangrove or upland shrub species such as wax myrtle or Brazilian pepper is difficult. Jones Edmunds estimated that approximately 373 acres of mangroves were present in this region of Longboat Key in 1972 due to the dredging versus 103 acres in 1948 (Figure 5-9 and Figure 5-11). As a result, the 1970s mangrove estimate could be an overestimate.

In 2010, an estimated 367 acres of mangroves were in Sarasota County portions of Sarasota Bay. Based on the 1948 mangrove acreage, this is a 38% reduction (Figure 5-12; Table 5-2). While mangrove acreage increased 28% in the 1970s, the majority of this increase occurred on Longboat Key where the delineation was very difficult. Most mangroves in the Sarasota County portion of Sarasota Bay are just north of Big Pass adjoining Lido Key and Otter Key and on the southeast tip of Longboat Key. The largest loss of mangrove acreage occurred primarily because of filling before 1970 for homes along the west shore of Roberts Bay North, the terminus of Phillippi Creek, and in the central Longboat Key (Figure 5-13).

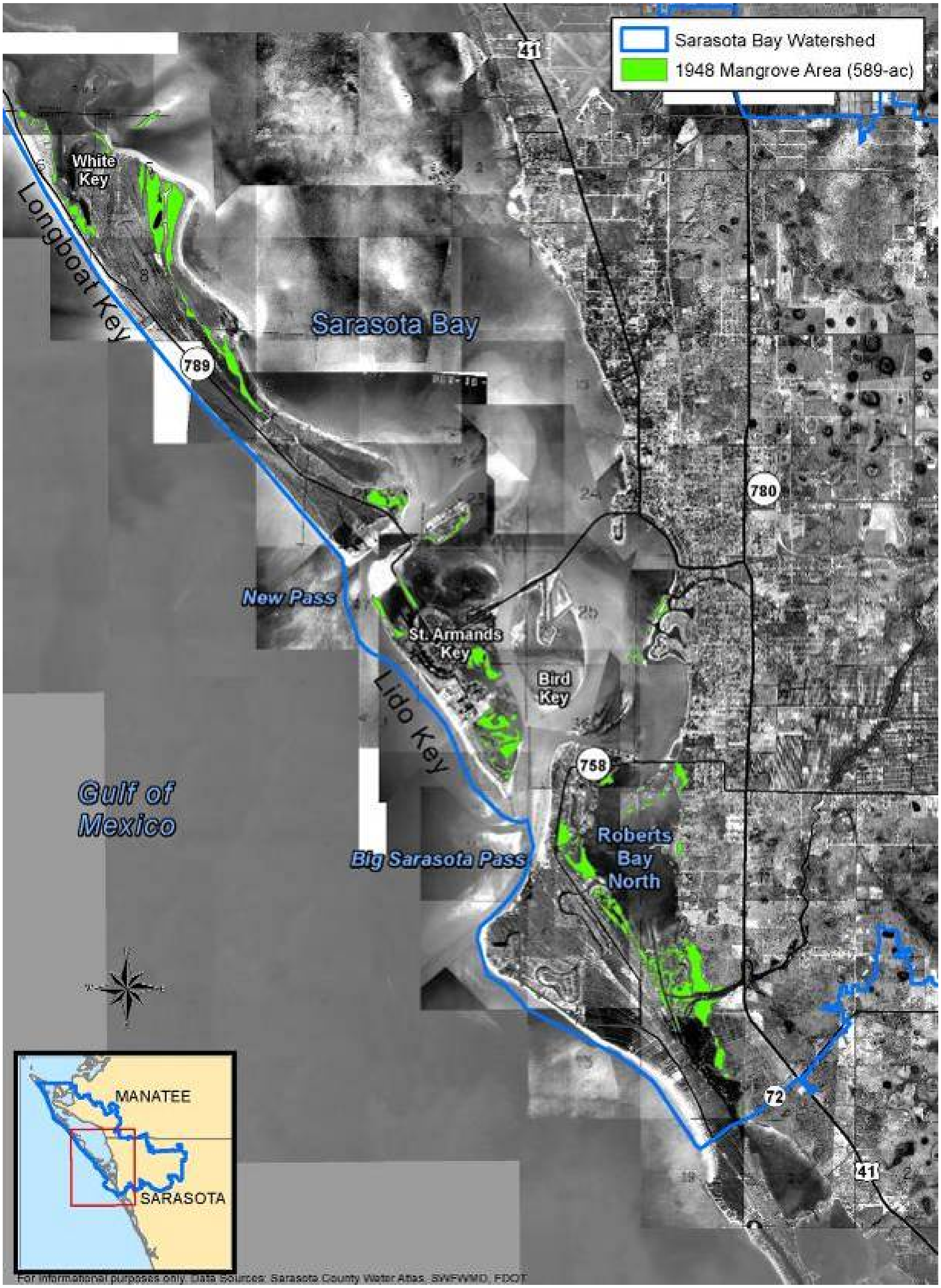


Figure 5-8 Historic 1948 Mangrove Coverage in Sarasota Bay

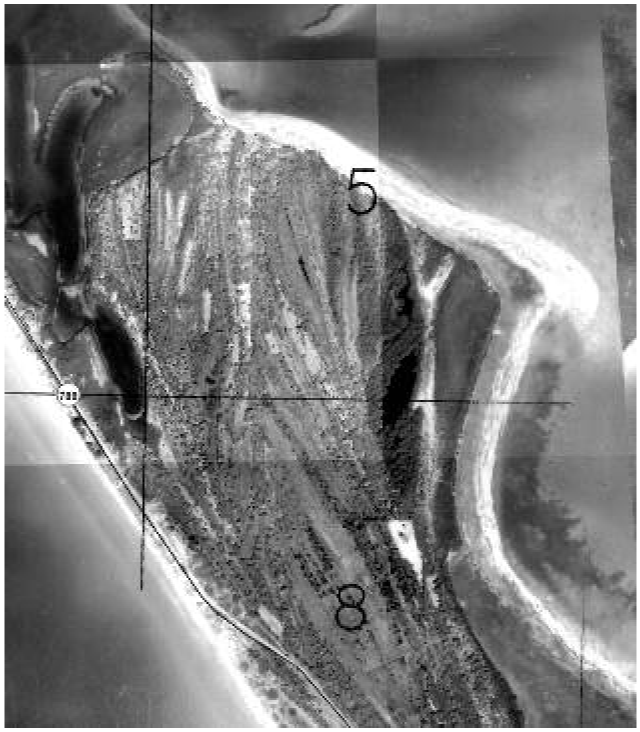


Figure 5-9 1948 Aerial Photo of Longboat Key

Figure 5-10 1957 Aerial Photo of Longboat Key

Figure 5-11 1972 Aerial Photo of Longboat Key

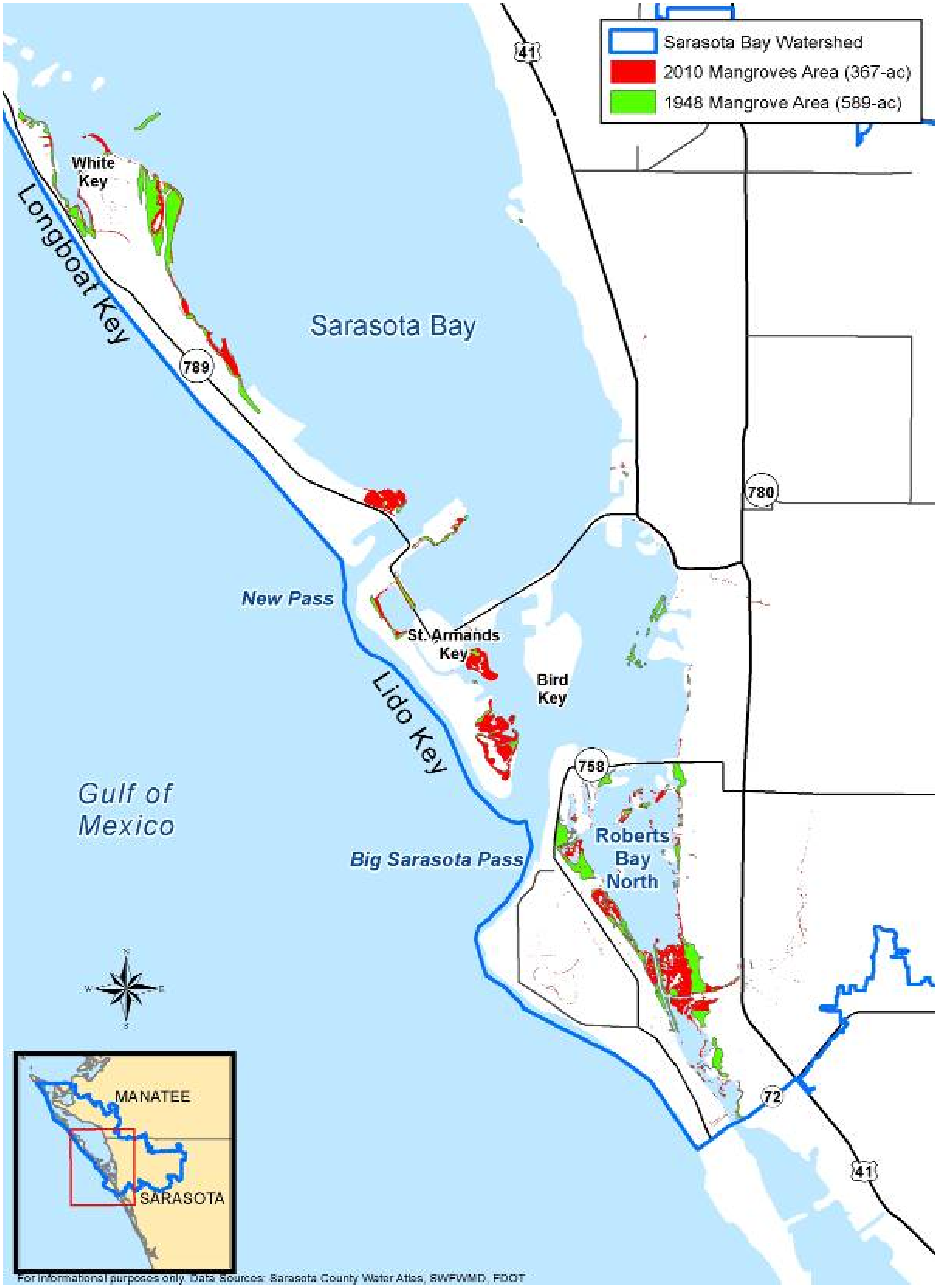


Figure 5-12 1948 and 2010 Mangrove Areas in Little Sarasota Bay

Figure 5-13 1948 and 2010 Mangrove Coverage on Longboat Key

Table 5-2 Summary of Mangrove Acreages			
Year	Acreage		% Change from Historical
	Natural	Artificial*	
1948	589	NA	NA
1970s	756	NA	+28%
2010	367	4.3	-38%

*Mangrove acreage in upland cut residential canals

5.3.3.1 Recommendations

Much of large contiguous mangrove acreage loss in Sarasota Bay occurred before legislation and regulations that protect wetlands from the dredging and filling were implemented. As a result, the 2010 mangrove acreage of 367 acres should be used. To accomplish this, the County must work closely with local municipalities to maintain the existing acreage of mangroves. More importantly, the County must work closely with municipalities to enforce and monitor mangrove trimming, which if not done in compliance with Sections 403.9321 through 403.9333, FS (referred to as the 1996 Mangrove Trimming and Preservation Act) can result in mangrove mortality. Additionally, SBEP adopted a goal of restoring 18 acres of saltwater wetlands per year, which could assist in increase mangrove acreage.

In July 2004 the County initiated a mangrove trimming study in limited portions of Sarasota Bay to assess the state of mangrove trimming within the County. The study was greatly expanded in 2007 and documented that 96% of parcels containing trimmed mangroves were trimmed in accordance with Florida Statutes (Sarasota County, 2009). The study noted that a substantial number of mangrove trimming events occur each year within Sarasota County. This County-led study provides extremely valuable information on the distribution, health, and extent of mangroves in Sarasota Bay and identifies incorrect trimming that could lead to mangrove mortality.

The following recommendations will help maintain the existing mangrove acreage and LOS that this critical habitat provides:

- Continue to conduct the mangrove trimming surveys County wide to identify non-compliant mangrove trimming and to qualitatively assess mangrove health.
- Identify neighborhood associations and individual property owners in locations identified in Sarasota County (2009) willing to plant mangroves.
- Hold mangrove planting workshop.
- Present the importance of mangroves and planting methodologies at Homeowners Associations (HOAs) where mangrove opportunities were identified in Resource Protection (2009).

- Promote, in educational materials and at presentations, additional benefits of untrimmed mangroves.

- Schedule and hold tours with property owners who have trimmed and untrimmed mangroves to show homeowners the expected results.

- Contact and coordinate with the IFAS Sarasota County Extension Office for grant funding and participation.

5.3.4 Watercourse Buffer

Vegetated buffers are strips of vegetated land ecologically and hydrologically connected to adjacent waterways such as creeks, rivers, marshes, and bays. Studies show that vegetative buffer zones protect, restore, and maintain the chemical, physical, and biological integrity of waterways. Vegetative buffers are highly effective at:

- Removing pollutants delivered in urban stormwater.
- Reducing erosion and controlling sedimentation.
- Protecting and stabilizing stream banks.
- Providing infiltration of stormwater runoff.
- Maintaining base flow of streams.
- Contributing organic matter that is a source of food and energy for the aquatic ecosystem.
- Providing tree canopy to shade streams and promote desirable aquatic habitat and providing wildlife habitat.
- Furnishing scenic value and recreational opportunity.

The effectiveness of a buffer depends on its width and vegetative cover. Scientific literature supports a minimum buffer width of 100 feet (with 2 additional feet per 1% slope) of native forest vegetation to provide sediment and contaminant control, quality aquatic habitat, and minimal terrestrial wildlife habitat. Buffers of at least 300 feet are, however, recommended to protect diverse terrestrial wildlife communities (Wegner, 1999). The technical literature is reviewed in Wegner (1999), which gives extensive scientific support for establishing and maintaining buffers along streams (Jones Edmunds, 2010). However, in many circumstances buffer distances of this magnitude are not feasible due to previously approved plats and the large single-family residence lot size that these buffers would require.

5.3.4.1 Established Buffer Regulations

To protect floodplain functions, including conveyance, storage, wildlife habitat, and water quality functions, Sarasota County's Land Development Regulation Subdivision Technical

Manual based on Sarasota County Ordinance No. 95-021 that went into effect in 1995 states the following:

a. “No net encroachment will be allowed into a floodplain up to that encompassed by the 100-year event or on floodplain-associated soils defined in Sarasota County Comprehensive Plan Future Land Use Policy 1.1.6.
b. Compensating storage shall be equivalently provided between the seasonal high water level and the flood level.
c. Vegetative buffers shall be established between future development and watercourses, including bay waters. Buffer widths shall be measured landward from the top of bank or the landward extent of wetland vegetation.
d. Minimum buffer widths shall be 50 feet.
e. Specific buffer-width standards, or flood plain protection measures, or water quality enhancement measures that are equivalent in water quality treatment and habitat protection to a 50-foot-wide vegetated buffer and the [that] have been imposed or approved through a critical area plan, including a sector plan or corridor plan; a planned development district; a development of regional impact pursuant to Chapter 380, Florida Statutes; a regional watershed plan; or a development permit, as defined in Sarasota County Ordinance [No.] 89-103, as amended, issued by Sarasota County, shall supersede the buffer width standards contained in these regulations.
f. Turf grass is acceptable within the 50-foot buffer
g. Native vegetation shall not be removed from buffers except as necessary for the following:
    (1) County maintenance and access
    (2) Road and utility crossings
    (3) Nature trails
    (4) Access to water-dependent uses such as docks
    (5) Subdivision amenities such as golf course fairways when such crossings are unavoidable”

The County has addressed the importance of maintaining or creating naturally vegetated buffers on properties fronting major watercourses not only with regulations but also with public education activities. For example, the County in cooperation with SBEP and SWFWMD, created and distributed the brochure *Living on the Water’s Edge*, which presents to homeowners a simple design to create a 10-foot naturally vegetated buffer zone between the backyard and seawall (Figure 5-14). Additionally, the Sarasota County Fertilizer and Landscape Management Code, Ordinance No. 2007-062, states that fertilizers cannot be applied within 10 feet of a waterbody or wetland.

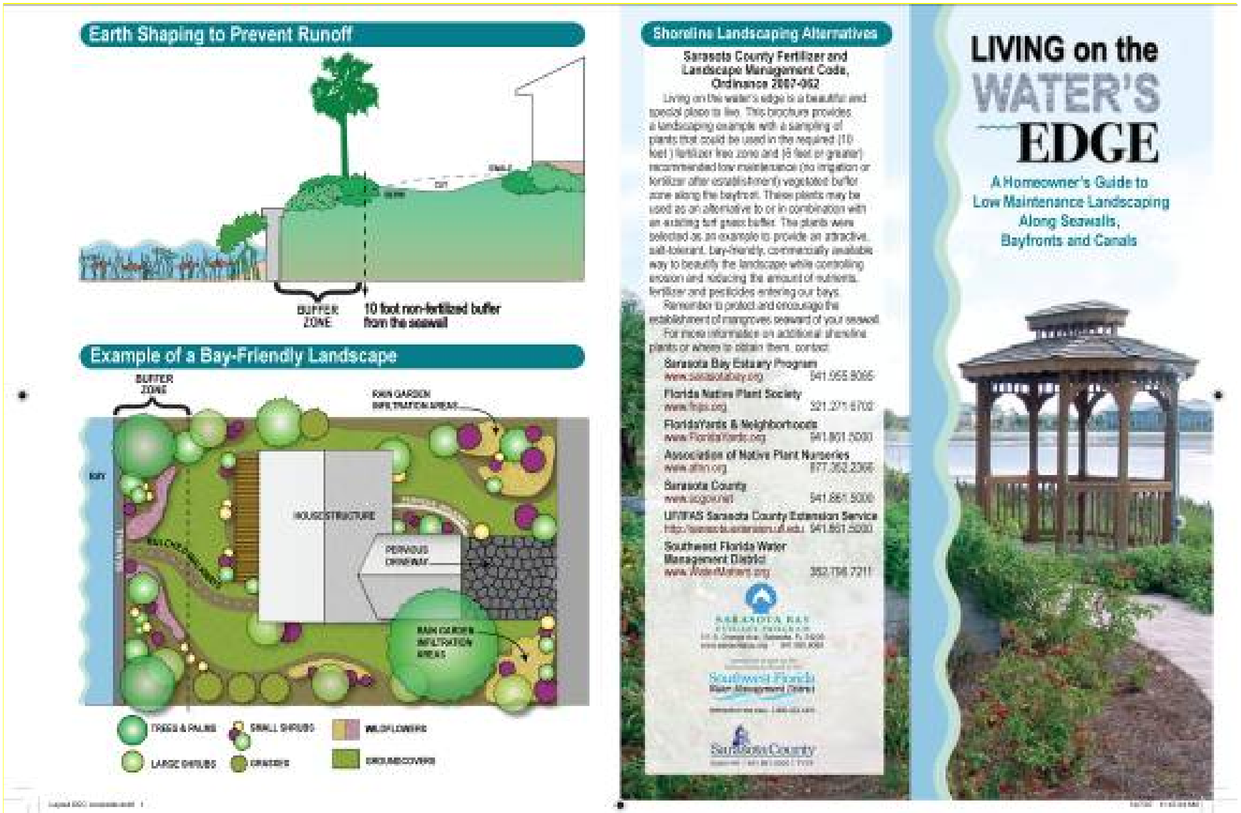


Figure 5-14 Brochure Promoting Creation of Landscaping Alternative for Homeowners Living on Watercourses

The State of Florida *Environmental Resource Permitting Information Manual, Part B: Basis of Review for 40-D Rules* (SWFWMD, 2002) includes the following language pertaining to buffer widths:

- "Secondary impacts to habitat functions of wetlands associated with adjacent upland activities will not be considered adverse if buffers with a minimum width of 15 feet and an average width of 25 feet are provided abutting those wetlands that will remain under the permitted design, unless additional measures are needed for protection of wetlands used by listed species for nesting, denning, or critically important feeding habitat."

1. "For projects located wholly or partially within 100 feet of an Outstanding Florida Water (OFW) or within 100 feet of any wetland abutting an OFW, applicants must provide reasonable assurance that the proposed construction or alteration of a system will not cause sedimentation in the OFW or adjacent wetlands and that filtration of all runoff will occur before discharge into the OFW or adjacent wetlands. Reasonable assurance is presumed if, in addition to implementation of the

requirements in Section 2.8.2, one or more of the following measures are implemented:

a. Maintenance of a vegetative buffer consisting of an area of undisturbed vegetation that is a minimum of 100 feet in width landward of the OFW or adjacent wetlands. During construction or alteration of the system, all runoff, including turbid discharges from dewatering activities, must be allowed to sheet flow across the buffer area. Concentrated or channelized runoff from upstream areas must be dispersed before flowing across the vegetative buffer. Construction activities of limited scope that are necessary for the placement of outfall structures may occur within the buffer area.

b. The structures described below must be installed or constructed at all outfalls to the OFW or adjacent wetlands before beginning any construction or alteration of the remainder of the system. These structures must be operated and maintained throughout construction or alteration of the permanent system. Although these structures may be located within the 100-foot buffer described in subparagraph (a) above, a buffer area of undisturbed vegetation that is a minimum of 25 feet in width must be maintained between the OFW or adjacent wetlands and any structure."

5.3.4.2 Watercourse Setback Analysis Results and Discussion

As previously mentioned, many subdivisions that front major watercourses were platted before 1995 and thus are not subject to the 50-foot requirement. Additionally, the City of Sarasota and Longboat Key municipalities, which make up 48% of the waterfront property, do not require such a buffer. However, this analysis is valuable as it provides resource managers an indication of the setback widths that are typically found at homes on major watercourses.

Mean and median watercourse setback distances present from the edge of homes/buildings to the watercourse in the City of Sarasota and Sarasota County are very similar. The mean and median watercourse setback distance observed in the City of Sarasota was 50 and 40 feet, respectively, while it was 52 and 39 feet, respectively, for Sarasota County (Table 5-3). Watercourse setback distances observed in the City of Longboat Key were significantly less with a mean of 36 feet. This is primarily due to the very small parcel sizes with lots typically being only 100 to 130 feet in depth (Figure 5-15).

Table 5-3 Summary of Watercourse Setback Distances Observed in SB by Municipality		
Municipality	Mean Setback Distance (ft)	Median Setback Distance (ft)
City of Sarasota	50	40
Longboat Key	36	27
Sarasota County	52	39

Figure 5-15 Subdivision within City of Longboat Key depicting Small Parcel Size

All three municipalities (City of Sarasota, City of Longboat Key) had very few home/buildings with less than a 15-foot (<8%) or greater than 100-foot (10% or less) wide watercourse setback. In the three municipalities, the setback width class with the highest percent occurrence was 15 to 30 feet (40%) for the City of Sarasota, 15 to 30 feet (40%) in Longboat Key and 30 to 50 feet (32%) in Sarasota County (Table 5-4). Of all the parcels fronting major watercourses, only 15% had a 50-foot setback that was dominated (>50%) by non-turf grass vegetation (trees and shrubs) (Figure 5-16). The remaining 85% of parcels had a 50-foot watercourse setback dominated by structures, impervious surface, or turf grass or a combination thereof.

Table 5-4 Summary of Watercourse Setback Analysis Based on Distance Classes			
Class*	Municipality	Number of Structures/Homes Within SB	% of Total Within SB
0 to 15 feet	City of Sarasota	56	4%
	Longboat Key	43	6%
	Sarasota County	153	7%
15 30 feet	City of Sarasota	270	21%
	Longboat Key	376	52%
	Sarasota County	564	26%
30 to 50 feet	City of Sarasota	511	40%
	Longboat Key	180	25%
	Sarasota County	687	32%
50 to 100 feet	City of Sarasota	335	26%
	Longboat Key	94	13%
	Sarasota County	525	24%
100 feet +	City of Sarasota	95	7%
	Longboat Key	29	4%
	Sarasota County	214	10%

*Represents the linear distance from the closest edge of a building to the watercourse polyline.

Figure 5-16 Map Depicting 50-Foot Watercourse Setbacks that are Developed Versus Natural

5.3.4.3 Recommendations

With over 90% of the parcels adjacent to major watercourses developed, the emphasis should be in persuading homeowners to incorporate naturally vegetated setbacks into their landscape rather than deterring buffer impacts on undeveloped parcels. The County and participating stakeholders initiated this by preparing and distributing the previously mentioned landscaping brochure (Figure 5-14). Additionally, the Sarasota County Environmental Policy Task Force (EPTF) is reviewing the current 50-foot buffer requirement and developing additional recommendations and modifications to the County's Comprehensive Plan. The EPTF is currently evaluating the following points related to the watercourse buffer:

1. Definition of Watercourse
   a. Clarify text to mirror Comprehensive Plan
   b. Simplify definition
2. Applicability of Buffers to SFR Parcels
3. Native Vegetation Removal
4. Purpose of Watercourse Buffer
   a. Explore and expand definition
5. Composition of Watercourse Buffers
   a. Clarify vegetation compositions
   b. Evaluate optimum composition
6. Incentives for Watercourse Buffers
   a. Program to provided discounted native plant material
   b. Allow equivalency not within buffer
   c. Reduce assessments
7. Develop Comprehensive Educational Materials

Based on results of this setback analysis, an abundance of opportunities exist to work with homeowners to convert waterward portions of their backyards dominated by turf grass to native, low-maintenance species. The County, within its jurisdiction and in cooperation with local municipalities, should continue to work with homeowners to encourage and/or provide incentives to convert turf-grass areas adjacent to these watercourses to a native vegetated buffer: The following are recommendations that could help facilitate more landowners implementing naturally vegetated watercourse setbacks:

1. Use data generated from this analysis to identify homeowners with 50 to 100 feet or greater watercourse setbacks as candidates for developing a naturally vegetated buffer.

2. Revise Sarasota Comprehensive Plan Chapter 2, Section V(C)2h to specify that native vegetation must be used within the required 15-foot buffer for new development.

3. Revise Land Development Regulations to specify that within the required 50-foot watercourse buffer, native vegetation must be used in lieu of turf grass within a minimum of 15 feet with an average of 25 feet. This requirement will be consistent with State regulatory requirements.

4. The County should work with City municipalities to implement a 10- to 15-foot naturally vegetated buffer for all new or rebuild residential home construction.

5. Schedule and Present Buffer Importance Information to HOAs—Many subdivisions with the lowest compliance are very affluent and likely have strong HOAs. During these presentations, the County must stress that the buffers can be low-growing herbaceous and shrub species that will not interfere with water views.

6. Cost-Share or Pay for a Pilot Project in Several Neighborhoods with Low Compliance—The County should sponsor one home in these neighborhoods with important watercourses and landscape a buffer at this home. The County would solicit the labor from neighborhood residents to remove turf grasses and plant and mulch an agreed-on buffer width. This home would serve as a showcase for neighborhood residents and for tours offered to show interested residents what a native landscaped buffer looks like.

7. Offer Gift-Certificates to Local Nurseries or Free Native Plant Offers for Residents.

8. Schedule and Hold Tours of Property Owners that have Implemented Native Landscaped Vegetated Buffers.

9. Engage IFAS Sarasota County Extension Office for Grant Funding and Participation (lead or assist with tours, assist with plantings, etc.).

5.3.5 Shoreline Hardening

Based on previous shoreline analysis presented in Section 2.3 (including portions in Manatee County) had approximately 93 miles of shoreline in 1948, 34.4 miles (37%) of which was hardened. The areas with the most significant modification are the mainland in the City of Sarasota downtown waterfront and the barrier islands south of Longboat Key including Bird Key, St. Armands Key, Coon Key, City Island, and Bay Island, which were all products of early dredge-and-fill operations. By 2008, Sarasota Bay had 150 miles of total shoreline, an increase of over 60%. The additional shoreline is mainly dredge-and-fill canals but is also due to the emergence of numerous mangrove islands in the bay. Substantial shoreline hardening had taken place as well, increasing by over 150% to 85.6 miles.

The previous shoreline analysis presented in Section 2.3 quantified hardened shorelines throughout the bay but did not differentiate whether the shore of the watercourses that were hardened were natural or artificial watercourses (created by excavating canals in uplands). In Sarasota County portions of Sarasota Bay, approximately 45 of the 124 miles of 2010 shoreline are artificial and 79 miles are naturally formed (historical) (Figure 5-17). Of the 79 miles of historical shoreline, 27.5 miles (35%) is currently hardened (Figure 5-18). Janicki's analysis found that 57% of Sarasota Bay, including Manatee County portions and artificial shorelines, was hardened in 2010.

In 1948, approximately 71.6 miles of shoreline existed. Of this, 15.4 miles (21.5%) had been hardened based on 1948 aerial imagery (Figure 5-19). Thus, from 1948 to 2010, 12.1 miles of shoreline had been hardened, which means that 50% of the total shoreline in Sarasota County portions of Sarasota Bay has been hardened and 57% of the total shoreline in all of Sarasota Bay (including Manatee County) is hardened.

5.3.5.1 Recommendations

As with mangroves, a target LOS for shorelines that attempts to measure success based on historical acreage is not appropriate, as much of the hardening occurred before wetland dredge-and-fill regulations were implemented. The goal for natural shoreline should be to maintain existing extents while working to increase extents over time, even at a parcel-by-parcel level.

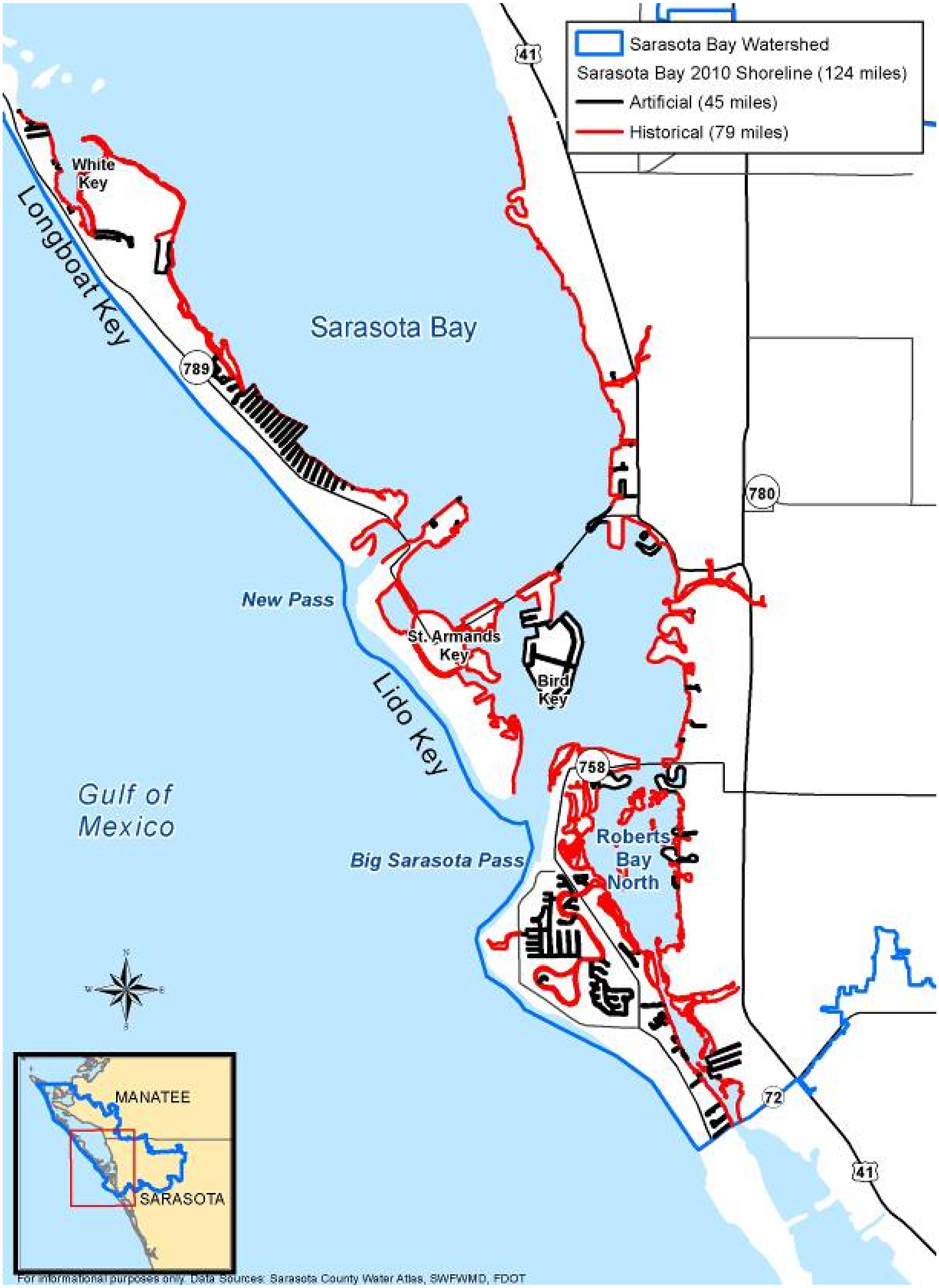


Figure 5-17 Sarasota Bay 2010 Historical and Artificial Shoreline Extents

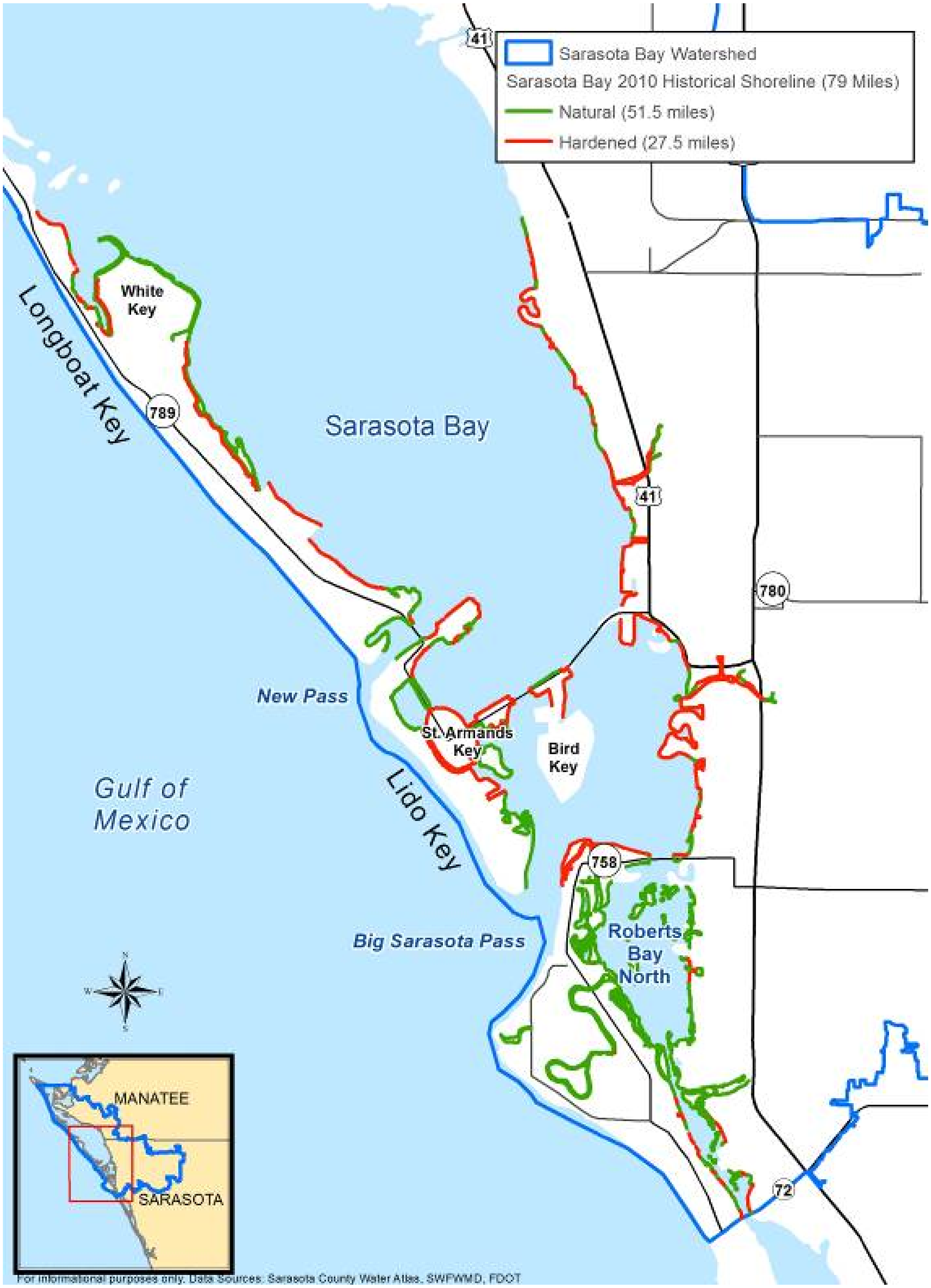


Figure 5-18 Sarasota Bay 2010 Natural and Hardened Shoreline Extents for Historically Occurring Shoreline

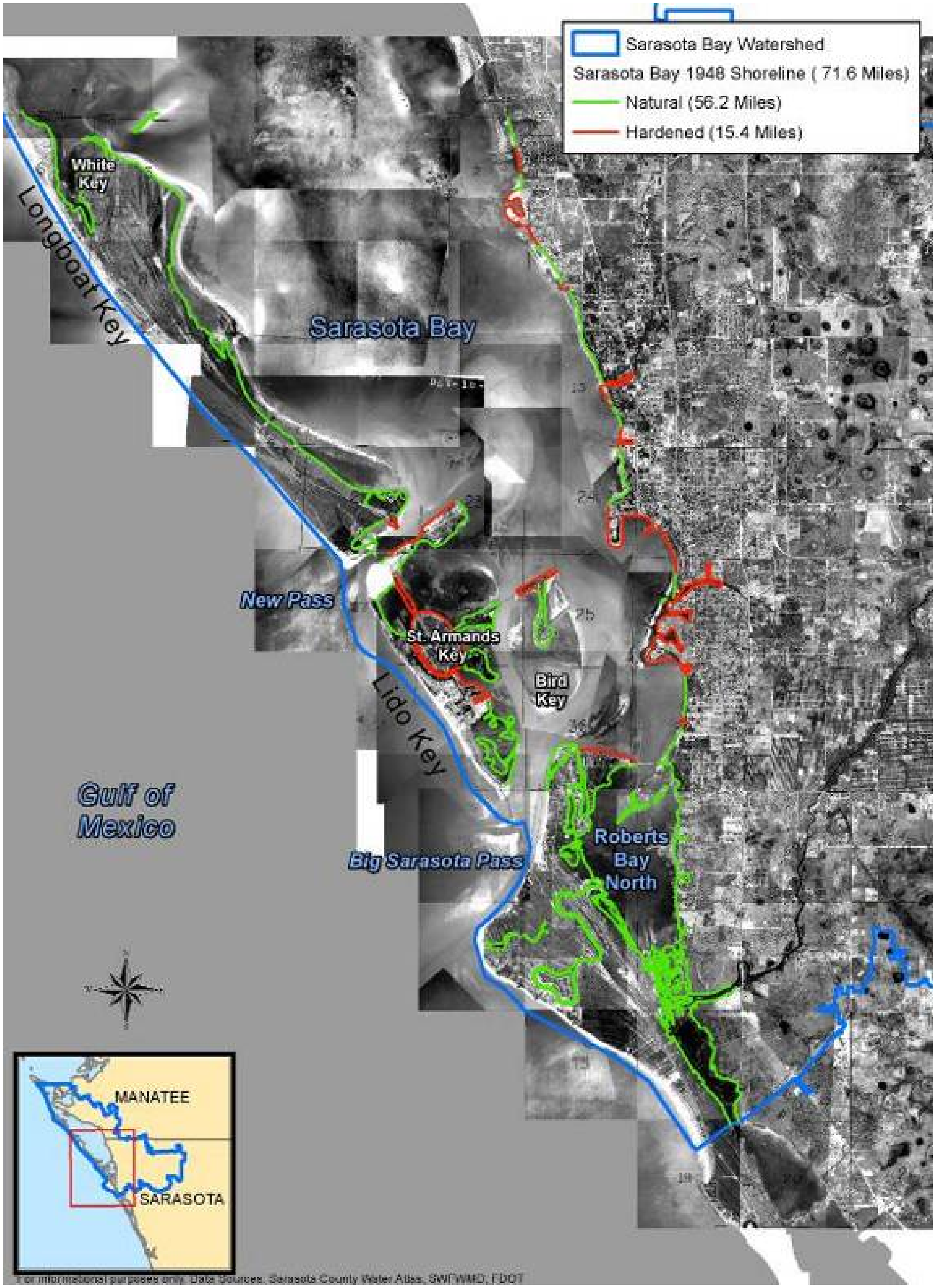


Figure 5-19 Sarasota Bay 1948 Natural and Hardened Shoreline Extents for Historically Occurring Shoreline

Despite over 50% of naturally occurring shoreline in Sarasota Bay being hardened, existing County, State, and Federal regulations should limit additional hardening. Where shoreline protection is warranted, the County should strongly promote soft, non-structural, or hybrid shoreline protection alternatives to persuade the applicants from constructing bulkheads or armoring. These “living shorelines” use a suite of bank stabilization techniques to stabilize the shoreline, minimize future erosion, and maintain coastal processes. The following recommendations will maintain or reduce shoreline hardening in Sarasota Bay:

1. Continue Building Department and Resource Protection coordination to present applicants with living shoreline or soft alternatives to bulkheads and armoring.

2. Work with SBEP to develop a living shoreline brochure that is available to the public at the Building Department and other County offices.

3. Solicit opportunities to present living shoreline concepts and projects (i.e., Herb Dolan Park) to HOAs.

4. Incorporate a living shoreline presentation into any neighborhood outreach being conducted.

5. Continue to encourage shoreline softening for developments proposing shoreline hardening per Sarasota County Comprehensive Plan (Environment Plan, ENV Goal 4, Policy 4.2.1).

6. Schedule and lead tours with SBEP to public project sites and private property owners where examples of living shorelines exist.

6.0 SUMMARY\CONCLUSIONS

Natural systems are self-sustaining living ecosystems such as wetlands, streams, seagrass beds, and upland vegetation communities that support a diversity of organisms and provide many valuable ecosystem-based services. This appendix presented a summary and trends of the critical estuarine and freshwater natural systems found in Sarasota Bay. Six opportunities to enhance existing or create natural systems on public lands were identified and conceptual designs developed.

Positive trends were observed in seagrass coverage in Sarasota Bay, and efforts by stakeholders to achieve this should be a model for other watersheds. No clear trends were observed for oysters. Large losses of mangrove acreage have occurred in Sarasota Bay since the 1940s and before wetland protection regulations were implemented. However, small (<0.25 acre) patches of mangroves are now widely distributed in Sarasota Bay in areas not present historically. The County's mangrove monitoring program provides valuable data to assess mangrove extent and trimming practices. With over 90% of the parcels adjacent to major watercourses developed before 1995 and lacking a naturally vegetated watercourse buffer, the emphasis should be on persuading homeowners to incorporate naturally vegetated setbacks into their landscape rather than deterring buffer impacts on undeveloped parcels. An abundance of opportunities exists to work with homeowners to convert waterward portions of their backyards dominated by turf grass to native, low-maintenance species. Approximately 50% of the total shoreline in Sarasota County portions of Sarasota Bay has been hardened. The goal for natural shoreline should be to maintain existing extents while working to increase extents over time, even at a parcel-by-parcel level. This appendix present LOS targets and recommendations for several of these important natural systems.

7.0 REFERENCES

Bahr, L.M. and W.P. Lanier. 1981. *The Ecology of Intertidal Oyster Reefs of the South Atlantic Coast: a Community Profile*. U.S. Department of Interior Fish and Wildlife Service. FWS/OBS-81/15. Washington, D.C.

Culter, J.K. and J.R. Leverone. 1993. *Bay Bottom Habitat Assessment Draft Final Report*. Prepared for Sarasota Bay Estuary program. Mote Marine Laboratory Technical Report No. 303. Sarasota, FL.

Diehl, T.H. 1994. *Causes and effects of valley plugs in West Tennessee*. In: M.J. Sale and R.O. Wadlington, Editors, Symposium on Responses to Changing Multiple-Use Demands: New Directions for Water Resources Planning and Management, Nashville, Tenn., April 17–20, Proceedings of Extended Abstracts, American Water Resources Association, Middleburg, VA (1994), pp. 97–100.

Environmental Services and Natural Resources, Resource Protection, Sarasota County. 2009. 2007–2008 Mangrove Trimming Study. Sarasota County, Florida.

Environmental Services and Natural Resources, Resource Protection, Sarasota County. 2006. 2005 Mangrove Trimming Study. Sarasota County, Florida.

Estevez, E.D. 2007. *Tidal Creek Condition Index for Coastal Streams in Sarasota County, Florida Final 2006 Report*. Prepared for Sarasota County Water Resources. Mote Marine Laboratory Technical Report No. 1131. Sarasota, FL.

Evans M.W. and R.K. Evans. 1988. *Sarasota County estuarine shoreline inventory: Final report*. Sarasota County Planning Department. Mote Marine Laboratory Technical Report no 120. 42 p. and appendix. Available from: Mote Marine Laboratory Library.

Florida Seagrant. 2003. *GIS coverage of historical oyster bar locations in Sarasota Bay*. Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

Grizzle, R.E. 1984. *Pollution indicator species of macrobenthos in a coastal lagoon*. Marine Ecology Progress Series. 18: 191–200.

Hutchings, P and P. Saenger, 1987. *Ecology of mangroves*. University of Queensland Press. Brisbane, Australia.

Janicki Environmental, Inc. 2010. *Numeric Nutrient Criteria for Sarasota Bay*. Prepared for Sarasota Bay Estuary Program, Sarasota, FL.

Jones, M.S., 2007. *Sarasota County Comprehensive Oyster Monitoring Program Annual Report 2006*. Prepared by Sarasota County Water Core Services. Sarasota, FL.

Jones Edmunds & Associates, Inc. 2010. *Roberts Bay North Watershed Management Plan*. Prepared for Sarasota County and the Southwest Florida Water Management District.

Knowles, S.C. and Davis, R.A., J r., 1983. *Hurricane influence on Holocene sediment accumulation in Sarasota Bay, Florida*. Am. Assoc. Pet. Geol. Bul l., 67(3): 481-496

MacDonald, T.C., E. Weather, P.W. Stevens, and R.H. McMichael, Jr. 2010. *Nekton of Sarasota Bay and a Comparison of Nekton Community Structure in Adjacent Southwest Florida Estuaries.* Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute. St. Petersburg, Florida. Ray, D. 1999. Ecological and morphological significance of old growth deadhead logs in The Blackwater River. Florida Department of Environmental Protection, NWD Unpublished Report.

Mangrove System, Inc. 1988. *Marine habitat trend analysis for Sarasota County*. Final report to Sarasota County Natural Resources Dept. 16 pp.

McRae, G. 2002. *Florida's Inshore Marine Monitoring and Assessment Program (IMAP) Annual Report Year 3*. Florida Fish and Wildlife Conservation Commission. Florida Marine Research Institute. St. Petersburg, FL.

Meaux, K. L. 2011. Sarasota County Water Resources. Personal Communication.

Odum, W.E., C.C. McIvor, and T.J. Smith. 1982. *The ecology of the mangroves of south Florida: a community profile*. FWS/OBS-81/24. United States Fish and Wildlife Service, Office of Biological Services. Washington, DC.

Photo Science, Inc. 2007. *GIS coverage of historical oyster bar locations in Sarasota Bay*. Prepared for Sarasota Bay Estuary Program. Sarasota, FL.

Ray, D. 1999. *Ecological And morphological Significance of Old growth deadhead Logs in The Blackwater River*. Florida Department of Environmental Protection, NWD Unpublished Report.

Sarasota Bay Numeric Nutrient Criteria: *Tidal Creeks Letter Memorandum*. 2011. Prepared by Janicki Environmental, Inc. Prepared for Sarasota Bay Estuary Program. Sarasota, Florida.

SBEP. 2011. Sarasota Bay Tidal Creek Workshops Sampling & Measurement Program(s) for Sarasota Bay Tidal Creek. SBEP Technical Advisory Committee. Sarasota, FL.

Sarasota County, Environmental Services and Natural Resources, Resource Protection. 2009. *2007–2008 Mangrove Trimming Study*. Sarasota County, Florida.

Sarasota County. 2008. Sarasota County/Sarasota Bay Watch 2008 Scallop Search Data. Sarasota County Department of Environmental Protection Services. Sarasota, FL.

Sarasota County, Environmental Services and Natural Resources, Resource Protection. 2006. *2005 Mangrove Trimming Study*. Sarasota County, Florida.

Serviss, G.M. and S. Sauers. 2003. *Sarasota Bay Juvenile Fisheries Habitat Assessment*. Prepared for Sarasota Bay National Estuary Program. Sarasota, Florida 34234

Shields, F.D., N. Morin, C.M. Cooper. 2004. *Large woody debris structures for sand-bed channels*. J. Hydraul. Eng. 130, 208–217.

Shumway, S.E. 1996. *Natural environmental factors*. In: V.S. Kennedy, R.I.E. Newell, and A.F. Eble, editors. The Eastern Oyster *Crassostrea virginica*. Maryland Sea Grant College, University of Maryland. College Park, MD. pp. 467-513.

Southwest Florida Water Management District (SWFWMD). 2010. *GIS seagrass coverage for Sarasota Bay system*. Brooksville, FL.

Southwest Florida Water Management District (SWFWMD). (2002) *Environmental Resource Permitting Information Manual, Part B: Basis of Review for 40-D Rules.*

Tolley, S.G., and A.K. Volety. 2005. *The role of oysters in habitat use of oyster reefs by resident fishes and decapod crustaceans*. Journal of Shellfish Research 24:1007-1012.

Wegner, S. (1999). *A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation.* Institute of Ecology, University of Georgia.

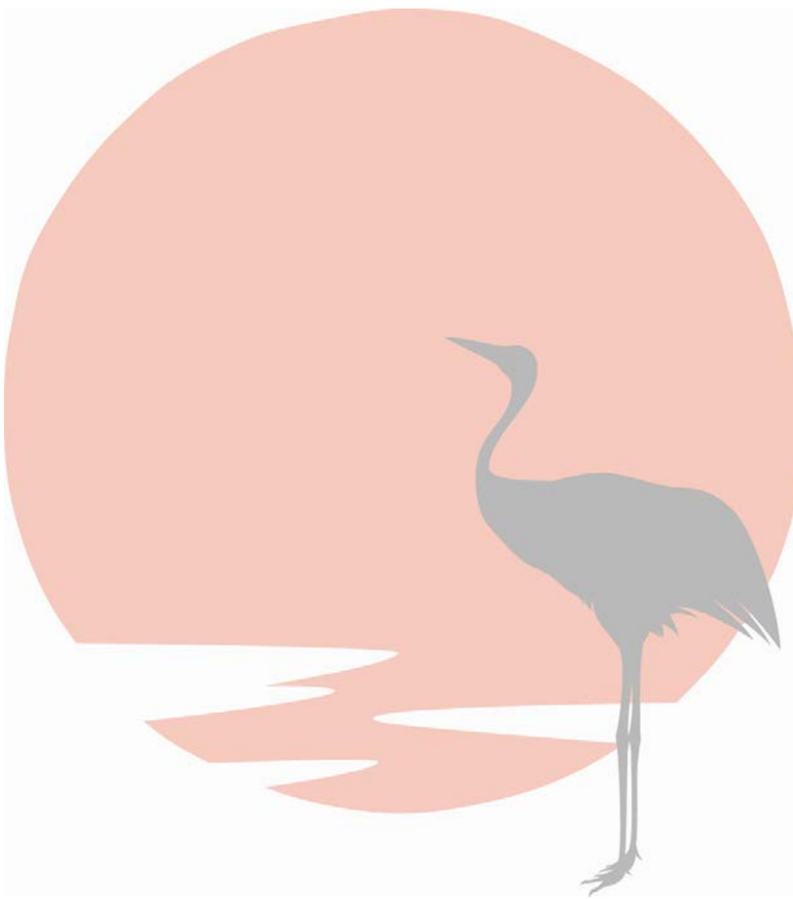
Wells, H.W. 1961. *The fauna of oyster beds, with special reference to the salinity factor*. Ecological Monographs 31(3): 239-266.

Wessel, M. R., A. Janicki, and R. Nijbroek. 2007. *Establishing water quality benchmarks for Sarasota County estuarine waters.* Report submitted to Sarasota County Water Resources. Sarasota, Florida.

Appendix E

Flood Protection

Appendix E
Flood Protection



December 2012

Sarasota County · Southwest Florida Water Management District · Jones Edmunds · Janicki Environmental, Inc.

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1.0 INTRODUCTION

The Sarasota Bay Watershed is subject to coastal and inland flooding. Coastal flooding sources include storm surge and wind-driven waves. Inland flooding results from excessive rainfall. Storm surges are caused by high winds, and coastal and inland flooding are usually associated with hurricanes or other tropical storms. The relatively flat and low-lying topography of Sarasota County make it inherently prone to both types of flooding, and the County's "poorly drained" soils further promote inland flooding. Additionally, development has changed the natural environment within the Sarasota Bay Watershed and likely exacerbated the flooding problem before modern stormwater management regulations were implemented. Increased impervious surfaces throughout the heavily urbanized Hudson Bayou, Whitaker Bayou, and Sarasota Coastal basins have decreased rainfall infiltration, and gutters and storm sewers speed runoff to the channels. As a result, more water runs off more quickly, and drainage systems, including creeks, can become overloaded, leading to flooding.

The Sarasota County Watershed Management Program endeavors to address inland flooding. The County's goal with regard to flood protection is to minimize flood risk to protect human safety and property in existing developed areas while protecting natural and beneficial functions of the remaining floodplain. This Watershed Quality Management Plan (WQMP) does not contain new analyses of flood conditions since the conditions have been analyzed and recommendations for improvements were previously proposed. Instead, this WQMP provides an overview of existing flood-protection-related activities and previous flood-protection recommendations. This section is an important component of the WQMP as flooding in the watershed directly impacts water quality in the tributaries and bay. Water quality best management practices (BMPs) are often designed to capture debris and sediment and remove pollutants during low-flow events and may not be as effective during larger storm events. Additionally, during large storm events, runoff may pool or flow in areas outside of drainage systems, such as over roads or in parking lots, and may collect more debris and pollutants than a low-flow event fully contained within a drainage system with water quality BMPs. Therefore, reducing the risk of flooding is an important component of improving water quality in Sarasota Bay.

This overview includes a background section followed by a description of the significant flood-protection-related policies, programs, planning studies and efforts and a summary of flood-protection activities for Sarasota County.

2.0 BACKGROUND

Historically, the Sarasota Bay Watershed was predominately a mosaic of isolated wetlands and pine flatwoods. During normal seasonal cycles, the water in these wetlands expanded into pine flatwoods with wet-season rainfall and contracted to isolated pockets of wetlands during the dry season. In the early 1900s, residents of Sarasota County established a Mosquito Control District that installed ditches in mangrove areas along the coast and extended the natural creeks inland to connect many of the large, isolated wetlands. The result is a network of man-made drainage ditches that dramatically altered the movement of freshwater from the land to tidal creeks, estuaries, and bays and in turn extended the tidal influence inland. Over time many wetlands and floodplains were filled without mitigation or compensation, and impervious surfaces were created. As a result, flood storage capacity was reduced and runoff increased, raising flood stages and decreasing water quality in creeks and bays. Since much of the watershed is now densely populated, flooding affects homes, businesses, and agriculture in the floodplains, especially those areas developed before the adoption of County Land Development Regulations (LDR) in 1981 (Figure 2-1).

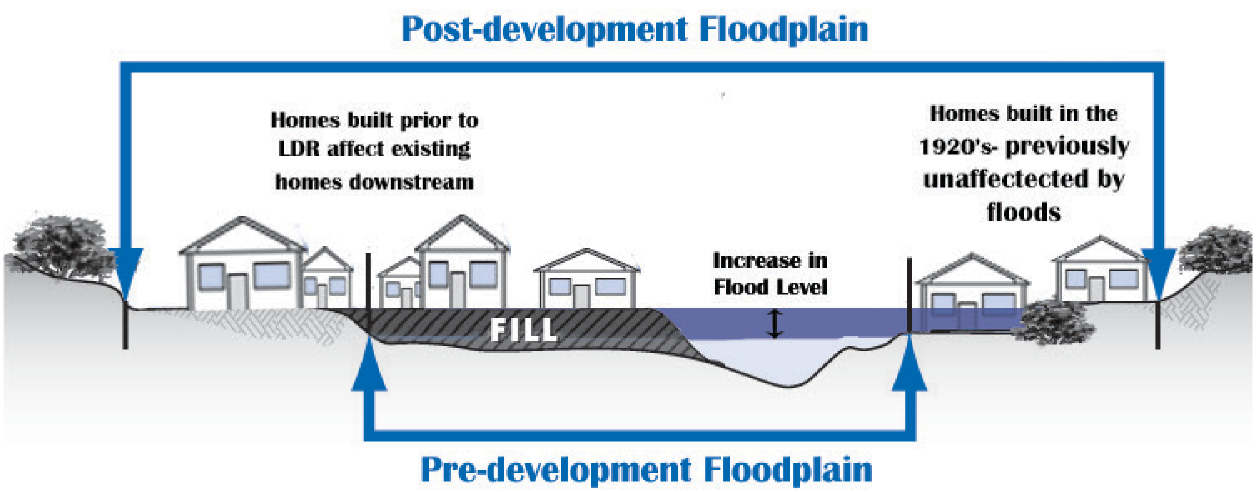


Figure 2-1 Floodplain Changes Schematic (Adapted from www.dnr.sc.gov)

Sarasota County recognizes its flooding problems and the need to improve the existing system. The County took the first step toward developing a stormwater program in 1981 with the creation of the Stormwater Management Division. Around that time, the County implemented its first LDR, requiring stormwater controls to be designed for a 25-year storm (8 inches of rain in 24 hours). In 1987, the Sarasota County Stormwater Master Plan was adopted. The Sarasota County Stormwater Environmental Utility (SEU) was established in 1989 to implement the plan.

By the early 1990s, the Sarasota County SEU initiated a Countywide basin master planning project to develop hydrologic and hydraulic models to identify problematic flooding areas for all of the County's major watersheds. These models are also used to analyze proposed drainage improvements to the County's stormwater system. The Hudson Bayou, Business District, and Whitaker Bayou Basin Master Plans were completed in 1994, 2002, and 2003, respectively. An addendum to the Hudson Bayou Basin Master Plan was issued in 1997. In addition, SEU continues to maintain the model by updating it periodically. The updated model is made available to developers to use as the base model to ensure that proposed projects will not impact neighboring areas.

In the mid 1990s, the LDR was modified to require stormwater systems to be designed for a 100-year storm (10 inches of rain in 24 hours). The County also started the first stormwater capital improvement assessments. The County then completed feasibility analyses for projects in problem areas identified in the Basin Master Plans. Several of these projects are included in the County's Capital Improvement Program (CIP). By the late 1990s, the SEU Strategic Plan was adopted and revenue bonds were issued to fund more stormwater improvement projects. Today, several CIP projects, such as stormwater control structures, retrofit projects, and retention and detention ponds, have been constructed throughout the Sarasota Bay Watershed (Figure 5-2).

Regular maintenance of stormwater management systems is essential to ensure the efficient function of existing stormwater conveyances and the new stormwater facilities. The County's Environmental Services Department follows a 1999 Strategic Maintenance Plan for the Drainage Operations Division. The plan identifies maintenance practices and classifies practices into *Routine*, *Extraordinary*, and *Support* activities in which the staff engages for maintenance repairs, improvement, management, and operation of the public stormwater system. For more information on Stormwater Management Facility Maintenance, refer to Chapter 7 of the Roberts Bay North Watershed Management Plan.

3.0 FLOOD-PROTECTION LEGISLATION AND ORDINANCES

The Sarasota County Comprehensive Plan is an official public document adopted by the Board of County Commissioners and approved by the State to provide the policy direction used in framing land use decisions and growth management initiatives. The plan covers legislation that has been adopted, planning studies and mitigation efforts, and levels of service for stormwater quality and quantity. The plan is subject to an annual amendment cycle as well as the Evaluation and Appraisal Report requirement every 7 years (last EAR update, November 2006). The 11 chapters that comprise the Sarasota County Comprehensive Plan include data and maps on and analysis of existing conditions and—based on that information—goals, objectives, and policies to guide future development and conservation activities.

3.1 LEGISLATION

The five water management districts—including the Southwest Florida Water Management District (SWFWMD)—were initially created by the State of Florida to control flooding. The SWFWMD Governing Board is authorized in Chapter 373 and other chapters of the Florida Statutes to direct a wide range of programs, initiatives, and actions. These programs include flood control, regulatory programs, water conservation, education, and supportive data collection and analysis. SWFWMD's goals for flood protection, water quality, and natural systems are:

- To minimize the potential for damage from floods by protecting and restoring the natural water storage and conveyance functions of flood-prone areas.
- To protect water quality by preventing further degradation of water resources and enhancing water quality wherever possible.
- To preserve, protect, and restore natural systems to support their natural hydrologic and ecologic functions.

Sarasota County supports the following State regulations through its Comprehensive Plan and a series of ordinances:

- Chapter 40D-2, Florida Administrative Code, includes stormwater system design criteria.
- Chapter 40D-4 and Chapter 40D-40 FAC, state that SWFWMD governs surface water permitting and stormwater runoff.
- Chapter 40D-4 limits peak discharge rates for new development. Rules also stipulate that activities affecting floodplains and floodways will not cause adverse impacts, such as increased flooding.

3.2 LOCAL ORDINANCES

New developments are required to consider the impacts of a 100-year storm event to protect existing structures with the first habitable floor elevation at or just above the estimated 100-year, 24-hour flood elevation required by the Federal Emergency Management Agency (FEMA) and Sarasota County Ordinance No. 92-055 as amended. Unless properly managed, the increased volume and rate of runoff as well as the change in timing from upstream new developments will increase 100-year flood elevations, thus impacting structures built to previously lower flood elevations.

Sarasota County Ordinance No. 2009-060 provides building construction requirements to maintain eligibility for flood insurance coverage in flood-prone areas in the unincorporated area of the County. This Ordinance amends Ordinance No. 92-055 as it relates to definition, adoption of flood hazard map, lowest floor elevation, and machinery and equipment and provides an effective date. The policy provides a guide for all new residential and non-residential construction and substantial improvements to existing residential and non-residential structures' lowest floor elevation in reference to the base flood elevation.

Sarasota County Ordinance No. 81-12, "Land Development Regulations," as amended provides regulations that guide development as it pertains to the force of flowing water and drainage of runoff. These regulations require that post-development conditions do not exceed those under pre-development conditions for the 100-year storm. Furthermore, the LDR regulates development activities within the 100-year floodplain by withholding approval "unless the developer submits substantial and competent evidence that all lands intended for use as building sites can be used safely for building purposes, without undue hazard from flood or adverse soil or foundation conditions." The LDR requires use of the applicable basin flood prediction model as the basis of review to ensure that development proposals of 35 or more total acres or 8 or more acres of impervious area will not result in an increase in offsite flood stages. Additionally, Ordinance No. 81-12 as amended requires new development to provide treatment of the first 1 inch of runoff. The Water Pollution Control Code, Ordinance No. 96-020 as amended provides regulations to prohibit discharges that cause pollution to surface water, groundwater, or the stormwater conveyance system.

Sarasota County established SEU in 1989 (Ordinance No. 89-117, as amended). SEU is responsible for funding, planning, and constructing improvements and maintaining the County's storm and surface water management facilities. SEU has been instrumental to the County's progress in protecting existing homes from flooding as well as allocating significant resources to identify the riverine floodplain in rural areas to help guide development away from flood-prone areas.

The Ordinance provides funding for the operation of SEU by enacting a "user fee." Each parcel of land is charged an annual fee based on the characteristics of the parcel and its relative contribution to stormwater runoff. An associated "credit" program was enacted that enables "credits" to be granted against the "user fee" for properties that maintain their drainage facilities in full-functioning condition. SEU is also responsible for permitting proposed changes in the watershed.

Since the inception of SEU in 1989, well over half of the 800 homes and business previously susceptible to riverine flooding (100-year, 24-hour storm) are protected.

Further, ongoing projects are expected to reduce the number of flooded homes and businesses during the 100-year, 24-hour storm to approximately 250.

Sarasota County adopted a floodplain management ordinance (Ordinance No. 2003-085, as amended). This ordinance adopts the current FEMA Flood Insurance Study and the Sarasota County Flood Studies. Minimum lowest finished floor elevations for new construction and substantial improvements are required to be either at or above the base flood elevation as determined by FEMA or 1 foot above the 100-year flood stages established by Sarasota County.

Since Fiscal Year 1993, the CIP contained funding for projects throughout the County. This program is well underway and is directed at addressing flood protection level-of-service (FPLOS) deficiencies, including flooded homes and businesses as well as flooded streets. To date, the primary focus of the stormwater improvement program has centered on flooded homes and businesses, with a secondary focus on street flooding. As this program reaches a point of diminishing returns in terms of addressing flooded buildings, it is likely to focus more on remaining street FPLOS deficiencies.

In addition, flood insurance is another tool used to mitigate flood loss and assist in a community's speedy recovery. Under the Community Rating System, flood insurance premium rates are adjusted to reflect the reduced flood risk resulting from BMPs. Sarasota County attained a Class 5 Rating in 2007, which equates to $5M–$6.3M in annual discounts for $11B in property protection.

4.0 FLOOD PROTECTION LEVEL OF SERVICE (FPLOS)

The stormwater quantity FPLOS requires that public and private stormwater management systems provide adequate control of stormwater runoff. The stormwater quantity or FPLOS and design criteria used throughout the Basin Master Plan program are defined in the Sarasota County Comprehensive Plan and LDR (Table 4-1) and used throughout the Basin Master Plan program (Section 5.1).

Table 4-1 Stormwater Quantity Level-of-Service (FPLOS) Design Criteria

Category		Flooding Reference	Level of Service (flood interval)
I.	Buildings	Emergency shelters and essential services	>100
		Habitable	100
		Employment/Service centers	100
II.	Roads Access	Evacuation	>100
		Arterials	100
		Collectors	25
		Neighborhood	10
III.	Sites	Urban (>1 unit/acre)	5
		Rural	2

The FPLOS criteria above can be adjusted to allow greater amounts of flooding of roads and sites if the flooding is provided for in a Basin Master Plan or as part of a stormwater management system design. Increased flooding should not adversely impact public health and safety, natural resources, or property.

The goal of the FPLOS design criteria is to prevent flooding of emergency shelters and structures providing essential services during storms equal to or exceeding the 100-year event (10 inches in 24 hours). The FPLOS goal for habitable structures and employment/service centers is no flooding from storms up to and including the 100-year storm. Flooding of garages, barns, sheds, and other out-buildings is not considered structure flooding. The FPLOS established for roadways varies depending on the classification of the street or roadway. The goal of these criteria is to prevent flooding of evacuation routes and major arterial roadways during storms up to and including the 100-year event. Flooding of agricultural land, developed open or green space, and undeveloped lands designated for future development is acceptable in storms greater than the 5-year event (7 inches in 24 hours) for urban areas (>1 unit/acre) and storms greater than the 2-year event (5 inches in 24 hours) in rural areas. This does not include areas incorporated into the Stormwater Basin Master Plan as flowways, floodplain, or flood-storage areas.

Table 4-2 shows acceptable flooding criteria for the 5-year, 10-year, 25-year, and 100-year design storm. Figure 4-1 shows acceptable flooding for a 100-year storm. FPLOS deficiencies consist of flooded homes and businesses as well as flooded streets. To date, the primary focus of the County's stormwater improvement program has been to address flooded homes and businesses, with a secondary focus on severe street flooding.

Table 4-2 Acceptable Flooding Criteria				
Description	5-year	10-year	25-year	100-year
Roadway: Evacuation	None	None	None	None
Roadway: Arterials	None	None	None	6 inches
Roadway: Collectors	None	None	6 inches	9 inches
Roadway: Neighborhood	None	6 inches	9 inches	12 inches
Parking Areas	3 inches	9 inches	9 inches	12 inches
Open Space	Flooding of open space is acceptable if it does not compromise public health and safety.			

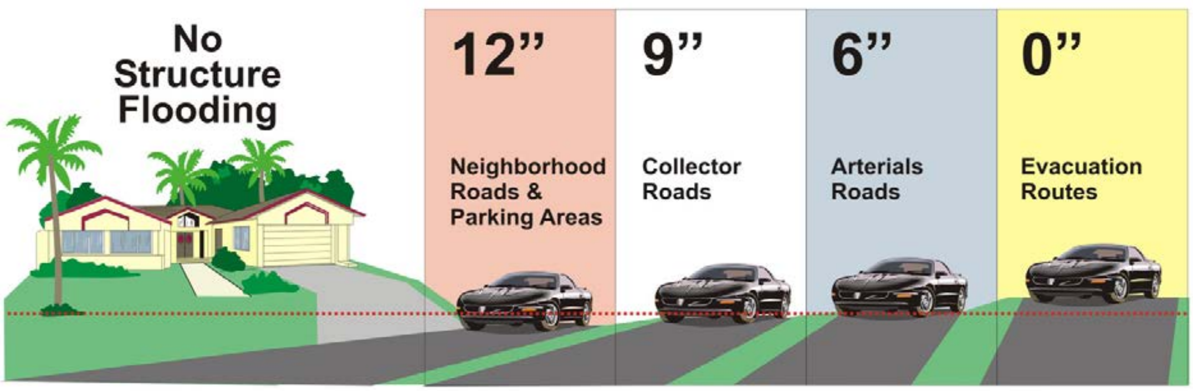


Figure 4-1 Acceptable Flooding for a 100-Year Storm

5.0 PLANNING STUDIES AND EFFORTS

The drainage plans and programs from the early 1920s through the 1960s emphasized removing surface waters from the land, primarily for mosquito control and agricultural uses. Water quality did not begin emerging as a major concern until the late 1960s.

In 1984 the Board of County Commissioners recognized major inadequacies in the existing stormwater management system and authorized the preparation of a Stormwater Master Plan to assess the need for improving major drainage systems in the developed portions of the County. The objectives of the plan included:

- Assessing the adequacy of primary stormwater conveyance systems in developed or developing basins.
- Estimating the cost for public stormwater improvements as watersheds are developed to their ultimate use.
- Prioritizing stormwater management needs of each basin within a framework of the needs within the entire County.
- Developing a plan or identifying options available to the County for financing the cost of construction, operation, and maintenance of stormwater management facilities.

The County began the Basin Master Planning Program in 1991, and by 2004 the Basin Master Plans for Whitaker Bayou and Hudson Bayou and Business District were completed. The planning process included developing runoff hydrographs and water surface profiles for existing and future (2010) land uses for 2-year, 5-year, 10-year, 25-year, and 100-year 24-hour storm events for each basin. Each Basin Master Plan also identifies improvements needed to the County drainage systems to meet the adopted FPLOS standards within the basin. More detailed information on the Basin Master Planning Program is provided below.

An important product of the Basin Master Plan effort is the horizontal limits of the riverine, 100-year floodplain. Much of the County riverine floodplain maps to be used for local stormwater management planning have been completed. These maps and the detailed flood-prediction models must, however, be kept up to date to reflect changes in the watershed, such as land development and stormwater projects, or they will become obsolete.

5.1 BASIN MASTER PLANNING

Numerous hydrologic studies dating back to the late 1970s have been completed throughout the Sarasota Bay Watershed. The Basin Master Plans listed below were based on a detailed analysis of these studies, the existing and projected land uses, existing drainage facilities, and projected stormwater drainage management needs. This information was used to develop hydrologic and hydraulic models using ICPR’s routing engine to simulate runoff, conveyance, and flooding conditions for the Whitaker Bayou and Hudson Bayou basins. Model results were used to identify the location and magnitude of existing flooding problems in the basins. Based on model results, the plans provide recommendations for facilities improvement and management standards that will need to be met by the private sector for new construction and the expansion of existing activities to bring stormwater conveyance systems within the basins into compliance with the recommended FPLOS criteria. See Figure 5-1 for the basin boundaries.

5.1.1 Whitaker Bayou

The Whitaker Bayou Basin Master Plan identifies numerous flood-prone areas. One-hundred-and-fifty-four habitable structures are estimated to be susceptible to flooding from the 100-year, 24-hour storm, and 275 roadway locations are estimated to have an FPLOS deficiency. Seven alternative improvements were evaluated in the Whitaker Bayou Basin Master Plan. Flooding conditions under the seven alternatives reveal that less than a third of the parcels are eliminated from structural flooding during at 100-year, 24-hour storm. Hence, structural flooding will continue to be a major concern in the Whitaker Bayou basin. Table 5-1 lists CIP projects that address deficient LOS in the Whitaker Bayou basin.

5.1.2 Hudson Bayou

The 1987 City-Wide Master Drainage Plan identified 15 flood-problem areas within the Hudson Bayou basin. The flooding problems are primarily described as street, driveway, and yard flooding. None of the 15 problem areas references house flooding. The causes of the problem listed in the Master Drainage Plan in these 15 areas are either undersized storm sewer pipes or constricted channel sections. The projects recommended in this study primarily address nuisance flooding areas or drainage complaints and do not necessarily address the City stormwater LOS for the project area. The 1994 Basin Master Plan for Hudson Bayou indicates a deficient LOS area within the Outfall No. 3 drainage area. The LOS analysis indicates that 30 buildings within the 25-year floodplain of the Arlington Drainage Canal, the Fruitville Drainage Canal, and the Euclid Drainage Canal would have flooding on the lowest floors. Deficiencies are also seen within Outfall No. 1 and No. 2 of the Hudson Bayou basin. However, no attempt was made to quantify the location or number of structures that might be flooded during a 25-year, 24-hour storm event due to the lack of lowest floor elevation and the inaccuracy in predicting flow depths of the closed conduit system. Table 5-1 lists CIP projects that address deficient LOS in the Hudson Bayou basin.

Sarasota Bay Watershed Basin Master Plans:

- *Whitaker Bayou – December 2003 and December 2004*
- *Hudson Bayou and Business District – September 1994*

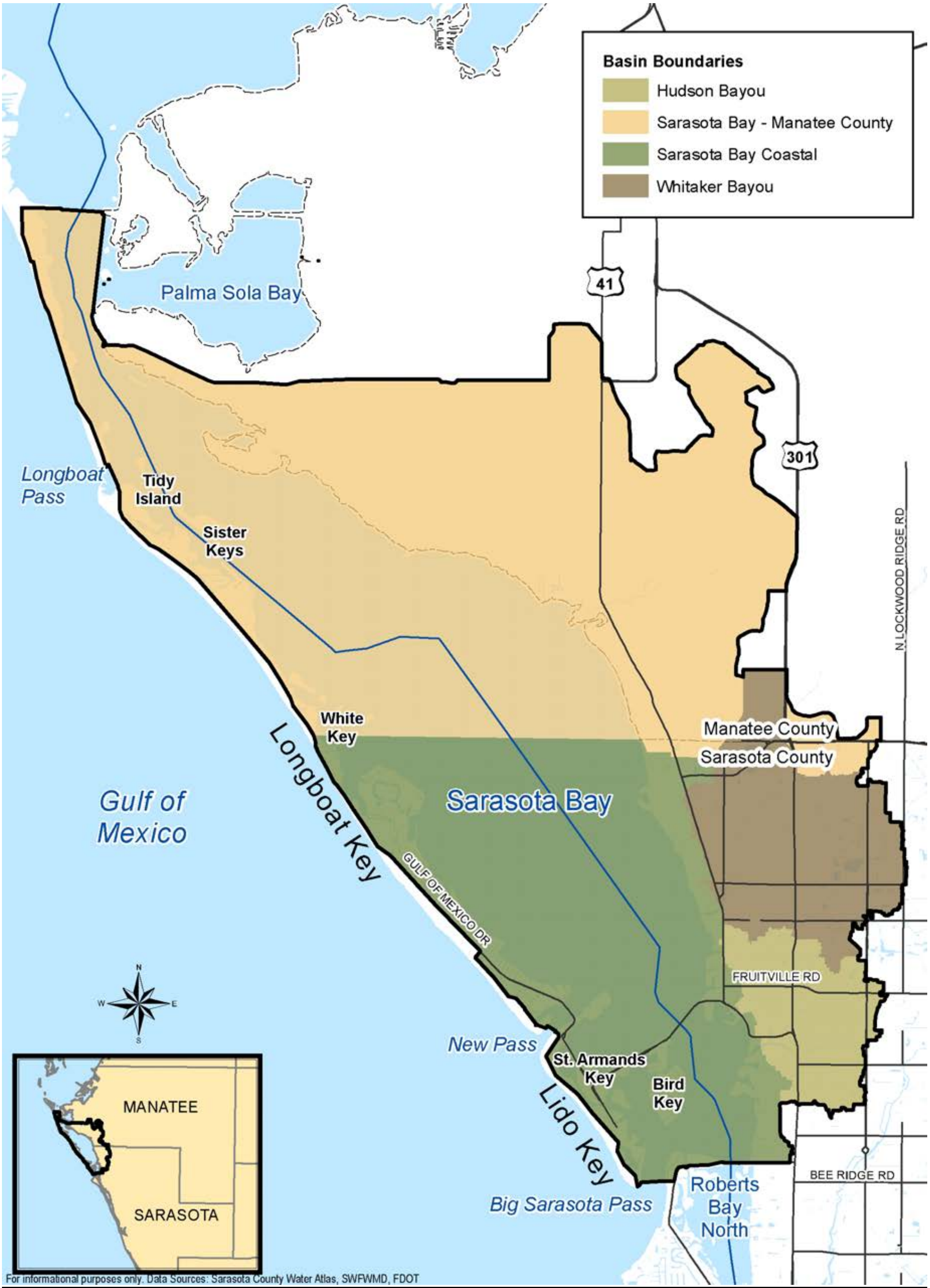


Figure 5-1 Basin Boundaries

Table 5-1 Sarasota Bay Watershed CIP Projects				
Map ID	Project ID	Project Title	Project Description	Status
1	75813	Arlington Canal at Euclid	This project has been identified in the Hudson Bayou Basin Study as one of the projects that will reduce flooding and provide increased water quality benefits to the bay. The project involves widening the north side of the existing canal from US 41 upstream to the confluence of the Euclid Canal, replacing an existing 72-inch corrugated metal pipe (CMP) with a double 72-inch RCP, and developing alternatives for the existing drainage system between Sarasota High School and Bahia Vista Street.	Completed
2	75814	Arlington Canal at Hawthorne	This project has been identified in the Hudson Bayou Basin Study as an inadequate culvert crossing. The project involves replacing an existing 72-inch CMP with a double 72-inch reinforced concrete pipe. This area has been identified as a flood-prone area in the City Wide Master Drainage Plan – Area 48.	Completed
3	75816	Euclid Canal Improvements – Hudson Bayou	This project has been identified in the Hudson Bayou Basin Study, which recommended improvement to culverts within the canal to improve the conveyance capacity. The improvements proposed under this project also include the activation of a 54-inch storm sewer pipe from Fruitville Road to Ringling Boulevard that was previously installed when Fruitville Road was constructed.	Completed
4	75817	Loma Linda	This project involves constructing a pipe to provide an outfall for stormwater to eliminate an existing flooding problem. Private developers are to construct an outfall pipe from Loma Linda Court to US 41, with reimbursement from the County through the City.	Completed
5	75822	Little Five Points – Hudson Bayou	The project has been redesigned and evaluated for partial stormwater improvements at the Little Five Points intersection. Improvements include upsizing old drainage pipes, relocating curb inlets, and installing a stormwater outfall treatment system.	Completed

Table 5-1 Sarasota Bay Watershed CIP Projects				
Map ID	Project ID	Project Title	Project Description	Status
6	75835	Euclid Canal Weir	This project proposes to replace failed concrete armoring downstream of the Euclid Canal Weir (north of Hatton Street and west of Shade Avenue). Approximately 80 feet of armoring (articulated block revetment) will be placed on the banks of the Euclid Canal.	Completed
7	75838	Lockwood Ridge Road	This initial phase of the project will investigate the cause of depressions forming in the pavement of Lockwood Ridge Road (17th Street north to DeSoto Road). Phase 1 includes cleaning and videoing the interior of the pipe for analysis and making decisions for Phase 2 to repair the problem and prevent future depressions.	Completed
8	75845	27th St – MLK Way, Culvert Rehabilitation	Project involves rehabilitating 100 feet of 72-inch-diameter CMP below 27th Street/MLK Way at the Canal 3-7 crossing using trenchless technology methods (i.e., no trench excavation).	Completed
9	75848	Brother Geenen Way Storm Culvert	This project is a citizens' request to design and construct 830 feet of stormwater culvert (4-foot-x-6-foot concrete box culvert or size and type of pipe determined through stormwater modeling and engineering) for City of Sarasota.	Active
10	75850	US 41 Canal Rehabilitation	This project proposes to rehabilitate existing stormwater infrastructure including an upland cut drainage canal west of US 41 sandwiched between Sarasota Quay and Ritz Carlton properties. This includes determining the methodology for lining pipes to return the pipe's structural integrity and substantially extend the life of the stormwater system pipes or to replace the pipe to ensure continued drainage control and serviceability. The exact method of rehabilitation to reestablish the slopes and stabilize canal banks will be determined at the conclusion of a preliminary design study.	Active

Table 5-1 Sarasota Bay Watershed CIP Projects

Map ID	Project ID	Project Title	Project Description	Status
11	75851	17th and 18th Streets Drainage Improvements	This project will rehabilitate and/or replace existing/old stormwater infrastructure including pipes, drainage structures, and canal system in 17th and 18th Streets at Orange Avenue and the neighboring area. This includes determining the methodology for lining pipes to return the pipe's structural integrity and substantially extend the life of the stormwater system pipes or to replace the pipes to ensure continued drainage control and serviceability. The exact method of rehabilitation to reestablish the slopes and stabilize canal banks will be determined at the conclusion of a preliminary design study.	Active
12	85745	15th–19th Streets	The project area involves an existing ditch conveyance between 15th throughout 19th Streets and Seminole Gulf Railroad within Sarasota City limits. The existing conveyance system is inadequate, resulting in frequent flooding along the eastern portions of these streets. The proposed plan for this project will involve installing pipe with ditch inlet structures and swale for water quality treatment.	Completed
13	85834	Newtown Canal 3-2 – Whitaker Bayou	This project will involve enclosing approximately 2,165 feet of open ditch along 20th and Osprey Streets with a double 43-inch-x-68-inch elliptical reinforced concrete pipe. This project will also construct a grass-lined swale to pre-treat stormwater runoff before discharge and line an existing CMP along 21st Street to improve overall conveyances of the system.	Completed
14	85836	St. Armands Drainage – Coastal	This project addresses severe flooding of a state road and evacuation route that runs through St. Armands Key. By addressing this major roadway flooding, local structure and roadway flooding will be incidentally addressed as well. This project proposes to install additional and larger pipes and inlets as well as a series of pump stations.	Completed

Table 5-1 Sarasota Bay Watershed CIP Projects

Map ID	Project ID	Project Title	Project Description	Status
15	85857	Pelican Drive Outfall – Hudson Bayou Basin	The project involves a closed drainage system to address street flooding in the short term. The design will include conveyance system improvements, pipe replacements, and a pipe slip line along South Pelican and South Lime Avenue. A future phase will address FPLOS for structure flooding of four homes. This depends on adjacent development, County purchase of railroad right-of-way, and coordination with City of Sarasota.	Active
16	85865	Arlington Canal Bypass – Hudson Bayou	This project, which has been identified within the Hudson Bayou Master Basin Plan Study, involves an existing storm sewer system from Waldemere Street to Floyd Street along the Arlington Canal that requires the design and construction of a new improved conveyance system.	Completed
17	85866	School Desiltation/School Bypass	This project will replace the existing metal pipes with a reinforced concrete box culvert from School Avenue to the stormwater outfall facility at Sarasota High School. This project also involves an existing canal between Euclid Avenue and School Avenue that has an inadequate conveyance capacity and severe bank erosion. This project is being coordinated with the Sarasota County School Board improvements adjacent to the canal.	Completed
18	85867	East Avenue – Hudson Bayou	This project involves replacing approximately 2,000 feet of existing storm sewer that has failed.	Completed
19	85868	Euclid Avenue - Hudson Bayou	This project involves an existing storm sewer system with an inadequate conveyance capacity located at Euclid Avenue and Courtland Street. The existing double 36-inch CMP installed in the 1950s has deteriorated substantially in recent years. The system requires a redesign to replace the existing pipe and associated inlet structures to reduce existing runoff from sheet flow across the pavement areas and erosion within the existing canal.	Completed

Table 5-1 Sarasota Bay Watershed CIP Projects				
Map ID	Project ID	Project Title	Project Description	Status
20	85893	Gocio Road Culvert – Stormwater	This project was added by IFAS upload.	Completed
21	95878	Arlington/Euclid Canal Improvement – Hudson Bayou	This project has been identified in the Hudson Bayou Basin Study as one that will reduce structure and street flooding. The project involves widening the channel, upsizing existing culverts, and constructing several control structures. The improvements also include activation of a 54-inch pipe under Fruitville Road that was previously installed when Fruitville Road was constructed.	Completed
22	95894	School Avenue By-Pass	This project will replace the existing metal pipes with a reinforced concrete box culvert from School Avenue to the stormwater outfall facility at Sarasota High School. This project also involves an existing canal between Euclid Avenue and School Avenue that has an inadequate conveyance capacity and severe bank erosion. This project is being coordinated with the Sarasota County School Board improvements adjacent to the canal.	Completed
23	85861	Leon & Noble Ave	This project involves an existing inadequate storm sewer system and inlet capacity in the Leon and Nobel Avenue areas within the City of Sarasota. This project will require a redesign to improve the conveyance efficiency of the system and reduce existing flooding problems. This project will reduce the current flooding problems in the areas adjacent to Leon and Nobel Avenues and will improve conveyance of the stormwater runoff.	Complete

Information provided by Sarasota County. Please contact the County office for additional details.
Completed: Project that has been constructed.
: Projects that are currently being constructed.
Proposed: Projects that are being proposed for improvements.

5.2 WATERSHED MODELING AND MAP MODERNIZATION

The County uses and maintains hydrologic and hydraulic watershed-specific models for most of the County. These models are used for development and CIP purposes to ensure that no adverse offsite impacts occur. Over time, land development, stormwater projects, erosion, and natural forces change water flow and drainage patterns. The risk of flooding in certain areas changes along with these factors. The detailed flood-prediction models and County floodplain maps must therefore be updated regularly to be used for local stormwater management planning.

Sarasota County is partnering with SWFWMD to provide model and flood map updates. SWFWMD became a Cooperative Technical Partner with the FEMA in 2001 to:

- ❖ Digitize the current paper flood maps.
- ❖ Input up-to-date flood data from more current Flood Study Updates for the County's 28 watershed basins.

The digital maps will reflect current flood risks, include areas of recent growth, and replace older paper maps. New digital mapping techniques and more detailed terrain information will provide more detailed, reliable, and current data on flood hazards. The new digital maps—known as Digital Flood Insurance Rate Maps or DFIRMs—will provide up-to-date, reliable information on a property-by-property basis electronically. The DFIRMs will include updated flood risks for riverine and coastal flooding and will generally be based on the 2007 LiDAR in NAVD 1988. After an adoption period, the maps will become the effective flood information for the National Flood Insurance Rate Program. The County will also continue to update the floodplain maps and models for flood insurance and stormwater management planning needs.

5.3 CAPITAL IMPROVEMENT PROJECTS

CIPs address FPLOS deficiencies for structures and roadways. SEU started its first CIP projects in 1994 to address structure flooding and severe street flooding. Stormwater Improvement Assessments were initiated in 1995. A revolving 5-year plan of CIPs, as required by the Comprehensive Plan, was established to prioritize the initiation and implementation of the projects. CIP projects in the Sarasota Bay Watershed are presented in Figure 5-2 and Table 5-1.

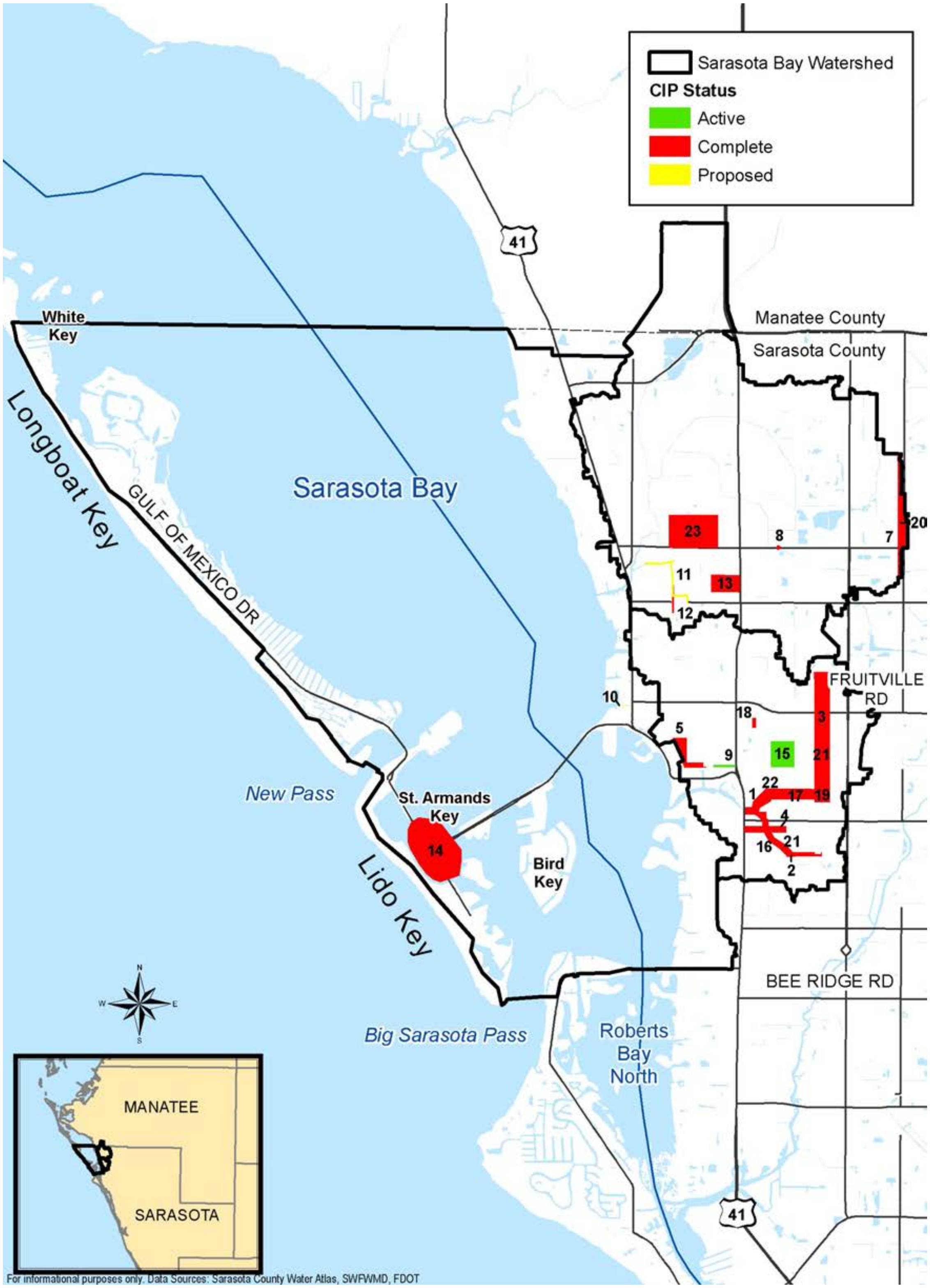


Figure 5-2 Sarasota Bay Watershed CIP Projects

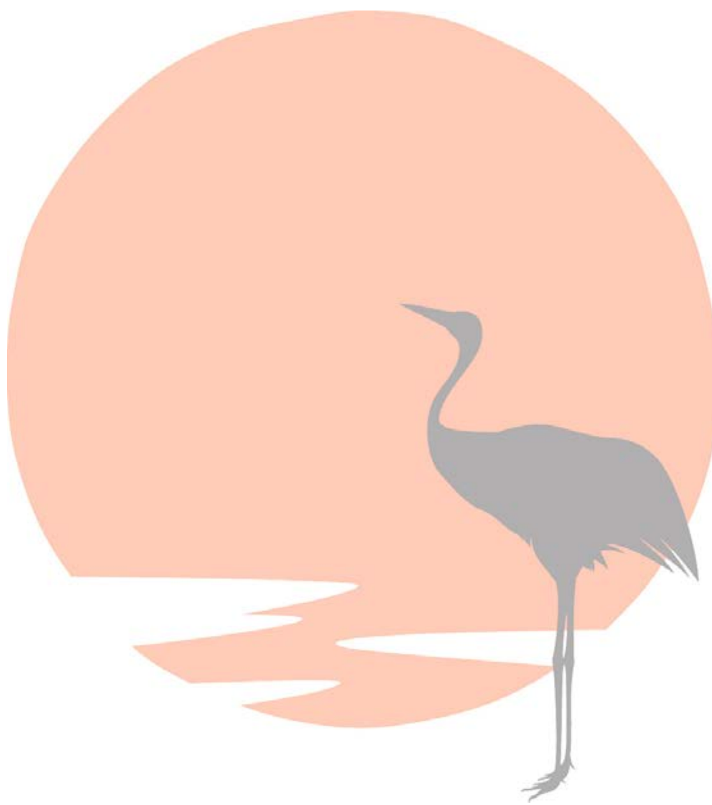
6.0 CONCLUSION

Sarasota County has flood-protection-related policies and programs in place to minimize flood risk to protect human safety and property in existing developed areas while protecting natural and beneficial functions of the remaining floodplain. In addition, the County LDR guide new development as it pertains to the force of flowing water and drainage of runoff. Several CIP projects—such as stormwater control structures and detention ponds—were implemented, were proposed, or are currently occurring throughout the watershed.

Appendix F

Sediment Management Plan

Appendix F
Sediment Management Plan



December 2012

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1.0 INTRODUCTION

Jones Edmunds & Associates, Inc. investigated the Sarasota Bay Watershed in search of potential sediment management opportunities. They identified six projects with the potential to reduce sediment loading and improve water quality. Details concerning site and project selection are provided in Section 2, and project and program recommendations are provided in Section 3.

1.1 BACKGROUND INFORMATION

Sediment is fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits and is transported by, suspended in, or deposited by water (USEPA, 2003). Although sedimentation is a natural process, sediment becomes problematic when it is present in excessive quantities or is of poor quality.

Sediment plays an important role in influencing water quality, ecosystem health, and flood control. Population growth and development can accelerate erosion and sediment deposition, overwhelming our natural systems. Excessive erosion and sedimentation are significant chemical and physical issues in watershed management. Sediment alters the natural landscape and pollutes water, resulting in environmental and economic impairment. The U.S. Environmental Protection Agency (USEPA) recognizes sediment as a major contributor to impairment of the nation's waters and has cited sediment as the leading cause of impairment (USEPA, 2003). Sediment-control strategies are therefore a key component of watershed management planning efforts.

This appendix is the sediment management component of the comprehensive water quality management plan for the Sarasota Bay Watershed. Watershed-based loading of sediment and other associated pollutants, identification of other sediment sources, and potential management and preventative erosion and sedimentation measures for the Sarasota Bay Watershed are discussed in this document.

1.2 SEDIMENT SOURCES

Sediment production is a natural watershed process, but urbanization and other land-use changes can impact the processes associated with the sedimentation cycle: erosion, transport, and deposition. Within an urbanized setting like the Sarasota Bay Watershed, sediment production has two primary sources: wash-off from land surface and in-stream channel erosion. Bank steepness, degree of concentration (runoff velocity), and stability (e.g., vegetation) influence the quantity of the sediment load that reaches the waterbody. Increased sediment load from wash-off and in-stream erosion can affect water quality, natural habitat, navigation, flood control, and recreational uses downstream. In addition, alterations in circulatory patterns caused by dredging can re-suspend and transport existing sediments.

1.2.1 Land Surface

In urban watersheds, the greatest contributor to wash-off is impervious surfaces. Impervious surfaces increase runoff volume and velocity, which carry a significant sediment load to the waterways. This increase can affect the physical character and the overall environmental condition of receiving tributaries. A study on the effect of imperviousness on sedimentation showed that significant degradation to stream stability, habitat, and water quality occurs at even minimal levels of imperviousness on the order of 10 to 15% (Fischenich, 2001).

1.2.2 In Stream Processes

In their historical condition, waterways collected water, nutrients, and sediments from upland runoff and distributed these elements to the contiguous wetlands and bay in a manner that supported productive biological communities. The timing and quantities of flow suited the complex biological cycles of the streams and bay. The water collected and delivered by the waterways, with its dissolved and suspended load, was and is a major component of the raw materials that fuel the productivity of wetlands, streams, and bays.

An open channel is dynamic and will naturally adjust slope, sinuosity, width, and depth to maintain equilibrium in the system. The equilibrium is dominated by the flow through the system and the sediment load. The natural process of stream channel erosion is typically accelerated and heightened by urbanization in the watershed. Streams adjust to these changes within the physical constraints of bridges, bank-stabilization measures, and other hardened surfaces to establish a new equilibrium condition that is often different from their previous “natural” state.

Impacts associated with the “new” equilibrium include the following:

- Greater and more frequent peak storm flows capable of eroding channel beds and banks.
- Enlargement of the channel through incision and widening processes or constriction of channels through sediment deposition.
- Decreased recharge of shallow- and medium-depth aquifers that sustain base and low flows.
- Higher nutrient and contaminant loading.
- Alteration of the channel substrate.
- Reduction of stream system function.

Stream channel erosion is a major contributor of sediment in urbanized watersheds. Channel erosion control should therefore be a priority in sediment management.

1.3 POLLUTANTS OF CONCERN

Sediment that is transported and deposited in waterbodies can disrupt aquatic ecosystems. Excess sediment can cloud the water, which can suffocate fish and block the light required by aquatic plants for photosynthesis. In addition, sediment-rich discharges tend to carry higher loadings of pollution because nutrients, pesticides, and heavy metals adsorb to and are transported along with sediment. Pollutants of concern including total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP) are associated with the sediment and contaminants attached to sediment in the Sarasota Bay Watershed. Appendix C (Water Quality) of the Sarasota Bay Watershed Water Quality Management Plan (WQMP) provides additional information on these pollutants and the water quality in the Sarasota Bay Watershed.

Nitrogen and phosphorus are nutrients that occur in soils naturally; increased erosion increases the nutrient load to the system. Other common sources of nitrogen and phosphorus in an urbanized area are septic systems, pet wastes, industrial wastes, landfills, and fertilizer. Excess nutrients combined with the tropical temperatures in Sarasota County can lead to excessive algae growth impacting the recreational aspects of the waterways as well as creating an oxygen deficit for the marine life and aquatic habitats.

Suspended solids loads are primarily a function of land use; an increase in the amount of impervious area in urban development is associated with an increase in suspended solids in stormwater runoff. If suspended solids remain suspended, the particulates reduce water clarity and limit the amount of sunlight reaching marine life; suspended solids that settle in a stream system adversely impact benthic habitats and the flood-control capacity of the system. Additionally, suspended solids may carry toxins and pathogens that adversely impact ecosystems.

Litter from lawn maintenance—such as leaves and grass clippings—and urban debris—such as cigarette butts, food packaging, and batteries—are also pollutants. Litter left on the ground frequently ends up in storm drains, ditches, and streams. In addition to being an eyesore, litter can contaminate waterways with excess nutrients and chemicals. Although natural streams have snags and leaf packs that provide habitat and nutrient processing, in large quantities they can add to the nutrient load in the waterway. Litter can also reduce and in some cases block flow, which can disrupt the ecosystem or cause flooding.

1.4 SEDIMENT CHARACTERISTICS IN THE WATERSHED

Florida's geology contains sedimentary deposits of marine origin, some of which are high in phosphorus content. The Sarasota Bay Watershed lies in a phosphorus-rich region, and local soils significantly influence the total phosphorus concentrations in the Little Sarasota Bay tributaries and estuary. Florida is divided into ecoregions for the proposed Numeric Nutrient Criteria (NNC), and there is currently a debate concerning the appropriate region for the Sarasota Bay Watershed. USEPA originally classified the watershed in the Bone Valley region (BV) but re-evaluated and proposed that the area belongs in the Peninsula Region (PR); however, the Southwest Florida Water Management District (SWFWMD) submitted comments to USEPA that the area containing the Sarasota Bay Watershed should be kept in the BV region SWFWMD, 2010).

There is currently a debate concerning the appropriate ecoregion for the Sarasota Bay Watershed for Numeric Nutrient Criteria.

Previous studies show some sediment in the Sarasota Bay tributaries contains substantial levels of contaminants, including toxic metals, pesticides, petroleum, and other organic compounds. The Sarasota Bay Watershed is highly urbanized with older neighborhoods that provide only minimal stormwater retention or detention. The untreated runoff contributes sediment and associated pollutants to Hudson and Whitaker Bayous and Sarasota Bay. However, sediments in the bay proper have been reported to be uncontaminated.

Hudson Bayou has areas of polluted sediments. Studies reveal lead concentrations as high as 510 ppm in sediment throughout the bayou, including the tidal portion. Testing of sediments in Hudson Bayou determined that the pollution is more concentrated in the deeper sediments than in the top sediment layers, indicating that historical activities in the watershed impacted the quality of sediments in the waterway, but conditions may have improved.

Previous studies found contaminated sediment in Whitaker Bayou as well. The bayou drains a part of the City of Sarasota that is highly urbanized, consisting primarily of older development. Whitaker Bayou also receives effluent from the City of Sarasota's advanced wastewater treatment facility, but the discharge from the treatment facility has been demonstrated to have minimal negative impact on the receiving waterbody and has met antidegradation standards as defined in the Florida Administrative Code. In August 2011, the City started construction on a deep well injection system to remove this discharge from entering the bayou.

1.5 SEDIMENT MANAGEMENT

Development throughout the watershed contributes to increased sediment loading to Sarasota Bay tributaries and Sarasota Bay. Controlling sedimentation by managing upstream sources and activities that increase stream erosion and sediment flowing to tributaries is a key component of effective sediment management.

Managing sedimentation in an urban setting requires a multi-pronged approach. We recommend the following three management strategies to reduce unwanted sediment in the system:

- Providing source control to reduce or remove solids in upland areas.
- Implementing maintenance practices designed to reduce sedimentation.
- Improving eroding and sloughing banks for long-term stability.

These strategies will reduce turbidity, increase clarity, and reduce nutrient and sediment load and therefore improve the health of the estuaries and Sarasota Bay.

Providing source control to reduce or remove TSS in the uplands keeps pollutants from running off in stormwater and reaching the receiving waters of the channel and ditch system and ultimately Sarasota Bay. Source-control activities include low-impact development (LID) projects, street sweeping, construction-area silt fencing, and capturing solids in dedicated, maintainable sedimentation areas.

Regularly scheduled maintenance practices minimize the amount of sediment, debris, and pollutants reaching County waterways. These activities include cleaning out baffle boxes, removing excess vegetation from swales and roadside ditches, replacing damaged infrastructure, and maintaining control structures and weirs.

Bank stabilization in an urban setting is challenging. Numerous stream banks in the County exhibit the following characteristics that lead to erosion and sloughing:

- Steep slopes.
- Loose soil matrix on steep slopes without hearty root systems or moisture-holding capacity.
- Direct runoff washing out the top of banks.
- Outfalls not properly reinforced.

For stabilization to be effective in the long term, improvements and restoration should not be limited to a single point in the stream but instead will be more effective when conducted as multiple projects along a channel system.

Watershed management includes identifying sediment problems, identifying the sediment sources, and recommending improvement projects. The activities listed above will improve the health of the system.

2.0 SEDIMENT MANAGEMENT OPPORTUNITIES

Jones Edmunds identified potential sediment management opportunities in the Sarasota Bay Watershed. Project and site-selection methodology are provided in the following subsections. Analysis of project and programmatic recommendations to reduce erosion and sedimentation in Sarasota Bay and its tributaries are described in Section 3.

2.1 METHODOLOGY

Jones Edmunds collected and assembled information, including previous studies, GIS data, and stakeholder input, to identify potential sediment management projects. Jones Edmunds began the investigation with a GIS desktop analysis to identify sediment 'hot spots' throughout the watershed. These hot spots were refined to potential sediment management project sites. This methodology is summarized in Figure 2-1 and detailed in the following sections. Finally, Jones Edmunds conducted a field investigation of these sites to evaluate potential sediment treatment options.

2.1.1 INVESTIGATION

2.1.1.1 Identification of Hot Spots

Jones Edmunds reviewed observations, input from stakeholders and County staff, and previous studies and data. Previous sediment studies in the Sarasota Bay Watershed are listed below. The sediment sampling locations for each study are shown in Figure 2-2.

- Sediment Contaminants in Selected Sarasota Bay Tributaries (1992).
- Bay Bottom Habitat Assessment (1993).
- Water and Sediment Quality: Trends and Status for Sarasota Bay (1993).
- Framework for Action Chapter 2: Physical and Chemical Properties; Bay Water and Sediment Quality (1993).
- Sarasota Bay – The Voyage to Paradise Reclaimed (1995).
- Surface Water and Sediment Sample Collection and Analysis for Big Slough, Hudson Bayou, and Phillippi Creek Basins, Sarasota County, Florida (1998).
- Whitaker Bayou Reconnaissance Report (2005).
- Hudson Bayou Stormwater Study (2001).
- County-Wide Survey of Sediment Quality at Weir Structures (2003).
- Sarasota Bay Estuary Program Outfall Prioritization Project (2007).

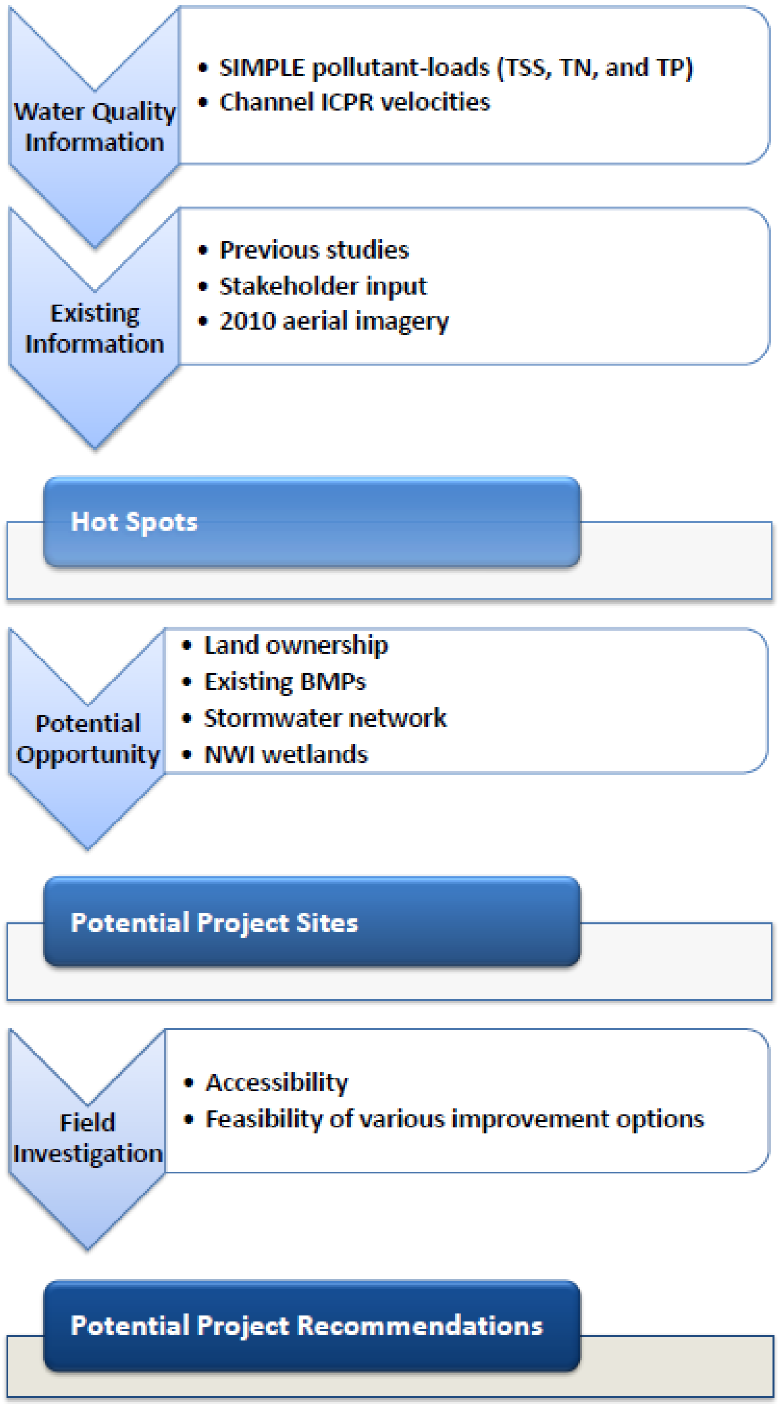


Figure 2-1 Sediment Management Opportunity Identification Methodology

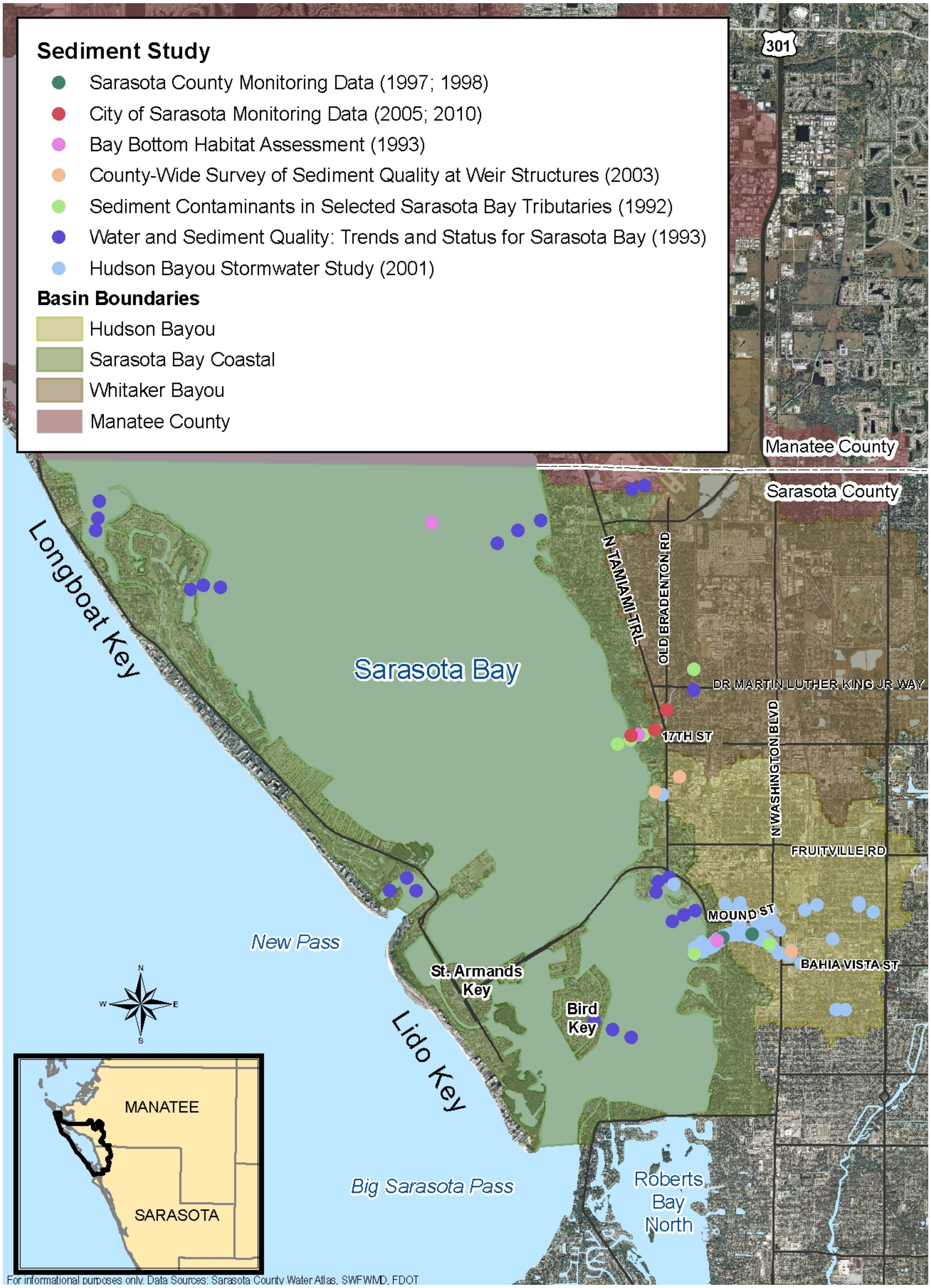


Figure 2-2 Previous Sediment Studies Sampling Points

Jones Edmunds used GIS to compile and review data developed from the Pollutant Loading Model results with aerials and other base data and information obtained from Sarasota County, SWFWMD, Florida Department of Environmental Protection (FDEP), and previous watershed studies and data. These datasets and information included the following:

- Pollutant loads as estimated from the Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE) (TSS, TP, and TN)—Pollutant-load results are detailed in the Pollutant Loading Analysis Technical Support Document: Current Loadings.
- Sarasota County surface water Interconnected Channel and Pond Routing (ICPR) model velocity results.
- 1948 U.S. Department of Agriculture (USDA) aerial imagery.
- 2010 SWFWMD aerial imagery.
- Areas of concern identified in previous studies.
- Areas of concern noted by stakeholders and County staff.

A GIS desktop analysis of the data above yielded potential erosion and/or sedimentation hot spots in the watershed.

2.1.1.2 Identification of Potential Project Sites

Jones Edmunds compiled the potential sediment hot spots with additional base data obtained from Sarasota County. Specifically, these datasets included the following:

- Sarasota County parcels.
- Existing best management practices (BMPs).
- Sarasota County Stormwater Inventory.

From the GIS desktop analysis of the parameters above, Jones Edmunds identified seven potential sediment management project sites in the watershed (Table 2-1 and Figure 2-3).

Table 2-1 List of Potential Sediment Management Project Sites

ID	Site Name	SIMPLE Basin ID
1	Brother Geenen Way	105
2	Robert Taylor Community Complex	111
3	Orange Avenue	109
4	Bayfront Drive North	101
5	Bayfront Drive South	101
6	Sarasota High School at Hatton Street Ditch	102
7	Sarasota High School at Tamiami Trail	102

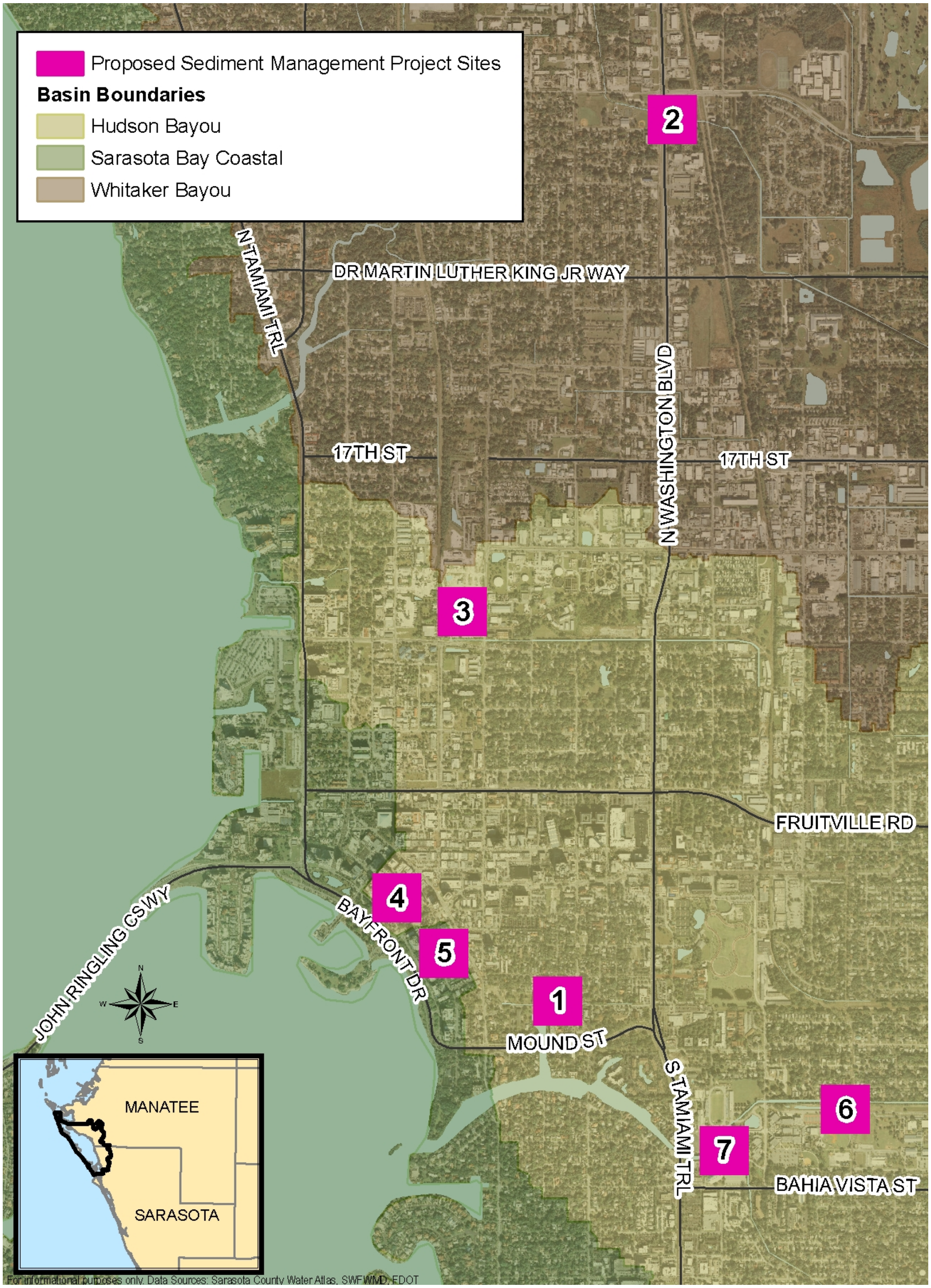


Figure 2-3 Proposed Sediment Management Project Sites

2.1.1.3 Field Investigation

Jones Edmunds visited the proposed sediment management sites in April 2011 to characterize the potential project areas and identify and determine potential sediment management options, including possible programmatic recommendations.

3.0 ANALYSIS\RECOMMENDATIONS

The following sections provide investigation summaries and recommendations for the selected project sites as well as program recommendations to help manage sediment in the watershed.

3.1 PROJECTS

This section describes the potential sediment management projects.

3.1.1 Site 1—Brother Geenen Way

3.1.1.1 GIS Desktop Analysis

The Brother Geenen Way site is in the Hudson Bayou Basin and is slightly northeast of the north branch of Hudson Bayou (Figure 3-1). Previous studies indicate high levels of lead in sediment in this system. Untreated stormwater from a large contributing area discharges into the bayou from a 36-inch pipe that runs through this site. SIMPLE pollutant-load results show elevated TSS and TP in the area. The County parcel coverage is void here; therefore, the site is assumed to be County easement. County staff indicated that there is an Automated Rainfall Monitoring System (ARMS) station (HUD-3) onsite and suggested the area as a potential location for a restoration project.

3.1.1.2 Field Investigation

This site is in a residential area and meets the tidal creek to Hudson Bayou on the west. A heavy tree canopy is over most of the site, and the creek banks are very steep and deep. An ARMS station is onsite. County staff indicated that the City of Sarasota is building a Multi-Use Recreational Path (MURP) through this site.

3.1.1.3 Recommendation

Implementing a sediment sump and diversion to capture sediment from the creek before it reaches the bayou would be beneficial; however, there does not appear to be enough space to accommodate a settling area and the MURP project. Therefore, Jones Edmunds recommends that the City incorporate LID into the MURP project.

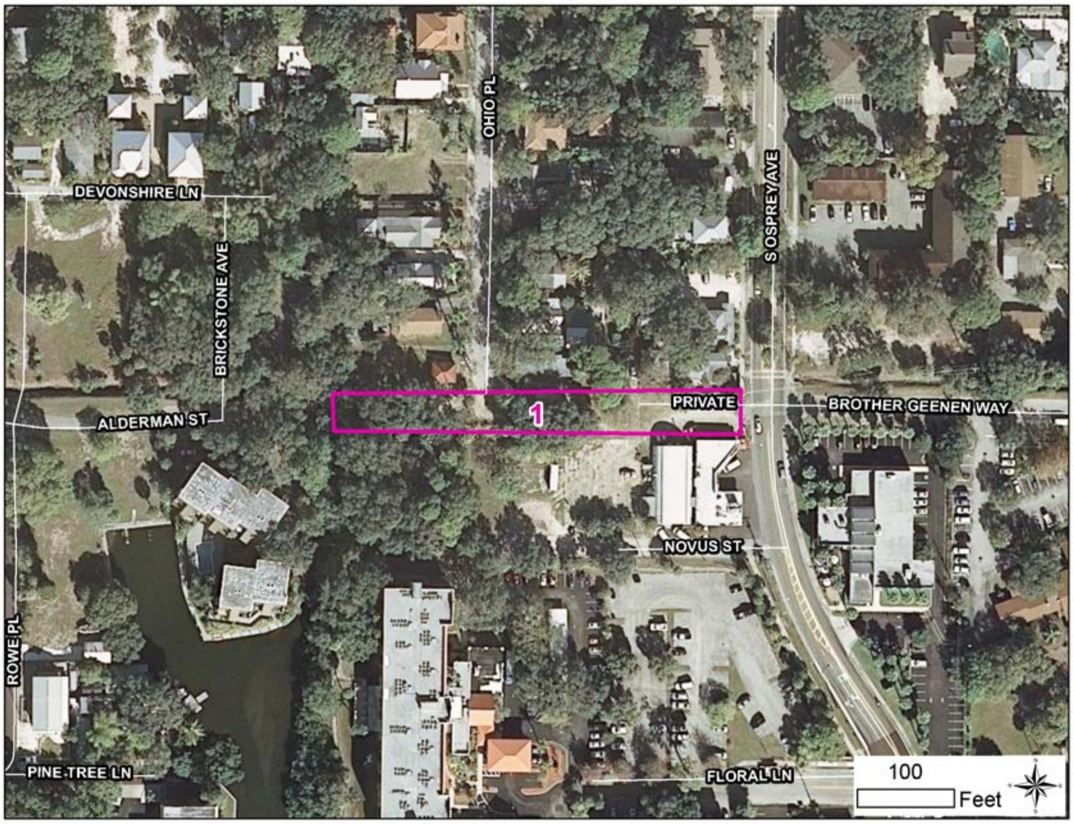


Figure 3-1 Aerial View of Site 1 (SWFWMD, 2010)

3.1.2 Site 2—Robert Taylor Community Complex

3.1.2.1 GIS Desktop Analysis

The Robert Taylor Community Complex site is in the Whitaker Bayou Basin near the area of Myrtle Street, Washington Street, and Leonard Reid Avenue (Figure 3-2). The site contains sediment build-up and bare earth west of Washington Boulevard, sediment build-up east of Washington Street, and dense vegetation east of Leonard Reid Avenue. The portion of Site 2 west of Washington Boulevard is owned by the City of Sarasota. The eastern portion of the property does not have parcel data and is assumed to be County easement.

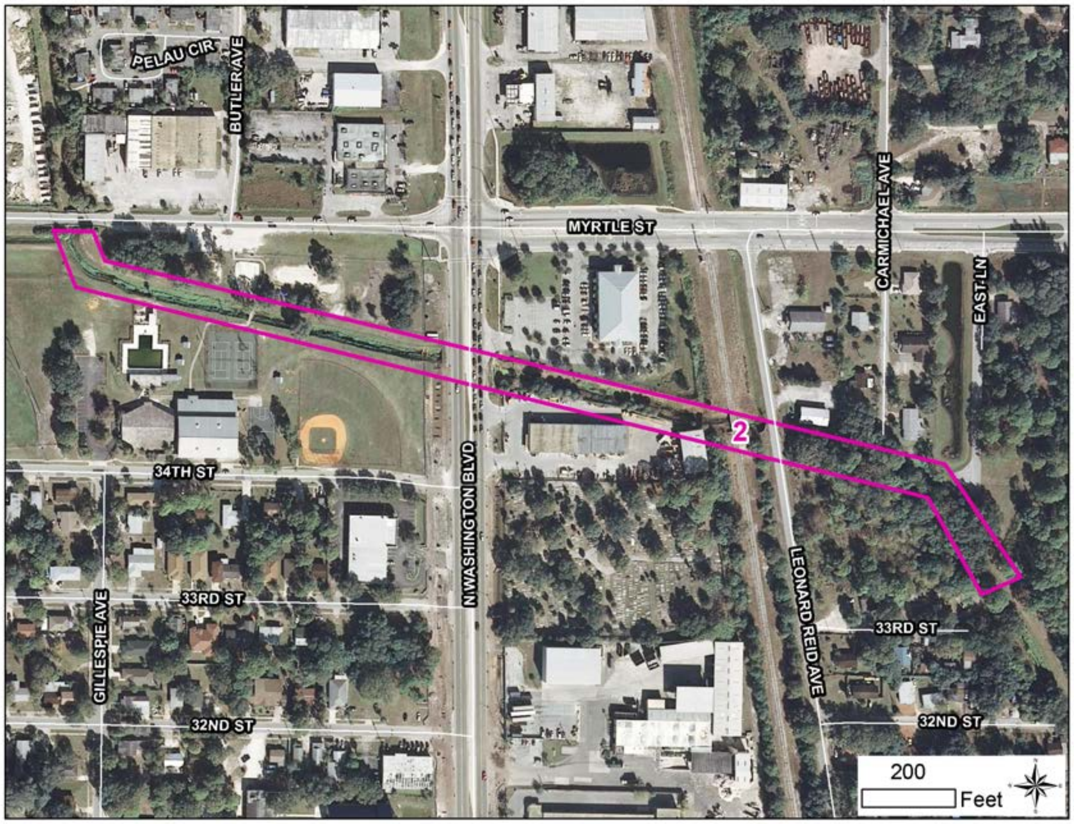


Figure 3-2 Aerial View of Site 2 (SWFWMD, 2010)

3.1.2.2 Field Investigation

The downstream portion (west of Washington Boulevard) of this proposed area is under construction. The upstream area appears viable for a project.

The banks of the waterway are eroded between Leonard Reid Avenue and Washington Boulevard (Figure 3-3). Runoff from Hertz Equipment Rental to the south appears to discharge to the stream without any treatment. There is sediment accumulation in the waterway, primarily under the railroad piers, and excessive duckweed in the waterway. A grassed swale parallel to Leonard Reid Avenue from Myrtle Street drains to the waterway (Figure 3-4). This area is mapped in the Bus Rapid Transit (BRT) alternatives, which may use railroad corridors.

Figure 3-3 Waterway on South Side of Myrtle Street, West of Leonard Reid Avenue, Facing West

Figure 3-4 Swale Parallel to Leonard Reid Avenue, Facing Southwest

There is also erosion along the banks of the waterway on the east side of Leonard Reid Avenue. (Figure 3-5). A small church has a gutter downspout discharging directly to the stream. Erosion at the top of bank has occurred at the outflow from the gutter (Figure 3-6).

Figure 3-5 Waterway on South Side of Myrtle Street, east of Leonard Reid Avenue, Facing South

Figure 3-6 Waterway and Church on South Side of Myrtle Street, East of Leonard Reid Avenue, Facing North

3.1.2.3 Recommendation

Jones Edmunds recommends bank restoration and stabilization between Leonard Reid Avenue and Washington Boulevard. A linear BMP to capture and treat the runoff from Hertz Equipment Rental in the drainage right-of-way should also be considered. The swale adjacent to Leonard Reid Avenue should be retrofitted with a biofiltration/bioretention swale. Adding a sediment sump and native vegetation along the waterway on the west side of Washington Boulevard would reduce the amount of sediment entering the system and moving downstream.

A bioswale to treat runoff from the church property should be constructed east of Leonard Reid Avenue. Gutter bubblers on the church gutter system should also be implemented.

Jones Edmunds does not recommend improvements for the portion of this site that is under construction.

3.1.3 Site 3—Orange Avenue

3.1.3.1 GIS Desktop Analysis

Site 3 is in the Hudson Bayou Basin and is on the City property west of Orange Avenue and 11th Street. A railroad track crosses the western part of the site (Figure 3-7). The area has elevated SIMPLE TSS loads and is adjacent to a large area of bare earth. Stormwater from 12th Street and the wastewater treatment plant flows via pipes down Orange Avenue, continues west along the northern bounds of Site 3, and eventually discharges at Pioneer Park.

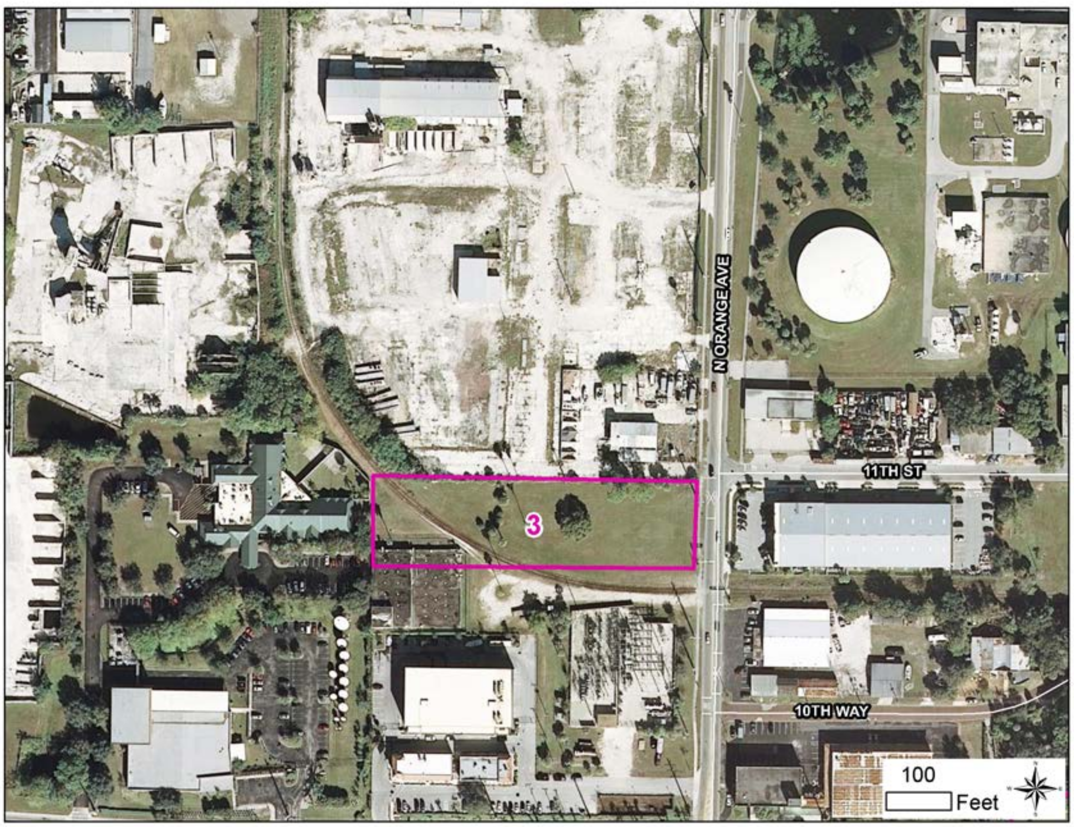


Figure 3-7 Aerial View of Site 3 (SWFWMD, 2010)

3.1.3.2 Field Investigation

The parcel is in an industrial area on the south side of a junk yard (Figure 3-8). A concrete slab of unknown purpose is present in the middle of the site (Figure 3-9). No facilities are noted in the data collected during the literature search for this plan. Additionally, an FPL substation is immediately south (Figure 3-10).

Figure 3-8 Site 3, Facing Northwest

Figure 3-9 Marked Concrete Slab at Site 3

Figure 3-10 Site 3, Facing Southeast

3.1.3.3 Recommendation

Jones Edmunds recommends diverting flow through a treatment system at this site to improve water quality before it gets to the bay. The parcel is large enough to accommodate a stormwater pond (+/-0.5 acre) to treat redirected flow from the 48-inch pipe as well as a sediment sump to remove solids. The area could also be used as a neighborhood enhancement by creating a park-like setting.

3.1.4 Site 4—Bayfront Drive North

3.1.4.1 GIS Desktop Analysis

Site 4 is in the Sarasota Bay Coastal Basin. This area appears to act as a buffer between Bayfront Drive and the businesses and residences in downtown Sarasota (Figure 3-11). The stormwater inventory shows underground infrastructure discharging to the bay without any treatment.

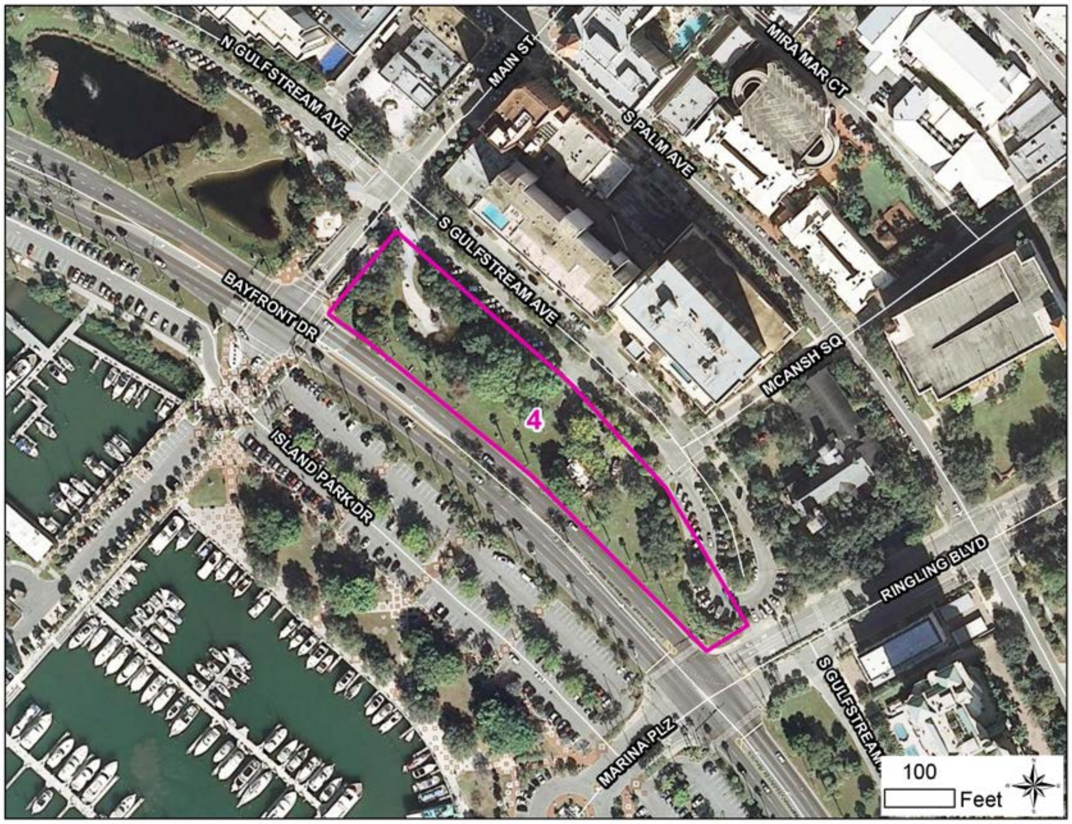


Figure 3-11 Aerial View of Site 4 (SWFWMD, 2010)

3.1.4.2 Field Investigation

This site has a public restroom at the south end and a curb inlet unusually positioned in the center of the parcel (Figure 3-12).

Figure 3-12 Site 4, Facing South

3.1.4.3 Recommendation

Jones Edmunds recommends replacing the curb inlet with a water feature, such as a stormwater pond. We also recommend diverting a portion of flow from the storm sewer system through the site to provide some treatment for runoff before it reaches the bay.

Additionally, curb cuts could be added to the east side of Tamiami Trail to allow runoff to enter the grassed area for infiltration and provide treatment along the roadway corridor.

3.1.5 Site 5—Bayfront Drive South

3.1.5.1 GIS Desktop Analysis

Site 5 is in the Sarasota Bay Coastal Basin. This area appears to act as a buffer between Bayfront Drive and the businesses and residences in downtown Sarasota (Figure 3-13). The stormwater inventory shows underground infrastructure discharging to the bay without any treatment.

Figure 3-13 Aerial View of Site 5 (SWFWMD, 2010)

3.1.5.2 Field Investigation

This site is narrow and slopes down from the northwest toward Gulf Stream Avenue (Figure 3-14). Runoff from the east flows into curb inlets and pipes to the bay and does not appear to flow over this site. There is a stormwater inlet at the northwest corner of this site at the southwest corner of the intersection of Ringling Boulevard and South Gulfstream Avenue.

Figure 3-14 Site 5, Facing South

3.1.5.3 Recommendation

Jones Edmunds recommends diverting a portion of the flow from the storm sewer system to a winding bioswale system with the underdrain discharging farther down in the storm sewer to provide water quality treatment before discharging to the bay. We also recommend adding benches, walkways, and educational kiosks for neighborhood enhancement. Additionally, curb cuts could be added to the east side of Tamiami Trail to allow runoff to enter the grassed area and install a bioswale for infiltration to provide treatment of runoff from Bayfront Drive.

3.1.6 Site 6—Sarasota High School at Hatton Street Ditch

3.1.6.1 GIS Desktop Analysis

Site 6 is in the Hudson Bayou Basin north of Sarasota High School. Stormwater runoff from a large drainage area flows through the Hatton Street ditch and eventually into Hudson Bayou (Figure 3-15). The ditch was noted on the Sarasota Bay Watershed tour as a potential area for restoration and/or mitigation.

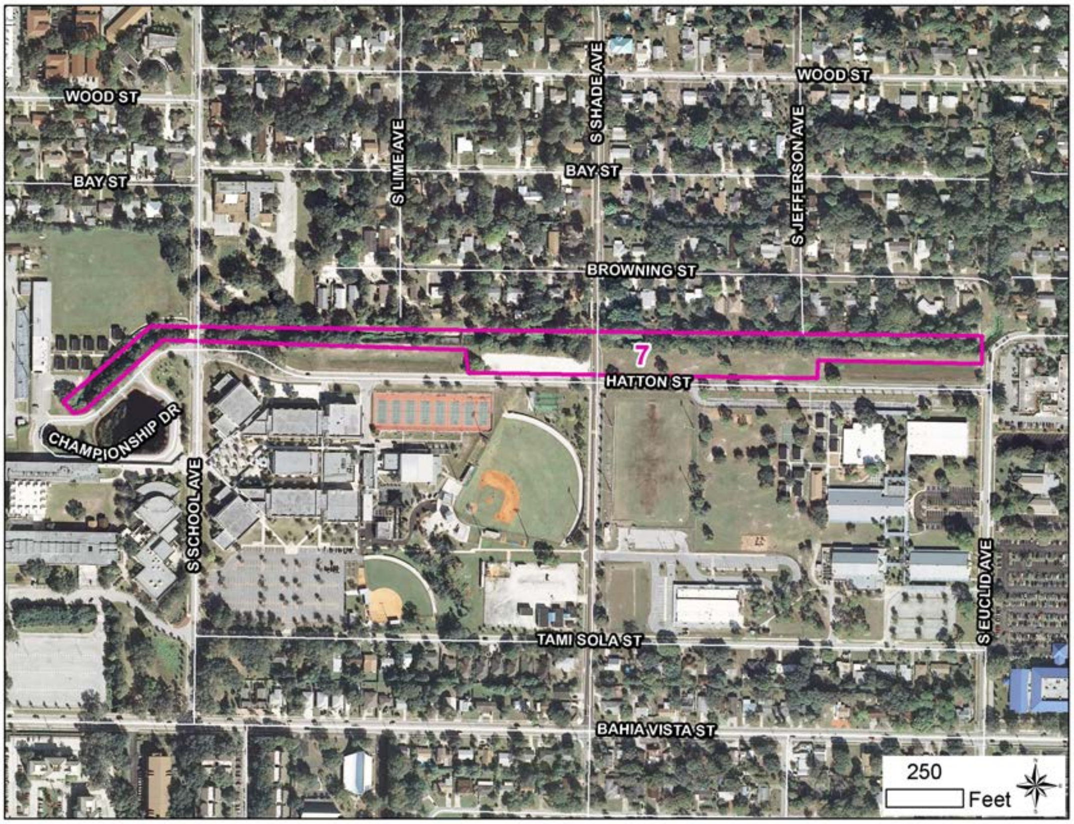


Figure 3-15 Aerial View of Site 6 (SWFWMD, 2010)

3.1.6.2 Field Investigation

The Hatton Street ditch has very steep banks, erosion, and sedimentation (Figure 3-16). There are multiple discharges without erosion-control measures (Figure 3-17), and a large weir west of Shade Avenue controls flow through the ditch (Figure 3-18). On the south side of the Hatton Street ditch are two stormwater ponds for the high school.

Figure 3-16 Hatton Street Ditch, Facing East

Figure 3-17 Outfalls to Hatton Street Ditch

Figure 3-18 Weir in Hatton Street Ditch, Facing Northwest

3.1.6.3 Recommendation

Jones Edmunds recommends removing exotic invasive plants and stabilizing the banks. The channel modifications should be modeled after the recently completed Upper Mullet Creek Erosion Control and Channel Improvements project in Safety Harbor, Florida, which incorporated geoweb and articulating blocks that provided function and aesthetics.

The berm between the pond and the ditch on the north side is significantly higher than the grate elevation on the control structure in the pond. The berm between the two should be lowered to make room to regrade the very steep north bank.

The waterway on the east side of Shade Avenue should be widened, and a sediment sump and wetland area should be added on the south side of the ditch. This would also provide educational opportunities.

Additionally, multiple LID techniques should be incorporated on the school site to reduce flow to the ponds and provide educational opportunities.

3.1.7 Site 7—Sarasota High School at Tamiami Trail

3.1.7.1 GIS Desktop Analysis

Site 7 is in the Hudson Bayou Basin. Previous studies revealed lead-contaminated sediment in this reach. A network of ditches and pipes conveys stormwater from a very large area through Site 7, which is the most downstream point in the watershed before stormwater is released at the head of Hudson Bayou. There is sediment buildup in the north part of the site and dense vegetation just downstream (Figure 3-19). The site is County-owned.

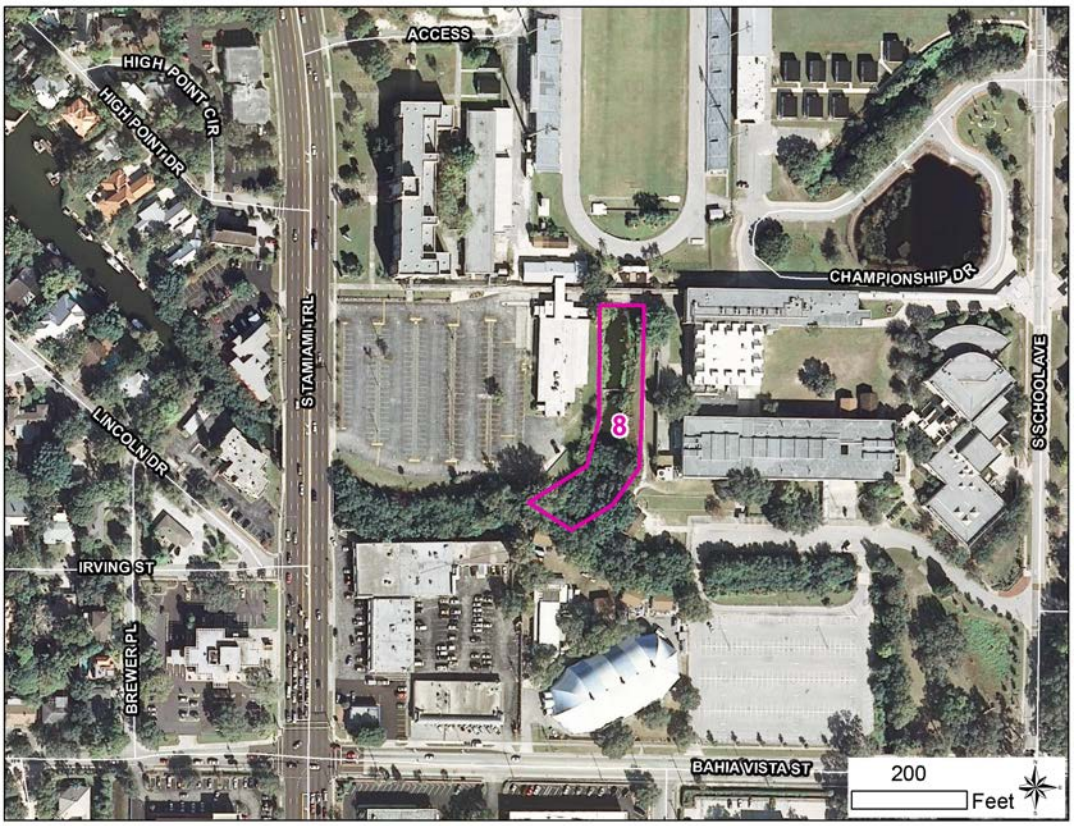


Figure 3-19 Aerial View of Site 7 (SWFWMD, 2010)

3.1.7.2 Field Investigation

The waterway is between the school maintenance building and the school. There is erosion on both banks, and herbicide has been applied on the west bank (Figure 3-20). A large weir controls the flow through this site (Figure 3-21). There is significant algae growth north of the weir and non-native vegetation in the waterway on the south side of the weir. The stretch of dead dried vegetation along the length of both sides of the waterway is evidence of herbicide use. There is an ARMS station with a small dock in disrepair onsite.

Figure 3-20 Site 7, Facing North

Figure 3-21 Site 7, Facing South

3.1.7.3 Recommendation

Jones Edmunds recommends eliminating the use of herbicides within the top of bank of the channel adjacent to the weir, adding a skimmer to the weir, pulling back the top of bank on the west side (adjacent to the maintenance building), regrading the eroded slopes, and moving the dumpsters and trash cans away from the waterway. There are educational opportunities at this site, such as LID and water quality testing projects for environmental science classes at the high school. This would also encourage environmental stewardship among the students.

We also recommend improvements to the high school parking lot west of this site. Adding curb cuts and biofiltration medians would decrease the sediment washing from the lot directly into the bayou just downstream from this site.

3.2 GENERAL SEDIMENT MANAGEMENT MEASURES

3.2.1 Geofabrics

3.2.1.1 Description

Geosynthetic fabrics or geofabrics are used to enhance the subgrade and prevent soil erosion without hardening the channel bank. Erosion-control fabrics are available with long and short (biodegradable) life spans to provide permanent protection or to provide vegetation with the proper conditions to become established. Non-biodegradable netting underlain by straw or mulch can also be used to allow time for vegetation to develop hearty root systems. Steeper slopes (less than 3:1 (H:V)) may require a geoweb, an additional element for stabilization. A geoweb averages 6 inches deep and contains pockets for soil media to be held in place, which help revegetate the bank and prevent sloughing. Either product can be used individually, but on steep banks using both a geofabric and a geoweb will generally provide a longer-term solution.

3.2.1.2 Recommendation

We recommend installing geofabrics on County projects as appropriate.

3.2.2 Soil Amendment

3.2.2.1 Description

Soil amendment is aimed at improving water retention, permeability, infiltration, drainage, and structure of the soil and providing a better environment for root systems. For amendment to be successful, the amendment media needs to be thoroughly mixed into the soil and not just buried. Soil amendment products are organic or inorganic. Common organic amendments are sawdust, wood chips, compost, manure, sphagnum moss, and biosolids. Common inorganic amendments are tire chunks, perlite, and vermiculite. Choosing a soil amendment is site specific, and some of the factors to consider are longevity, pH, texture, and salinity of the soil. Soil amendment does not depend on installing geofabric and may be done independently.

3.2.2.2 Recommendation

The County should implement the Composting Pilot Study recommended in the Roberts Bay Watershed Management Plan (Chapter 8, RBP26). Compost collected during the study should be worked into stream banks that need to be stabilized during routine maintenance by County staff.

The County should evaluate the results of the composting study to determine the most beneficial soil amendment material based on cost, maintenance requirements, and effectiveness of preventing erosion.

3.2.3 Vegetation

3.2.3.1 Description

Planting and recruiting native vegetation with adequate root systems are common practices in bank stabilization. Vegetation protects the soil against erosion by building soil structure. The plants create a more cohesive soil matrix and filter pollutants commonly found in stormwater runoff.

3.2.3.2 Recommendation

Native plant species will provide longer-term erosion control and bank protection and should be planted during regular maintenance or during the construction of new County projects. The appropriate selection of plants during the design phase of a project is essential as fast-growing plants with abundant foliage may impede the flow and reduce the overall flood capacity of a conveyance system. Suggested plantings of upland and wetland plant species for stream/ditch bank stabilization are listed in Table 3-1, and suggested wetland plants for stormwater ponds are listed in Table 3-2. These are general recommendations for plantings for successful recruitment of vegetation.

Table 3-1 Proposed Species for Stream/Ditch Stabilization

Common Name	Scientific Name	Location	Size
Yaupon holly	*Ilex vomitoria*	Upper side slopes	1 gallon
Dwarf palmetto	*Sabal minor*	Upper side slopes	1 gallon
Knotgrass	*Paspalum vaginatum*	Upper side slopes	1 gallon
Sand cordgrass	*Spartina bakerii*	Upper side slopes	4-inch liner
Cinnamon fern	*Osmunda cinnamomea*	Lower side slopes	1 gallon
Bacopa	*Bacopa spp.*	Lower side slopes	Bare root
Lizards tail	*Saururus cernuss*	Lower side slopes	Bare root

Table 3-2 Proposed Wetland Plant Species for Stormwater Ponds		
Common Name	Scientific Name	Location
Soft rush	*Juncus effuses*	Side slopes
Sand cordgrass	*Spartina bakerii*	Side slopes
Yellow canna	*Canna* sp.	Side slopes
Giant bulrush	*Scirpus californicus*	Pond basin
Pickerelweed	*Pontedaria cordata*	Pond basin
Cow lily	*Nuphar luteum*	Pond basin
Water lily	*Nymphae odorata*	Pond basin

3.2.4 Sediment Sumps

3.2.4.1 Description

Sediment sumps allow coarse-grained suspended solids to settle out of the flow, reducing the sediment load carried downstream. When the sumps are designed in conjunction with a low-flow weir for small storm events, a fraction of the finer-grained sediment will also settle out of the water behind the weir. Properly designed sediment sumps allow suspended sediment to settle out of the flow in a desirable location—one that will not adversely impact the natural system. Detailed design studies of flow rate, particle characteristics, and settling rates will provide the optimal location and size of the sump.

3.2.4.2 Recommendation

The County should perform regular maintenance on their sediment sumps. When a sump is filled to 40 to 50% of the original capacity, accumulated sediment should be removed to maintain the design removal efficiency of the BMP.

3.2.5 Monitoring for Constituents of Concern

3.2.5.1 Description

FDEP has developed two levels of guidance to address heavy metal contaminant concentrations in sediment: Effects Levels and Target Cleanup Levels.

Threshold Effect Level (TEL) and Probable Effect Level (PEL) address lower and upper limits for adverse biological effects on aquatic organisms. The TEL represents the upper limit of the range of sediment contaminant concentrations in which no adverse effects on aquatic organisms have been shown through testing and sampling. Within this range, concentrations of sediment-associated contaminants are not considered to represent significant hazards to aquatic organisms (FDEP, Chapter 5, p. 37). The PEL represents the lower limit of the range of contaminant concentrations that are usually or always associated with adverse biological effects. The concentrations of sediment-associated contaminants are considered to represent significant and immediate hazards to aquatic organisms. Within this range of concentrations, adverse biological effects are possible, but it is difficult to predict the occurrence, nature, and severity of the effects.

Additionally, FDEP developed Soil Cleanup Target Levels (SCTL) to help protect human health from direct exposure to anthropogenically-contaminated soils in residential and commercial settings. Table 3-3 shows the current FDEP guidelines.

Table 3-3 FDEP Guidelines

Metal	SCTL (residential)	SCTL (commercial)	TEL	PEL
	Sediment Contamination (mg/kg)			
Aluminum (Al)	80,000	N/A	N/A	N/A
Antimony (Sb)	27	370	N/A	N/A
Arsenic (As)	2.1	12	7.24	41.6
Barium (Ba)	120	130,000	N/A	N/A
Beryllium (Be)	120	1,400	N/A	N/A
Cadmium (Cd)	82	1,700	0.676	4.21
Chromium Cr)	210	470	52.3	160
Copper (Cu)	150	89,000	18.7	108
Lead (Pb)	400	1,400	30.2	112
Nickel (Ni)	340	35,000	15.9	42.8
Selenium (Se)	440	11,000	N/A	N/A
Silver (Ag)	410	8,200	0.733	1.77
Thallium (Tl)	6.1	150	N/A	N/A
Zinc (Zn)	26,000	630,000	124	271
Mercury (Hg)	3	17	0.13	0.696

3.2.5.2 Recommendation

We recommend monitoring for constituents of concern in areas that have been identified by others as having heavy metal contaminants.

3.2.6 Street Sweeping

3.2.6.1 Description

New technology incorporated into street sweepers has brought about a re-evaluation of the benefits and effectiveness of street sweeping. Vacuum-assisted and regenerative-air sweepers are now able to pick up fine-grained sediments that carry a large portion of the pollutant load. Two distinctive but not mutually exclusive removal rates are cited in the literature: the removal of sediment load and the removal of nutrients associated with the sediment load due to stormwater runoff.

The amount of sediment removed by street sweeping depends on several factors. The intensity of a rainfall event, the length of time between sweeping events, particle size, land use, and the location of the impervious surface (up gradient or down gradient) all contribute to the amount of sediment available for sweeping and the efficiency of sediment removal and the quantity of sediment removed from the potential sediment load to stormwater runoff. The frequency of sweeping in wet and dry seasons impacts the overall removal rates, and the U.S. Geological Survey (Breault et al., 2005) reports that only a small fraction of the total load is removed unless intensive sweeping programs are implemented. Total sediment load reduction by street sweeping is cited in the literature as 15 to 90% of the potential sediment load to the stormwater system.

3.2.6.2 Recommendation

We recommend street sweeping select areas in the watershed twice per month during the wet season and every other month during the dry season to maximize removal of sediment and pollutants between rain events. Based on the hot spot analysis, street sweeping is recommended for the following areas in order of priority (Figure 3-22):

1. Roadways in the Whitaker Bayou basin south of Dr. Martin Luther King Jr. Way.
2. Roadways in the Hudson Bayou basin from Fruitville Road and Washington Boulevard to the Bayou.
3. Roadways throughout the downtown area in the Hudson Bayou basin, including Bayfront Drive.
4. Roadways in the northern Hudson Bayou basin that drain to the 10th Street boat ramp.
5. Bayfront Boulevard and roadways adjacent to the bay in the Sarasota Bay Coastal basin from 22nd Street south to Hudson Bayou.

3.2.7 Maintenance Buffer

3.2.7.1 Description

Buffer zones along watercourses provide important benefits, including water quality improvement, flood protection, bank stabilization, and habitat protection. While most research has focused on forested buffers, the same benefits may be realized in an urban setting. A buffer in an urban setting is typically an area of vegetation consisting of trees, shrubs, and grass designed to:

- Trap and remove sediment, phosphorus, nitrogen, and other nutrients.
- Protect stream banks from erosion by providing hearty root systems to increase the cohesiveness of the soil matrix and reduce the velocity of overland flow.

The width and slope of the buffer zone as well as the sediment size impact the removal efficiency of a buffer zone.

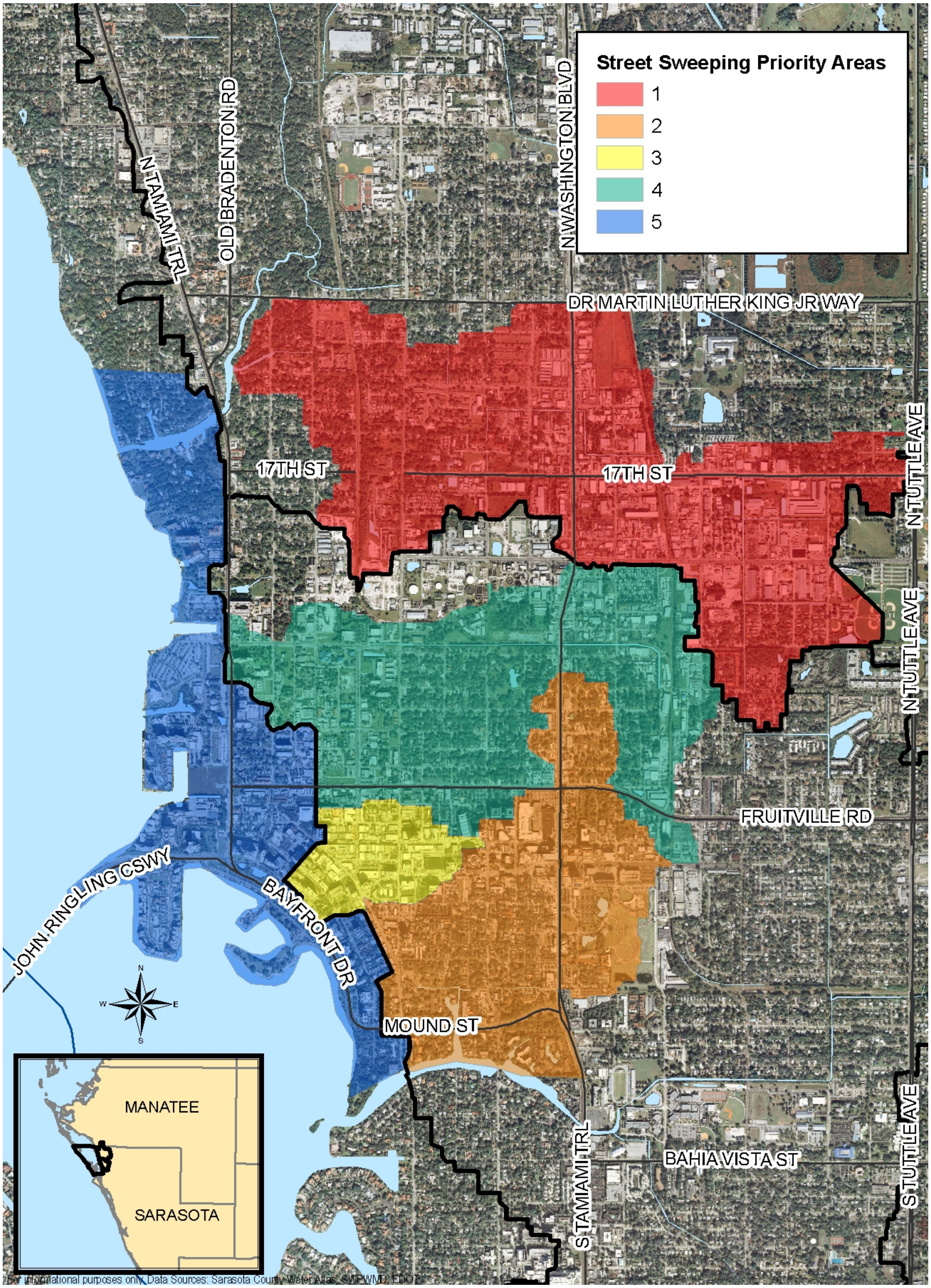


Figure 3-22 Sarasota Bay Watershed Street Sweeping Priority Areas

3.2.7.2 Recommendation

We recommend working with residents through Neighborhood Environmental Stewardship Team or other programs to evaluate areas that could be improved by the addition of buffer zones. Adding buffers on properties that were developed along waterways before the land development regulations were implemented should be a primary goal.

3.2.8 Strategic Maintenance Plan

3.2.8.1 Description

The *Strategic Maintenance Plan,* adopted in 1999, establishes level-of-service (LOS) goals for maintenance activities in the County. The plan identifies maintenance practices and classifies practices into *Routine*, *Extraordinary*, and *Support* activities in which the staff engages for maintenance repairs, improvement, management, and operation of the public stormwater system.

Stormwater maintenance has traditionally played an active role in maintaining the flood capacity of the stormwater system throughout the County. A more robust maintenance program incorporating the recommendations described below will play a larger role in improving the quality of the runoff reaching the estuaries and bays of Sarasota County.

3.2.8.2 Recommendation

Jones Edmunds recommends the following approach to expand and enhance the focus of the stormwater maintenance process to include water quality in addition to flood protection:

- Implement the 1999 Strategic Maintenance Plan.
- Achieve the inspection and maintenance frequency required in the MS4 Permit.
- Update the Strategic Maintenance Plan.
- Adopt practices listed below when fiscally feasible.

Updating the *Strategic Maintenance Plan* and adopting several non-structural BMPs and source-control practices may provide the best opportunities to increase awareness and implement maintenance improvements aimed at improving water quality. The following modifications, additions, or removal of maintenance practices will help the County meet its water quality goals:

- Inspection and Permit Compliance:
  - NPDES Inspection.
  - Asset Management.
- FEMA Community Rating System.
- Facility Maintenance and BMPs:
  - Facilities: Scheduling.
  - Facilities: Denuding Conveyance Features.

- Non-Structural BMPs: Buffer Zones.
- Non-Structural and Structural BMPs: LID.
- Source Control: Street Sweeping.
- Source Control: Herbicides.
- Source Control: Fertilizer Management.
- Source Control: Harvesters.

Jones Edmunds analyzed current maintenance policies and procedures as part of the Roberts Bay North and Lemon Bay Watershed Management Plans (WMPs). The recommendations listed above are detailed in the Roberts Bay North and Lemon Bay WMPs.

3.2.9 Keep Sarasota County Beautiful

3.2.9.1 Description

Keep Sarasota County Beautiful is a County-wide program with a mission to enhance and promote public interest and participation in the general improvement of the environment throughout Sarasota County. This is done through education, cleanup programs, recycling and other methods of reducing solid waste. It is an affiliate of Keep America Beautiful, Inc., a national, non-profit, public education organization dedicated to improving waste handling practices in American communities.

3.2.9.2 Recommendation

Litter is one of the most visible stormwater pollution issues in the watershed. Jones Edmunds recommends that the County increase the number of community cleanup projects in the watershed through the Keep Sarasota County Beautiful program. The County should work with homeowner associations and neighborhoods to recruit volunteers and organize educational and cleanup events. The County should also work with marinas to organize boating cleanups.

In addition, Jones Edmunds recommends the County review dumpster and trash can locations and handling and inspection procedures. The County should make sure that there are adequate trash receptacles in public areas, especially in marinas, along the waterfront, and near major storm drains, and they that are being properly emptied and maintained.

4.0 CONCLUSION

Six of the potential project sites were deemed viable locations for projects designed to improve erosion and sedimentation issues (Table 4-1). Implementation of these projects and programmatic recommendations will significantly reduce erosion, sediment, and associated pollutant loading and improve water quality in the Sarasota Bay Watershed.

Table 4-1 Recommended Sediment Management Projects

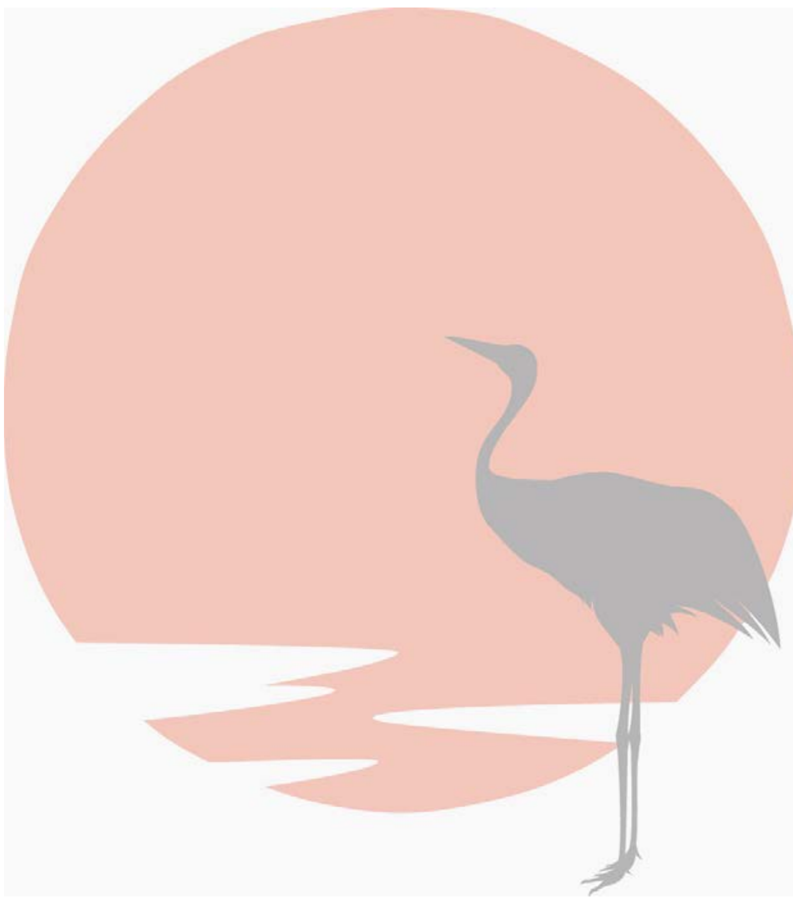
ID	Site Name	Recommended
1	Brother Geenen Way	
2	Robert Taylor Community Complex	x
3	Orange Avenue	x
4	Bayfront Drive North	x
5	Bayfront Drive South	x
6	Sarasota High School at Hatton Street Ditch	x
7	Sarasota High School at Tamiami Trail	x

Jones Edmunds will calculate pollutant-load reduction, develop conceptual plans and cost estimates, and provide project and program rankings for the selected project sites in Appendix G.

Appendix G

Project and Program Recommendations

Appendix G
Project and Program Recommendations



December 2012

Sarasota County
Southwest Florida Water Management District
JONES EDMUNDS
Janicki Environmental, Inc.

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1.0 INTRODUCTION

This Appendix integrates the project and program recommendations in Appendices B, C, D, and F for this WQMP into a final set of prioritized recommendations that are consistent with and support the County's established levels of service (LOS) and other goals. The recommendations cover four categories: water quality, natural systems, water supply, and flood control. This four-category grouping mirrors the State Water Management Districts' four "Areas of Responsibility." Project recommendations include capital improvement and programmatic projects. The inclusion of proposed projects in this plan does not confer any special status, approval, permitting, standing, or funding from Southwest Florida Water Management District (SWFWMD). Requests for funding assistance will have to meet the requirements of funding programs and be subject to the District's Governing Board's appropriating funds. (Note: SWFWMD funding is not the only source of funding contemplated for these projects.)

After a funding source has been identified and before scopes and projects begin, a workshop should be held with public, community and other stakeholders to ensure public and stakeholder support for the project.

Further, all projects are subject to County and SWFWMD regulatory review and permitting and are designed to be consistent with the Sarasota County Comprehensive Plan and the Sarasota County Code of Ordinances. Where applicable, all regulatory authorizations shall be obtained before a project can begin. To address these concerns, regulatory coordination will occur at the planning stages for each project discussed in this Appendix to ensure a streamlined permitting review process and address consistency with the Sarasota County Comprehensive Plan and Sarasota County Code of Ordinances before the project is designed.

Project prioritization typically includes evaluating costs, benefits, and other measures such as permittability. Comparing benefits that achieve distinctly disparate goals makes comparing projects over multiple areas of responsibility a challenge. For instance, how comparable are the benefits of a project that provides flood protection to two homes to those of a project that reduces total nitrogen (TN) loading by 500 pounds per year? To address this challenge, qualitative scoring systems are often developed to overcome the difficulty of equating benefits between different project categories. For instance, projects may accumulate relative benefit scores on a fixed scale (e.g., 0 to 10) in multiple categories, with a weighted or unweighted total determining their overall relative benefit. Although this method is simple to implement and understand, it tends to compress the actual scale of benefits and make costs a greater determining factor in the recommendations.

The approach applied in this document uses a quantitative evaluation of benefits in combination with benefit values to provide a more equivalent comparison of costs and benefits for each recommended project. To implement this type of approach, a common metric must be used for benefits, and minor benefits and other subjective measurements such as permittability must not be considered. An example of a minor benefit is a small reduction in flood stage (e.g., 0.1 foot) that results from an erosion-control project and does not contribute to a change in the flood protection LOS. Although these types of benefits may have some level of importance, they are generally small compared to major benefits. Subjective measurements, such as permittability, were not considered in the quantitative evaluation of benefits; however, these factors were applied at the project evaluation stage within each area of interest. For instance, an erosion-control project that would be difficult to permit because it would increase flood stages is unlikely to be a recommended project. Additionally, ownership of all proposed projects was verified at the project evaluation stage within each area of interest. All proposed projects are on public lands, so there are no associated real estate costs.

Although not a part of the cost-benefit analysis, non-quantifiable project benefits including water quality needs, environmental benefits, connections to policy, community interest, funding, potential partners, and whether selection criteria are addressed are a valuable component of project selection. Water quality projects, for example, were initially identified in areas that pollutant loads (TN, total phosphorus [TP], and total suspended solids [TSS]) exceeded the watershed median loads. If two projects with a similar value are compared, the one that reduces TN, TP, and TSS and has potential partners could be a better choice than the one that only reduces TN.

2.0 MEASURES OF BENEFITS

Based on the discussion above, this analysis focuses on measures of major benefits for each recommendation. The metric that allows the best comparison of major benefits to costs across multiple areas of responsibility is dollars. Therefore, the major benefits, how they would be measured, and the dollar value associated with each measure were determined. The following measures of major benefits were determined to be the most significant and appropriate for this project:

- Water Quality—Pounds per year of TN reduction provided by the project. This measure could be changed or expanded to include other water quality measurements if Total Maximum Daily Loads (TMDLs) within the stream segments change.

- Natural Systems—Functional gain using Uniform Mitigation Assessment Methodology (UMAM).

- Water Supply—Total acre-feet per year of alternative water supply beneficially used/supplied by a project.

- Flood Control—Number of road segments and homes in which an improved flood protection LOS is provided by the project. Also, the total cubic yards of sedimentation removed at sediment sumps or erosion prevented by a project.

3.0 BENEFIT VALUE

The following total benefit value for the measures above were determined from published information concerning the dollar value per unit of benefit as follows:

- Water Quality—The benefit value of $4,800 per pound of TN removed per year is based on average nitrogen removal costs reported in Florida Department of Environmental Protection (FDEP) grant projects as well as recent Sarasota County Water Quality Projects. The Sarasota County benefit values include Operation and Maintenance (O&M) costs, it is unknown if the FDEP values also include O&M costs.. In this case, the benefit may be thought of as the cost avoided by not having to implement another or different project.

- Natural Systems—The benefit value of wetland creation or preservation is $142,000 per Functional Gain Credit for herbaceous wetlands and $105,000 per Functional Gain Credit for forested wetlands based on costs of credits at nearby wetland mitigation banks.

- Water Supply—The benefit value for water supply is $12,043 per acre-foot per year of water based on the second-tier Sarasota County residential water use fees of $3.08 per 1,000 gallons per month for consumption of 4,001 to 8,000 gallons per property as stated in Sarasota County Resolution No. 2009-201. First-tier consumption includes household uses up to 4,000 gallons of water per month. Residents consuming more than 4,000 gallons per month are likely using water for irrigation; therefore, the second-tier rates were used as the benefit value in this analysis. The water supply benefit is essentially the cost avoided by not having to provide the potable water that would otherwise be used for irrigation.

- Flood Control—The value of benefits for flood control projects is based primarily on using Sarasota County's Stormwater Environmental Utility's Cost-Effective Analysis for Stormwater Projects. No flood protection LOS improvements were found in any of the recommended projects at the conceptual level. Erosion prevention and sediment removal, however, are included in some recommended projects. The benefit value is $40 per cubic yard, with sediment removal at sump locations being an annual occurrence and the total benefit being over the useful life of the project. This benefit value is based on the median cost of dredging in Sarasota County in 2011.

4.0 PROJECT ANALYSIS

Benefits and costs, including capital and operation and maintenance costs, were calculated at a conceptual level for each recommended project. Non-quantitative benefits were also documented and considered in ranking the projects based on priority. Section 4.1, Section 4.2, Section 4.3, Section 4.4, and Section 4.5 describe the methodology used to determine project benefits. Table 4-4 and Table 4-5 summarize the project cost-benefits and non-quantitative benefits.

Recommended projects are only conceptual. Each project should be modeled during the design phase to ensure that it will not negatively affect the existing floodplain or increase maximum flood stages before being implemented.

4.1 WATER QUALITY BENEFITS

To measure the water quality benefits of the recommended projects, load reductions were estimated for each recommended project. The average annual catchment pollutant loads as estimated from the Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE) by appropriate source (i.e., direct runoff [DRO] for a bioswale, total load [TOTAL] for a wetland, and atmospheric deposition [ATM] for a cistern) were applied to the reasonable drainage areas for each best management practice (BMP) component of each project to yield the estimated treatable load for each component.

The average removal efficiencies of each BMP (Table 4-1) were applied to the estimated loads, resulting in the expected nutrient reduction by individual BMP. Of course, a great deal of variability occurs in the range of removal efficiencies of structural and source control BMPs. The geographic location, climate, degree of urbanization, and study limitations all impact the variance found in removal efficiencies. The removal efficiency ranges used in these reduction estimates are based on existing literature (Attachment 1) unless otherwise noted.

These load reductions calculated from the estimated loads and the average BMP removal efficiencies were summed for each project, giving the total projected load reduction for each recommended project. The total benefit value for nitrogen removal ($4,800/lb/yr) was then applied to each project.

Table 4-1 Pollutant Removal Efficiencies
Load Type: Direct Runoff (DRO), Atmospheric Deposition (ATM), Total Load (total)

BMP Type	Load Type	TSS	TP	TN
Baffle Box/Catch Basin	DRO	57%	5%	21%
Bioretention Swale	DRO	50%	76%	50%
Dry Retention Pond	DRO	90%	80%	90%
Riparian Maintenance Buffer	DRO	61%	55%	75%
Sediment Sump	DRO	48%	0%	0%
Stream Enhancement	TOTAL	2.55 lb/lf	0.0035 lb/lf	0.02 lb/ft
SW Treatment Wetland	TOTAL	66%	55%	34%
Wet Detention Pond	TOTAL	75%	56%	34%
Wetland	TOTAL	88%	55%	34%
Wetland Enhancement*	TOTAL	22%	14%	8%
Water Bars**	DRO	50%	76%	50%
Pervious Pavement	DRO	88%	48%	55%
Pervious Sidewalks	DRO	88%	48%	55%
Cisterns***	ATM	0%	50%	50%
Green Roof****	ATM	0%	53%	63%

* Jones Edmunds estimated a 25% efficiency improvement for enhancement of existing wetlands. Wetlands that need restoration are likely not fully functional and therefore are not removing nutrients at optimal efficiency. Enhancement is assumed to improve function by 25%.

** Waterbars divert runoff to a bioretention area; therefore, Jones Edmunds assigned bioretention load reductions.

*** Jones Edmunds assumed that 50% of the annual rainfall over each roof with cisterns or rain barrels could be captured and used for irrigation, thereby reducing the nutrient load by 50%. Since the loads for rain barrels and cisterns were estimated from ATM, no reduction of TSS was estimated for cisterns.

**** Since the loads for green roofs were estimated from ATM, no reduction of TSS was estimated for green roofs.

4.2 NATURAL SYSTEMS BENEFITS

The natural systems benefit that could occur from restoring a particular site was quantified using the Uniform Mitigation Assessment Methodology (UMAM). To calculate the potential ecological lift, the UMAM requires the current condition of each site and the perceived condition of the site after restoration to be scored. UMAM is used to quantitatively score the assessment area for three categories: (1) Location and Landscape Support, (2) Water Environment, and (3) Community Structure. These categories are scored on a scale of 0 to 10 (10 being the highest), summed, and then divided by 30, which yields a value referred to as *the Score*, which has no units. For these sites the habitat improvement value achieved is determined by calculating the Relative Functional Gain (RFG), which represents the amount of wetland functions that will be gained with the proposed mitigation. A “time lag” and “risk factor” are incorporated into the calculations of RFG. Time lag represents the amount of time (in years) required for the proposed mitigation to reach maturity and replace the lowest functional value (e.g., wildlife habitat, vegetation structure) that was lost. Time lag values vary from 1.0 (1-year time lag) to 3.9 (greater than 55 years) (Table 4-2).

Table 4-2 Time Lag Values Used in the UMAM Analysis

Year	T-factor
< or = 1	1
2	1.03
3	1.07
4	1.10
5	1.14
6–10	1.25
11–15	1.46
16–20	1.68
21–25	1.92
26–30	2.18
31–35	2.45
36–40	2.73
41–45	3.03
46–50	3.34
51–55	3.65
>55	3.91

The acreage of habitat that would be restored or enhanced was determined in the field using a GPS unit in combination with a review of 2008 digital ortho quarter quadrangle imagery. Based on these reviews, the approximated enhancement/restoration acreage was digitized in a GIS over the imagery to be used in the UMAM calculations. The RFG is then multiplied by this acreage to determine the expected credits based on a habitat improvement project or component. The UMAM Functional Gain could be used to offset capital improvement projects that impact existing wetlands within the basin where the habitat improvement activities are taking place. The benefit value ($142,000 per mitigation bank credit for herbaceous wetlands and $105,000 per mitigation bank credit for forested wetlands) was applied to the calculated UMAM Functional Gain. Credit prices are Myakka Mitigation Bank prices as of June 2012, which is the closest bank to Sarasota Bay Watershed.

4.3 WATER SUPPLY

The water supply projects consist of stormwater-derived alternative water supplies for irrigation use aimed at reducing the amount of potable water being used for irrigation. To measure the water supply benefits of the recommended projects, the average annual SIMPLE DRO volume was applied to the drainage areas for each stormwater-harvesting project and the direct rainfall was applied to the roof drainage areas for rain barrels and cisterns to yield the total volume that could be captured for irrigation needs. Jones Edmunds estimated that 50% of this volume would be available for irrigation. This reduction will account for the timing variation between supply and demand and factors such as permanent pool maintenance in stormwater detention areas and cistern and rain barrel capacity. The irrigation requirements for each project were estimated based on irrigable area and a need for 1 inch of irrigation per week. The lower volume between the available supply or irrigation requirements is the water supply volume for each project. The total benefit value for water supply ($12,043 ac-ft/yr) was applied to the projected volume for each project.

4.4 FLOOD PROTECTION

Flood protection LOS benefits were not identified, as the recommended projects were only taken to the conceptual level. However, as plans are developed and modeling is done for the recommended projects, flood protection LOS benefits may become evident. Several recommended projects include erosion prevention and sediment control components. To quantify erosion and sediment control measures, the length and average slope of the existing bank area to be stabilized were estimated using LiDAR and the bank area was calculated. A 1-foot sediment depth was used with the bank area to calculate sediment volume. Lastly, the benefit value ($70/cubic yard) was applied to the predicted volume of erosion prevention and sediment control.

4.5 INTANGIBLE BENEFITS

Although dollar value is the metric that allows the best comparison of major benefits to costs across multiple areas of responsibility, numerous benefits were non-quantifiable. Therefore, intangible benefits were also taken into account for project rank. The following intangible benefits, which are summarized in Table 4-3, were determined to be the most influential in determining the need for each project:

- Water Quality Need—The water quality need assesses the project need based on the water quality status within the TMDL program. Projects associated with impaired WBIDs or LOS deficiencies are considered priority projects. To be considered a priority, the project must be in an impaired water body that has a TMDL, has not yet been assigned a TMDL but has an FDEP Consent Decree, does not have an FDEP Consent Decree, or is associated with a water quality LOS deficiency.

Table 4-3 Description of Intangible Benefits

Intangible Benefit		Description
Water Quality Need	TMDL	Project is within a TMDL Water Body ID (WBID).
	TMDL Consent Decree	The project is within an impaired WBID that has not yet been assigned a TMDL but does have an FDEP Consent Decree.
	Impaired (No TMDL)	Project is within a WBID; however, a TMDL has not yet been assigned.
	Pollutant Hot Spots	Project is within a WBID with a water quality LOS deficiency.
Environmental Benefits	Habitat Restoration	Project provides habitat restoration.
	Hydrologic Restoration	Project provides hydrologic restoration.
	Floodplain Restoration	Project contributes floodplain restoration.
Policy	Weak Policy Connection	Project has weak connection to Sarasota County policy.
	Conflicting Policy Considerations	Project is not consistent with Sarasota County policy.
	Direct Policy Connection	Project is directly connected to and consistent with Sarasota County policy.
	Indirect Policy Connection	Project is indirectly associated with Sarasota County policy.
Interest	Potential Partners	Potential partners for project may include Economic Development Corporation, Neighborhood Associations, New College, Ringling College, Sarasota Bay Estuary Program, Science and Environment Council and Partners, SWFWMD, UF IFAS, and University of South Florida.
	Current Community Interest	Potential community participation in project.
Funding	Stormwater Environmental Utility	Project can be funded through the Stormwater Environmental Utility.
	Water/sewer Utility	Project can be funded through Water/Sewer Utility.
	Surtax III	Project can be funded through Surtax III.
	None identified	No potential funding identified for project.
	Other	Other potential funding identified for project.
	Potential Grant Sources	Project has potential grant sources.

Table 4-3 Description of Intangible Benefits

Intangible Benefit		Description
Project Area Selection Criteria (*Project addresses criteria)	TN load above watershed median load	Watershed catchments that exceeded the median TN/ac/yr of the watershed.
	TP above watershed median load	Watershed catchments that exceeded the median TP/ac/yr of the watershed.
	TSS load above watershed median load	Watershed catchments that exceeded the median TSS/ac/yr of the watershed.
	Sediment/ Erosion Problem	Areas noted to have visible sedimentation or erosion during ArcGIS desktop analysis, field trips, or stakeholder input. Areas with high stream flow based on the County's ICPR model results were also considered.
	Available DRO	Areas that are not currently served with reclaimed water for irrigation and have more than 0.5 ac-ft/ac/yr of DRO than existed historically.
	Ownership: Public Property	Project area is on a publicly owned parcel.

- ❖ Environmental Benefits—Projects were assessed based on their contribution of environmental benefits. Projects providing hydrologic restoration, and/or habitat restoration, and/or contribute floodplain restoration are considered to have intangible environmental benefits.

- ❖ Policy—Projects were assessed based on their consistency with Sarasota County policy as defined in the Comprehensive Plan and/or ordinances. Projects are considered to have intangible policy benefits if they have a direct or indirect policy connection. Weak or conflicting policy connections are not considered to have this intangible benefit.

- ❖ Potential Partners—Projects were assessed based on the potential for partnerships. Potential partners are defined as the following: Economic Development Corporation, Neighborhood Associations, New College, Ringling College, Sarasota Bay Estuary Program (SBEP), Science and Environment Council and Partners, SWFWMD, UF IFAS, University of South Florida. Projects with the potential for one or more of these partnerships are considered to have this intangible benefit.

- ❖ Funding—Projects were assessed based on the availability of funding at the time of this plan. Projects that can be funded through the Stormwater Environmental Utility, Water/Sewer Utility, Surtax III, or another source are considered to have this intangible benefit.

- ❖ Potential Grant Sources—Projects were assessed based on the potential for grant opportunities. Potential grant opportunities are identified as the following: FDEP 319, SWFWMD, FDEP TMDL, NOAA, EPA, or other grant sources. Projects are considered to have this intangible benefit if one or more of these grant opportunities was identified at the time of this plan.

- ❖ Project Selection Criteria—Projects and their locations were initially selected based on their potential to reduce a pollutant and/or sediment load and/or use available surface water for irrigation. Areas with TN, TP, and/or TSS loads that are above the median load of the watershed were selected for their potential to reduce loading. Loads were estimated with SIMPLE. See Appendix C (Water Quality) for details. Areas with visible sedimentation or erosion or high stream flow based on the County's ICPR model results were selected for potential sediment and erosion remediation projects. See Appendix F (Sediment Management Plan) for details. Areas with an irrigation need that are not currently served with reclaimed water for irrigation and have more than 0.5 ac-ft/ac/yr of DRO than existed historically were chosen for potential reuse projects. See Appendix B (Water Quantity) for details. Areas identified as having a pollutant or sediment load or available water for irrigation are marked as "yes" in Table 4-3.

Projects that address a pollutant and/or sediment load and/or reuse surface water for irrigation and are on public property are considered to have this intangible benefit and are denoted with an asterisk (*) in the table.

4.6 PROJECTS

Project locations are shown in Figure 4-1 and a summary of the quantifiable benefits and costs of each project are in Table 4-4. Intangible benefits are summarized by project in Table 4-5. Project rankings are summarized in Table 4-6.

4.7 CONCEPTUAL-LEVEL PROJECT SHEETS AND COST ESTIMATES

Section 6.0 contains a project sheet and opinion of probable cost for each recommended project. The project sheets summarize Site Evaluation, Project Elements, Project Benefits, Estimated Pollutant Removal or UMAM Mitigation Bank Credits, and Opinion of Probable Cost. More detailed information for each project can be found in Appendix B (Water Quantity), Appendix C (Water Quality), Appendix D (Natural Systems), and Appendix F (Sediment Management Plan); however, some projects were modified or removed after further analysis. Projects that were identified later are not included in those appendices and are denoted with "*". The project ID will indicate the referenced appendix. (i.e., SMP = Appendix F (Sediment Management Plan), NS = Appendix D (Natural Systems), WQ = Appendix C (Water Quality), WS = Appendix B (Water Quantity). The numbers indicate the project number assigned during the analysis.

4.8 STATUS OF PROJECTS FROM PREVIOUS PLANS

Previous plans and studies were reviewed within the Sarasota Bay WQMP framework. Although not evaluated as part of the WQMP, the projects are important to the County's goals of preserving, protecting, and enhancing natural systems and water quality in Sarasota Bay ecosystems; supporting a sustainable water supply; and providing flood protection. Attachment 2 lists projects recommended by others and their statuses.

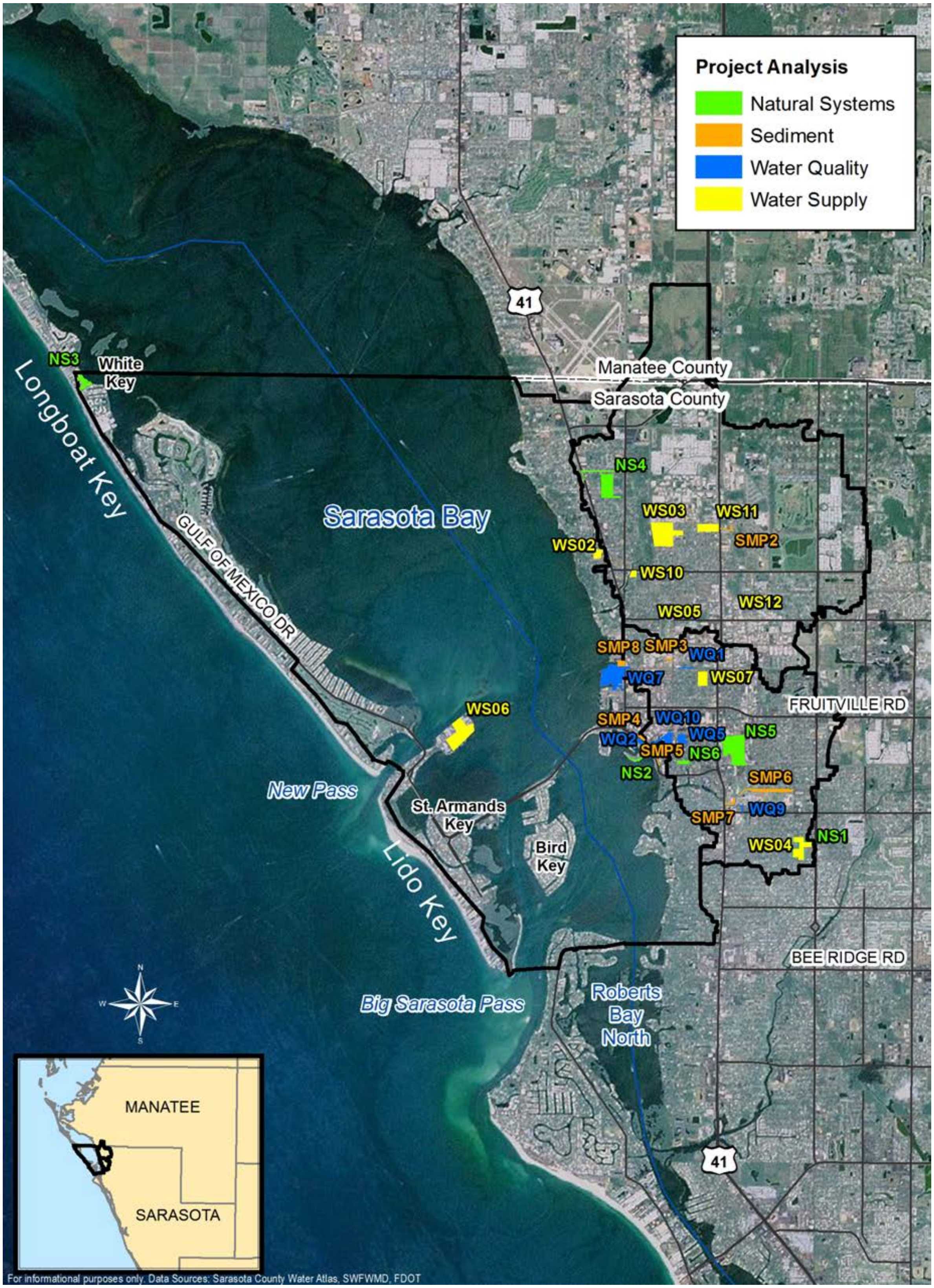


Figure 4-1 Location of Recommended Capital Improvement Projects

Table 4-4 Project Cost-Benefits

Project ID	Project Name	Basin (HB: Hudson Bayou, WB: Whitaker Bayou, SBC: Sarasota Bay Coastal)	SIMPLE Basin	Flood Protection	Water Quality		Natural Systems		Water Supply	Estimated Value of Major Benefits	Opinion of Probable Cost	Present Value of O & M	Present Value of Costs	Benefits / Costs			Benefits / Costs
				County Flood Control Benefits	Cubic Yards of Erosion Prevention and Sediment Control	Annual Pounds of Total Nitrogen Removal	UMAM Mitigation Bank Credits of Herbaceous Wetlands	UMAM Mitigation Bank Credits of Forested Wetlands	Annual Acre-feet of Beneficially Used Harvested Water					Cost per Pound of Nitrogen Removal	Cost per UMAM Credit	Benefits / Costs	
NS1	Arlington Park	HB	**103**	0	0	61	0.12	0.17	0	$329,540.00	$83,194.50	$46,444.00	$129,638.50	$2,125	N/A	2.54	2.54
NS2	Bayfront Park Shore	SBC	**101**	0	2270	0	0.04	0	0	$95,000.00	$20,055.00	$4,962.00	$25,017.00	N/A	$625,425	3.80	3.80
NS3	Longboat Key Bayfront Park	SBC	**117**	0	0	17	0.18	0	0	$100,500.00	$101,621.13	$73,339.00	$174,960.13	$10,292	N/A	0.57	0.57
NS4	North Water Tower Park	WB	**112**	0	0	775	0.35	0.99	0	$3,897,330.00	$653,737.75	$110,047.00	$763,784.75	$986	N/A	5.10	5.10
NS5	Payne Park	HB	**104 & 105**	0	0	74	0.19	0.05	0	$382,250.00	$162,151.63	$46,444.00	$208,595.63	$2,819	$869,148	1.83	1.83
NS6	Hudson Bayou Oak Street Canal	HB	**105**	0	0	9	0	0.02	0	$46,040.00	$33,093.75	$9,924.00	$43,017.75	$4,780	N/A	1.07	1.07
SMP2	Whitaker Canal at Leonard Reid Ave	WB	**111**	0	1400	157	0	0	0	$809,600.00	$189,200.00	$94,041.00	$283,241.00	$1,804	N/A	2.86	2.86
SMP3	Orange Avenue	HB	**109**	0	85	90	0.00	0.00	0	$435,400.00	$226,500.00	$92,449.00	$318,949.00	$3,544	N/A	1.37	1.37
SMP4	Bayfront Park and Marina North	SBC	**101 & 107**	0	0	14	0.00	0.00	0	$67,200.00	$124,000.00	$46,444.00	$170,444.00	$12,175	N/A	0.39	0.39
SMP5	Bayfront Park and Marina South	SBC	**101**	0	0	31	0.00	0.00	0	$148,800.00	$137,500.00	$7,047.00	$144,547.00	$4,663	N/A	1.03	1.03
SMP6	Sarasota High School at Hatton Street	HB	**102**	0	21574	105	0.00	0.00	0	$1,366,960.00	$368,600.00	$106,543.00	$475,143.00	$4,525	N/A	2.88	2.88
SMP7	Sarasota High School at Tamiami Trail	HB	**102**	0	0	16	0.00	0.00	0	$76,800.00	$48,100.00	$17,617.00	$65,717.00	$4,107	N/A	1.17	1.17
SMP8*	10th St Boat Basin Dock	SBC	**101 & 108**	0	630	0	0.00	0.00	0	$25,200.00	$476,400.00	$46,005.00	$522,405.00	N/A	N/A	0.05	0.05
WQ1	North Gillespie Park	HB	**108**	0	460	0	0.00	0.00	0	$18,400.00	$103,700.00	$60,099.00	$163,799.00	N/A	N/A	0.11	0.11
WQ10	Ringling Blvd. Sidewalks	HB	**101, 105 & 107**	0	0	20	0.00	0.00	0	$96,000.00	$396,400.00	$17,159.00	$413,559.00	$20,678	N/A	0.23	0.23
WQ2	Bayfront Parking Lot	SBC	**101**	0	0	217	0.00	0.00	0	$1,041,600.00	$938,500.00	$63,164.00	$1,001,664.00	$4,616	N/A	1.04	1.04
WQ5	Hudson Bayou North Branch	HB	**105 & 107**	0	0	9	0.00	0.00	1	$55,243.00	$52,900.00	$14,094.00	$66,994.00	$7,444	N/A	0.82	0.82
WQ7	10th St Outfall	SBC	**101 & 108**	0	0	192	0.00	0.00	0	$921,600.00	$1,362,400.00	$90,059.00	$1,452,459.00	$7,565	N/A	0.63	0.63
WQ9	Hudson Bayou East Branch	HB	**103**	0	92	0	0.00	0.00	0	$3,680.00	$112,900.00	$60,099.00	$172,999.00	N/A	N/A	0.02	0.02
WS02	Bay Haven Elementary School	SBC	**101**	0	0	4	0.00	0.00	3	$55,329.00	$80,800.00	$7,047.00	$87,847.00	$21,962	N/A	0.63	0.63
WS04	Arlington Park and Aquatic Complex	HB	**103**	0	0	0	0.00	0.00	33	$397,419.00	$39,200.00	$46,444.00	$85,644.00	N/A	N/A	4.64	4.64
WS05	Orange Avenue Park	WB	**110**	0	0	18	0.00	0.00	6	$158,658.00	$103,100.00	$46,444.00	$149,544.00	$8,308	N/A	1.06	1.06
WS06	Ken Thompson Park Preserve	SBC	**117**	0	0	11	0.00	0.00	4	$100,972.00	$884,900.00	$37,384.00	$922,284.00	$83,844	N/A	0.11	0.11
WS07	Gillespie Park	HB	**108**	0	0	0	0.00	0.00	9	$108,387.00	$32,300.00	$59,622.00	$91,922.00	N/A	N/A	1.18	1.18
WS10	Martin Luther King Park	WB	**110 & 112**	0	0	1	0.00	0.00	0	$4,800.00	$187,200.00	$30,337.00	$217,537.00	$217,537	N/A	0.02	0.02
WS11	Robert Taylor Community Complex	WB	**111**	0	0	1	0.00	0.00	1	$16,843.00	$77,200.00	$7,047.00	$84,247.00	$84,247	N/A	0.20	0.20
WS12	Lime Lake Park	WB	**111**	0	0	0	0.00	0.00	10	$120,430.00	$25,500.00	$46,444.00	$71,944.00	N/A	N/A	1.67	1.67

Note: The higher the number in the last column, the higher the rank.

Table 4-5 Project Intangible Benefits

Project ID	Project Name	Benefits / Costs	Water Quality Need					Environmental Benefits			Policy				Potential Partners								Current Community Interest				Funding			Potential Grant Sources		Project Selection Criteria (*Project adresses criteria)					
			TMDL	TMDL Consent Decree	Impaired (No TMDL)	Impairment	Pollutant Hot Spots	Habitat Resoration	Hydrologic Restoration	Floodplain Restoration	Weak Policy Connection	Conflicting Policy Considerations	Direct Policy Connection	Indirect Policy Connection	Town of Longboat Key	City of Sarasota	Neighborhood Associations	Sarasota Bay Estuary Program	SWFWMD	Sarasota County S chool Board	Downtown Condo Association	North Trail Revitalization Association	Localized	Expansive	Favorable	No Bias	Stormwater Environmental Utility	Water/sewer Utility	Surtax III	SWFWMD	EPA 319	TN load above watershed median load	TP above watershed median load	TSS load above watershed median load	Probable Sediment/ Erosion Problem	Available Direct Runoff	Ownership: Public Property
NS1	Arlington Park	2.54	None	No	No	-	DO, TN	X	-	-	-	-	-	X	-	X	X	X	X	-	-	-	X	-	X	X	-	-	X	X	X	*YES	*NO	*NO	NO	YES	Y
NS2	Bayfront Park Shore	3.80	None	No	No	-	-	X	-	-	-	-	-	X	-	X	X	X	X	-	X	-	X	-	X	-	-	-	X	X	X	NO	NO	NO	*NO	NO	Y
NS3	Longboat Key Bayfront Park	0.57	None	No	No	-	DO, TN	X	-	-	-	-	-	X	X	-	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*NO	*NO	*NO	NO	YES	Y
NS4	North Water Tower Park	5.10	None	No	No	-	TN	X	X	-	-	-	-	X	-	X	X	X	X	-	-	X	-	X	X	-	-	-	X	X	X	*YES	*YES	*NO	NO	*NO	Y
NS5	Payne Park	1.83	None	Yes	Yes	DO, Fecal Coliform	DO, TN	X	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*YES	*YES	*YES	NO	YES	Y
NS6	Hudson Bayou Oak Street Canal	1.07	None	Yes	Yes	DO, Fecal Coliform	DO, TN	X	-	-	-	-	-	X	-	X	X	X	X	-	-	-	X	-	X	-	-	-	X	X	X	*YES	*YES	*YES	NO	YES	Y
SMP2	Whitaker Canal at Leonard Reid Ave	2.86	None	No	No	-	-	X			-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*NO	*NO	*YES	*YES	YES	Y
SMP3	Orange Avenue	1.37	None	No	No	-	DO, TN	X	-	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*NO	*NO	*YES	*YES	*YES	Y
SMP4	Bayfront Park and Marina North	0.39	None	No	No	-	DO, TN	-	X	-	-	-	-	X	-	X	X	X	X	-	X	-	X	-	X	-	-	-	X	X	X	*YES	*YES	*YES	NO	*NO	Y
SMP5	Bayfront Park and Marina South	1.03	None	No	No	-	-	X	-	-	-	-	-	X	-	X	X	X	X	-	X	-	X	-	X	-	-	-	X	X	X	*YES	*NO	*NO	NO	NO	Y
SMP6	Sarasota High School at Hatton Street	2.88	None	No	No	-	DO, TN	-	-	-	-	-	-	X	-	X	X	X	X	X	-	-	-	-	-	-	-	-	X	X	X	*YES	*YES	*NO	*YES	YES	Y
SMP7	Sarasota High School at Tamiami Trail	1.17	None	No	No	-	DO, TN	X	-	-	-	-	-	X	-	X	X	X	X	X	-	-	-	-	-	-	-	-	X	X	X	*NO	*YES	*NO	YES	YES	Y
SMP8*	10th St Boat Basin Dock	0.05	None	No	No	-	DO, TN	-	-	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	YES	NO	YES	*YES	NO	Y
WQ1	North Gillespie Park	0.11	None	No	No	-	DO, TN	-	-	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	YES	NO	YES	*YES	YES	Y
WQ10	Ringling Blvd. Sidewalks	0.23	None	Yes	Yes	DO, Fecal Coliform	DO, TN	-	-	-	-	-	-	X	-	X	X	X	X	-	-	-	X	-	X	-	-	-	X	X	X	*YES	*YES	*YES	YES	YES	Y
WQ2	Bayfront Parking Lot	1.04	None	No	No	-	-	-	-	-	-	-	-	X	-	X	X	X	X	-	X	-	X	-	X	-	-	-	X	X	X	*YES	*YES	*YES	NO	NO	Y
WQ5	Hudson Bayou North Branch	0.82	None	Yes	Yes	DO, Fecal Coliform	DO, TN	-	-	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*YES	*YES	*YES	NO	*YES	Y
WQ7	10th St Outfall	0.63	None	No	No	-	DO, TN	X	X	-	-	-	-	X	-	X	X	X	X	-	-	-	X	-	X	-	-	-	X	X	X	*YES	*NO	*YES	YES	*NO	Y
WQ9	Hudson Bayou East Branch	0.02	None	No	No	-	DO, TN	-	-	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	YES	NO	NO	*YES	YES	Y
WS02	Bay Haven Elementary School	0.63	None	No	No	-	DO, TN	-	X	-	-	-	-	X	-	X	X	X	X	X	-	-	-	-	-	-	-	-	X	X	X	*NO	*NO	NO	NO	*NO	Y
WS04	Arlington Park and Aquatic Complex	4.64	None	No	No	-	DO, TN	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	YES	NO	NO	NO	*YES	Y
WS05	Orange Avenue Park	1.06	None	Yes	Yes	TN, DO, Fecal Coliform	-	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*YES	*YES	*YES	NO	*YES	Y
WS06	Ken Thompson Park Preserve	0.11	None	No	No	-	DO, TN	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*NO	*NO	*NO	NO	*YES	Y
WS07	Gillespie Park	1.18	None	No	No	-	DO, TN	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*YES	*NO	YES	NO	*YES	Y
WS10	Martin Luther King Park	0.02	None	Yes	Yes	TN, DO, Fecal Coliform	TN	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	X	-	X	-	-	-	X	X	X	*YES	*YES	*YES	YES	*NO	Y
WS11	Robert Taylor Community Complex	0.20	None	No	No	-	-	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	*NO	*NO	YES	YES	*YES	Y
WS12	Lime Lake Park	1.67	None	Yes	Yes	TN, DO, Fecal Coliform	-	-	X	-	-	-	-	X	-	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	NO	NO	YES	NO	*YES	Y

Table 4-6 Project Priority Ranks by Benefit to Cost Ratio

Project ID	Project Name	Benefits / Costs	Priority Rank
NS4	North Water Tower Park	5.10	1
WS04	Arlington Park and Aquatic Complex	4.64	2
NS2	Bayfront Park Shore	3.80	3
SMP6	Sarasota High School at Hatton Street	2.88	4
SMP2	Whitaker Canal at Leonard Reid Ave	2.86	5
NS1	Arlington Park	2.54	6
NS5	Payne Park	1.83	7
WS12	Lime Lake Park	1.67	8
SMP3	Orange Avenue	1.37	9
WS07	Gillespie Park	1.18	10
SMP7	Sarasota High School at Tamiami Trail	1.17	11
NS6	Hudson Bayou Oak Street Canal	1.07	12
WS05	Orange Avenue Park	1.06	13
WQ2	Bayfront Parking Lot	1.04	14
SMP5	Bayfront Park and Marina South	1.03	15
WQ5	Hudson Bayou North Branch	0.82	16
WQ7	10th St Outfall	0.63	17
WS02	Bay Haven Elementary School	0.63	18
NS3	Longboat Key Bayfront Park	0.57	19
SMP4	Bayfront Park and Marina North	0.39	20
WQ10	Ringling Blvd. Sidewalks	0.23	21
WS11	Robert Taylor Community Complex	0.20	22
WQ1	North Gillespie Park	0.11	23
WS06	Ken Thompson Park Preserve	0.11	24
SMP8*	10th St Boat Basin Dock	0.05	25
WS10	Martin Luther King Park	0.02	26
WQ9	Hudson Bayou East Branch	0.02	27

Table 4-7 Project Priority Ranks by Regulatory Impairment

Project ID	Project Name	Basin	Impairment	TN Reduction (lb/year)	Sediment & Erosion Prevention (cy)	Benefits / Costs	Priority Rank
Impaired WBID (FDEP Consent Decree) No TMDL							
NS5	Payne Park	HB	DO, Fecal Coliform	74	0	1.83	7
WS12	Lime Lake Park	WB	TN, DO, Fecal Coliform	0	0	1.67	8
NS6	Hudson Bayou Oak Street Canal	HB	DO, Fecal Coliform	9	0	1.07	12
WS05	Orange Avenue Park	WB	TN, DO, Fecal Coliform	18	0	1.06	13
WQ5	Hudson Bayou North Branch	HB	DO, Fecal Coliform	9	0	0.82	16
WQ10	Ringling Blvd. Sidewalks	HB	DO, Fecal Coliform	20	0	0.23	21
WS10	Martin Luther King Park	WB	TN, DO, Fecal Coliform	1	0	0.02	26
No Impairment							
NS4	North Water Tower Park	WB	-	775	0	5.10	1
WS04	Arlington Park and Aquatic Complex	HB	-	0	0	4.64	2
NS2	Bayfront Park Shore	SBC	-	0	2270	3.80	3
SMP6	Sarasota High School at Hatton Street	HB	-	105	21574	2.88	4
SMP2	Whitaker Canal at Leonard Reid Ave	WB	-	157	1400	2.86	5
NS1	Arlington Park	HB	-	61	0	2.54	6
SMP3	Orange Avenue	HB	-	90	85	1.37	9

Table 4-7 Project Priority Ranks by Regulatory Impairment

WS07	Gillespie Park	HB	-	0	0	1.18	10
SMP7	Sarasota High School at Tamiami Trail	HB	-	16	0	1.17	11
WQ2	Bayfront Parking Lot	SBC	-	217	0	1.04	14
SMP5	Bayfront Park and Marina South	SBC	-	31	0	1.03	15
WQ7	10th St Outfall	SBC	-	192	0	0.63	17
WS02	Bay Haven Elementary School	SBC	-	4	0	0.63	18
NS3	Longboat Key Bayfront Park	SBC	-	17	0	0.57	19
SMP4	Bayfront Park and Marina North	SBC	-	14	0	0.39	20
WS11	Robert Taylor Community Complex	WB	-	1	0	0.20	22
WQ1	North Gillespie Park	HB	-	0	460	0.11	23
WS06	Ken Thompson Park Preserve	SBC	-	11	0	0.11	24
SMP8*	10th St Boat Basin Dock	SBC	-	0	630	0.05	25
WQ9	Hudson Bayou East Branch	HB	-	0	92	0.02	27

5.0 PROGRAM RECOMMENDATIONS

In addition to projects, programs centered on sustainability and conservation were identified. Some have direct nutrient-reduction impacts, while others have less quantifiable impacts but are important to improving environmental quality throughout the County. Sections 5.1 through 5.26 are recommendations for continuing, revising, and implementing programs to engage residents and help the County achieve its sustainability goals. Programs denoted with * have measurable benefits. Table 5-1 lists all recommended programs. Table 5-2 summarizes the methods and assumptions used to calculate the nutrient reductions for recommended programs with measurable impacts, and Table 5-3 summarizes the benefits of each.

Table 5-1 Program Recommendations

Section	Program Name	Existing County Program
5.1	Stormwater Harvesting*	
5.2	Rainwater Harvesting/Cisterns*	Yes
5.3	Fertilizer Ordinance*	Yes
5.4	Watercourse Setback	Yes
5.5	Septic Tank Pump-Out Regulation*	Yes
5.6	Public Outreach and Education*	Yes
5.7	Teacher Training/Campus Projects*	
5.8	Aquatic Harvester*	
5.9	Street Sweeping*	Yes
5.10	National Pollutant Discharge Elimination System (NPDES)	Yes
5.11	Facilitating Agricultural Resource Management Systems	
5.12	Preservation Areas	Yes
5.13	Mangrove Monitoring	Yes
5.14	Shoreline Softening	
5.15	Septic Replacement Program	Yes
5.16	Septic to Cistern	Yes
5.17	Strategic Maintenance Manual	Yes
5.18	Stormwater Manual	Yes
5.19	Composting Pilot Study	
5.20	Low-Impact Development (LID)	Yes
5.21	Exotic Species Management Program	Yes
5.22	Boat Ramp BMP Program	
5.23	Irrigation Utilities for New Development	Yes
5.24	Public Education on Water Conservation Practices	Yes
5.25	Potable Water Demand-Side Management Analysis	
5.26	Florida Water Star℠	Yes

Table 5-2 Program Pollutant Reduction Methodology

Section	Program	Data	Assumption	Methodology
5.1	Stormwater Harvesting	Current land use coverage Future land use coverage SIMPLE TN load from DRO	25% of future growth participates with an 80% reuse efficiency.	TN reduction = 80% of the average annual TN load from DRO over 25% of new future residential acres.
5.2	Rainwater Harvesting/Cisterns	Average annual rainfall SIMPLE TN load from ATM Current land use coverage	10% of residential land use would have an average 5% reduction in volume and loads.	Volume reduction = 5% of the average annual rainfall over 10% of residential acres. TN reduction = 5% of the average annual TN load from atmospheric over 10% of residential acres.
5.3	Fertilizer Ordinance	Current land use coverage – commercial and residential (high and med only) SIMPLE TN load from DRO	5% reduction of nitrogen loading in commercial, residential (high and med only), and golf course land uses in the watershed.	DRO TN reduction = 5% of the average annual TN load from DRO over commercial, residential (high and med only), land use areas.
5.4	Watercourse Setback	Naturally vegetated buffer zones around water courses in compliance with the current County 50-foot setback regulation as estimated from GIS analysis. (See Section 5.3.4 of Appendix D, Natural Systems for more information)	50-ft to 100-ft buffer along the undeveloped property identified in the watershed with a removal efficiency between 65% and 85% Contributing area = 0.01 ac/noncompliant linear ft.	DRO TN reduction = 75% of the average annual TN load from DRO over noncompliant government parcel contributing area.
5.5	Septic Tank Pump-out Regulation	SIMPLE TN load from septic	Expected 5% reduction in failure rate.	Septic TN reduction = 5% of the average annual TN load from septic over the entire watershed.

Table 5-2 Program Pollutant Reduction Methodology

Section	Program	Data	Assumption	Methodology
5.6	Public Outreach and Education	Current land use coverage SIMPLE TN load from DRO	10% of watershed residents see public education materials and take action, which yields a 5% TN load reduction from DRO in residential areas.	DRO TN reduction = 5% of the average annual TN load from DRO over 10% of residential acres.
5.7	Teacher Training/ Campus Projects	Parcels coverage – School Board owned	10% of school parcels would have an average 5% reduction in ATM volume and loads from cisterns/rain barrels.	DRO TN reduction = 2% of the average annual TN load from DRO over 25% of public school parcels.
		SIMPLE TN load from DRO	On-site instructional programs will lead to implementation and will reduce DRO nitrogen loading on ¼ of the campus by 2%.	Volume reduction = 5% of the average annual rainfall over 10% of public school parcels area.
		SIMPLE TN load from ATM		Atmospheric TN reduction = 5% of the average annual TN load from atmospheric over 10% of school parcel area.
5.8	Aquatic Harvester	Watershed makes up 3% of total County	20,000-lb TN across County, based on percent of TN in a wet plant (N = 2.3% of total dry weight).	TN reduction = 3% of the 20,000 lb of TN from aquatic plants across County.
5.9	Street Sweeping	Sarasota County streets and major roads coverage SIMPLE TN load from DRO	Roadways would have an average 37% reduction in TN load from DRO.	DRO TN reduction = 37% of the average annual TN load from DRO over roadway areas.

Table 5-3 Quantifiable Program Benefits

Program Name	Section	Flood Protection	Water Quality	Natural Systems			Water Supply	Estimated Value of Major Benefits
		County Flood Control Benefits	Cubic Yards of Erosion Prevention and Sediment Control	Annual Pounds of Total Nitrogen Removal	UMAM Credits of Herbaceous Wetlands	UMAM Credits of Forested Wetlands	Annual Acre-feet of Beneficially Used Harvested Water	
Fertilizer Ordinance	5.3	0	0	1703	0	0	0	$8,174,000
Stormwater Harvesting	5.1	0	0	354	0	0	113	$3,060,000
Aquatic Harvester	5.8	0	0	600	0	0	0	$2,880,000
Street Sweeping (target areas)	5.9	0	0	573	0	0	0	$2,750,000
Watercource Setback	5.4	0	0	427	0	0	0	$2,050,000
Rainwater Harvesting/Cisterns	5.2	0	0	136	0	0	111	$1,990,000
Public Education	5.6	0	0	170	0	0	0	$816,000
Septic Tank Pump-out Regulation	5.5	0	0	68	0	0	0	$326,000
Teacher Training/ Campus projects	5.7	0	0	11	0	0	4	$101,000

Actual benefits will vary with level of implementation.

5.1 STORMWATER HARVESTING*

Stormwater harvesting is the method of collecting and storing stormwater runoff for future non-potable use. Runoff from overland flow, stormwater conveyances, and creeks in a drainage area is collected in stormwater-harvesting ponds to supply irrigation to the surrounding area. Using harvested stormwater will offset potable water irrigation needs. New construction, therefore, should be encouraged to incorporate stormwater-harvesting ponds and distribution systems into developments.

5.1.1 Estimated Load Reduction Methodology

Jones Edmunds recommends that the County encourage new developments to incorporate stormwater-harvesting ponds and distribution systems.

First, Jones Edmunds estimated the watershed area to be developed into residential land in the future using the current and future land use coverages. The future land use coverage is the same coverage used in SIMPLE to estimate future pollutant loads for this WQMP. Next, the TN load and volume from DRO over the projected future residential area was estimated from SIMPLE. Jones Edmunds estimated TN load and volume reductions based on the assumption that if a stormwater harvesting program is implemented in the watershed, 25% of future residential growth will participate and the harvesting systems will function at 80% efficiency. Therefore, the estimated reduction is 20% of the projected future residential TN load and volume from DRO.

5.1.2 Recommendation

Jones Edmunds recommends that the County encourage new developments to incorporate stormwater-harvesting ponds and distribution systems.

The implementation of these recommendations would further the goals and intent described in the Environmental Objectives 2.1, 4.2, and 4.3; Environmental Policy 4.6.9; Management Guideline Principles V.A.2.f, V.B.2.a, V.C.2.c, VI.A.2.b, VI.A.2.e; and Water Objectives 1.3 and 1.4 of the Sarasota County Comprehensive Plan.

5.2 RAINWATER HARVESTING/CISTERNS*

Rainwater-harvesting systems capture and store rainfall for future non-potable use. Rainfall is diverted from roofs into a rain barrels or cisterns, which can be above or below ground. The water can be used for irrigation on site as needed. Harvested rainwater will offset potable water irrigation needs. Residents should participate in rainwater harvesting to protect the future water supply of Sarasota County.

In September 2009, Resolution 2009-178 was passed that allowed Sarasota County Air and Water Quality to implement a rain barrel water conservation program by making rain barrels available for purchase by Sarasota County residents for the wholesale cost of $37.00 each. The rain barrels are 55-gallon, food-grade quality, recycled polyethylene barrels. Harvested stormwater collected in the barrels is considered non-potable.

To implement the program, Air and Water Quality staff partnered with UF/IFAS Sarasota County Extension (http://sarasota.extension.ufl.edu/FYN/Rainbarrel.shtml). The County Extension received grant funding from SWFWMD for a part-time Florida Yards and Neighborhoods Homeowner Outreach Educator. Public education and monthly workshops have been scheduled every year since 2010. Workshop dates and locations are listed on the website.

Residents can register for upcoming classes at http://sarasota.ifas.ufl.edu/. The following topics are included as part of public education to residents:

- Rainwater harvesting can reduce the use of potable water and provide cost savings on water and wastewater utility bills.
- Rain barrels help reduce stormwater runoff by diverting and storing runoff from impervious areas such as roofs, decreasing the undesirable impacts of runoff.
- The use of rain barrels is a sustainable practice that conserves water.

5.2.1 Estimated Load Reduction Methodology

Jones Edmunds estimated the average rainfall volume from the average annual NEXRAD rainfall across current residential land use coverage. TN load was estimated from the average SIMPLE watershed TN load from ATM across the current residential land use coverage. Reductions were estimated based on the assumption that 10% of residents will participate in the program and 5% of the rainfall over those residences would be used. Therefore, the estimated reduction is 5% of 10% of the current residential TN load and volume from precipitation.

5.2.2 Recommendation

Jones Edmunds recommends that the County continue to partner with SWFWMD and UF/IFAS to offer rain barrel education courses and rain barrels at a reduced rate. The County could encourage and support local-scale rain barrel stormwater-harvesting projects through some form of funding assistance or homeowner rebate program.

The implementation of these recommendations would further the goals and intent described in the Environmental Objectives 2.1, 4.2, and 4.3; Environmental Policy 4.6.9; Management Guideline Principles V.A.2.f, V.B.2.a, V.C.2.c, VI.A.2.b, VI.A.2.e; and Water Objectives 1.3 and 1.4 of the Sarasota County Comprehensive Plan.

5.3 FERTILIZER ORDINANCE*

The Sarasota County Commission approved an ordinance regulating the use of fertilizers containing nitrogen and/or phosphorus in Sarasota County in 2007. Ordinance No. 2007-062, the Sarasota County Fertilizer and Landscape Management Code, regulates the proper use of fertilizer containing nitrogen and phosphorus and requires the use of BMPs to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers. The ordinance establishes a restricted season, fertilizer content and application rates, fertilizer-free zones, recommended low-maintenance zones, exemptions, and training and licensing requirements for commercial and institutional fertilizer applicators.

Jones Edmunds recommends that the County continue current education efforts and commercial training and certification. Additionally, the County should strictly enforce fertilizer ordinance violations. The fees collected for violating the ordinance should be used to fund the enforcement task and expand public education about fertilizer. The County should also request the additional 4.1% reduction for enforcement.

Negative effects from fertilizer have been observed in and on Sarasota County's natural and artificial stormwater and drainage conveyances, lakes, canals, estuaries, interior freshwater wetlands, the Myakka River, and nearshore waters of the Gulf of Mexico. The health of these water bodies is critical to the environmental, recreational, cultural, and economic wellbeing of stakeholders and the health of the public. Water quality problems, including harmful algal blooms, hypoxic zones, and declines in wildlife and habitat, can arise when excess nutrients get into water bodies. Overgrowth of algae and vegetation can hinder the effectiveness of flood attenuation provided by natural and artificial stormwater and drainage conveyances. Therefore, regulation of nutrients including phosphorus and nitrogen in fertilizer is critical to improving and maintaining water and habitat quality (Sarasota County Ordinance No. 2007-062).

Fertilizers can contribute excess nutrients, including nitrogen to surface waters. The nitrogen loading from urbanized areas tends to be high due to the use of fertilizer, compacted soils, and abundance of impervious surface (TBEP, 2008). Although only 30% of the Sarasota Bay watershed is residential land use, the residential areas of the watershed contribute 50% of the TN loading from DRO. Implementing fertilizer restrictions can result in a 5% TN load reduction credit for education, and enforcing fertilizer restrictions can yield an additional 4.1% reduction credit (TBEP, 2008).

Sarasota County is educating residents about fertilizer by promoting the Florida Yards and Neighborhoods, Neighborhood Environmental Stewardship Team (NEST), Be Floridian campaign, and Estuary Programs. The County publishes numerous public education materials, such as the "Living on Water's Edge" brochure series, and requires mandatory training for all fertilizer applicators (other than private homeowners). Additionally, commercial applicators are required to have a fertilizer certification to be eligible for an occupational license and a decal must be displayed on commercial trucks and trailers.

5.3.1 Estimated Load Reduction Methodology

Based on SIMPLE model results, the average annual TN load from residential land use in the Sarasota Bay watershed is over 34,000 lb. By implementing the Sarasota County Ordinance No. 2007-062, an estimated 5% reduction in TN loading yields about a 1,700-lb reduction in the watershed. Enforcing the fertilizer ordinance can reduce the TN load by an additional 4.1%, yielding another 1,300-lb reduction.

5.3.2 Recommendation

Jones Edmunds recommends that the County continue current education efforts and commercial training and certification. Additionally, the County should strictly enforce fertilizer ordinance violations. The fees collected for violating the ordinance should be used to fund the enforcement task and expand public education about fertilizer. The County should also request the additional 4.1% reduction in TN for enforcing the ordinance.

The implementation of these recommendations would further the goals and intent described in the Environmental Objectives 2.1, and 4.2; Environmental Policies 4.7.5 and 4.7.6; and Management Guideline Principles V.A.2.f, V.B.2.a, and VI.A.2.b of the Sarasota County Comprehensive Plan.

5.4 WATERCOURSE SETBACK*

Vegetated buffers are strips of vegetated land ecologically and hydrologically connected to adjacent waterways such as creeks, rivers, marshes, and bays. Studies show that vegetative buffer zones protect, restore, and maintain the chemical, physical, and biological integrity of waterways. Vegetative buffers are highly effective at:

- Removing pollutants delivered in urban stormwater.
- Reducing erosion and controlling sedimentation.
- Protecting and stabilizing stream banks.
- Providing infiltration of stormwater runoff.
- Maintaining base flow of streams.
- Contributing organic matter that is a source of food and energy for the aquatic ecosystem.
- Providing tree canopy to shade streams and promote desirable aquatic and wildlife habitat.
- Furnishing scenic value and recreational opportunity.

The effectiveness of a buffer depends on its width and vegetative cover. Sarasota County requires watercourse buffers for public and private projects subject to Chapter 74 of the Sarasota County Code of Ordinances (Land Development Regulations [LDRs]) to protect floodplain functions, including conveyance, storage, wildlife habitat, and water quality functions. The minimum buffer width is at least 50 feet between future development and watercourses, including bay waters (Section 5.3.4 of Appendix D, Natural Systems). Watercourse buffers may be less than 50 feet wide where they are equivalent in water quality treatment and habitat protection to a 50-foot-wide vegetated buffer. Watercourse buffers consistent with the LDRs are required during development of County-owned parcels adjacent to watercourses.

5.4.1 Estimated Load Reduction Methodology

For County-owned parcels where development pre-dates the watercourse buffer requirement, Jones Edmunds recommends that the County implement watercourse buffers.

Because the County addressed the importance of maintaining or creating naturally vegetated buffers on properties fronting major watercourses not only with regulations but also with public education activities, the focus of this program recommendation is on government-owned properties that do not currently have a 50-foot or equivalent buffer. As such, Jones Edmunds did a GIS analysis based on zoning categories that were specifically called out as Governmental use to estimate the length of government watercourse property and determined the width, if any, of existing buffer. (See Section 5.3.4 of Appendix D, Natural Systems for more information). Jones Edmunds assumed a contributing area of 0.01 acre per linear foot of property along watercourse lengths that do not currently have a 50-foot or equivalent buffer. The average SIMPLE TN load from DRO over the watercourse basins was applied to the contributing area to estimate the TN load that can be reduced by adding a buffer. Consistent with the project load reductions, an average efficiency of 75% for buffers was applied to this load. Therefore, establishing 50- to 100-foot buffers along the approximate 9,200 linear feet of Government use waterfront property without at least a 50-foot or equivalent buffer would decrease the TN load from DRO from about 150 lb/yr to under 40 lb/yr.

5.4.2 Recommendation

For County-owned parcels where development pre-dates the 1995 watercourse buffer requirement, Jones Edmunds recommends that the County implement watercourse buffers.

Additionally, the County could improve existing buffer regulations and educational outreach with the following recommendations:

- ❖ Provide incentives and assistance to homeowners with 50 to 100 feet or greater watercourse setbacks to develop a naturally vegetated buffer.

- ❖ Revise Sarasota Comprehensive Plan Chapter 2, Section V(C)2h to specify that native vegetation must be used within the required 15-foot buffer for new development.

- ❖ Revise LDRs to specify that within the required 50-foot watercourse buffer, native vegetation must be used in lieu of turf grass within a minimum of 15 feet and an average of 25 feet. This requirement will be consistent with State regulatory requirements.

- ❖ Work with municipalities to implement a 10- to 15-foot naturally vegetated buffer for all new or rebuild residential home construction.

- ❖ Schedule and present buffer importance information to Homeowners Associations (HOAs)—Many subdivisions with the lowest compliance are very affluent and likely have strong HOAs. During these presentations, the County must stress that the buffers can be low-growing herbaceous and shrub species that will not interfere with water views.

- ❖ Cost-share or pay for a pilot project in several neighborhoods with low compliance—The County should sponsor one home in these neighborhoods with important watercourses and landscape a buffer at this home. The County would solicit the labor from neighborhood residents to remove turf grasses and plant and mulch an agreed-on buffer width. This home would serve as a showcase for neighborhood residents and for tours to show interested residents what a native landscaped buffer looks like.

- ❖ Offer gift certificates to local nurseries or free native plants for residents.

- ❖ Schedule and hold tours of property owners that have implemented native landscaped vegetated buffers.

- ❖ Engage IFAS Sarasota County Extension Office for grant funding and participation (lead or assist with tours, assist with plantings, etc.).

The implementation of these recommendations would further the goals and intent described in the Environmental Objectives 2.1, and 4.2 and Management Guideline Principles V.A.2.f, V.B.2.a, V.C.2.h, VI.A.2.b, VI.A.2.h, VI.B.2.h, and VII.A.2.j of the Sarasota County Comprehensive Plan.

5.5 SEPTIC TANK PUMP-OUT REGULATION*

Regular pumping and inspection of septic tanks extend the life of the system, ultimately lowering long-term costs to homeowners. Poorly maintained systems can release inadequately treated wastewater into the environment. Implementing a septic tank pump-out regulation will reduce the failure rate of systems in the watershed and result in reduced nutrient loads and health risks.

5.5.1 Estimated Load Reduction Methodology

Based on SIMPLE model results, septic tanks contribute an average 1,362 lb of TN load annually. By implementing a pump-out regulation, an estimated 5% reduction in failure rate is expected. Therefore, regular pumping and inspection can potentially reduce the TN load from septic tanks by almost 70 lb per year.

5.5.2 Recommendation

Jones Edmunds recommends that the County implement and enforce a septic tank pump-out regulation.

5.6 PUBLIC OUTREACH AND EDUCATION*

Jones Edmunds recommends that the County continue to fund and implement public education programs and activities.

Sarasota County has numerous public outreach and education programs such as the Storm Drain Marking Program; Adopt-a-Road, Adopt-a-Pond, Adopt-a-Spot Program; Florida-Friendly Landscaping™ Program; Cigarette Litter Prevention Program; Monofilament/Fishing Line Recovery and Recycling Program; Be Floridian Campaign, Integrated Pest Management Program, and Neighborhood Environmental Stewardship Teams (NEST) Program. The Adopt-a-Road, Pond, and Spot Program provides stormwater education, safety training, and guidance to citizens to help them maintain adopted roads, ponds, and spots. The Florida-Friendly Landscaping™ Program, implemented through the UF/IFAS Sarasota County Extension Service, was developed to help reduce the nutrient load in stormwater runoff. This hands-on outreach program helps residents create landscapes with minimal negative environmental impact—a Florida-Friendly landscape. The Cigarette Litter Prevention Program promotes awareness to lessen cigarette litter in the County. The Litter Prevention Hotline, 365-TAGS, gives citizens more power to report cigarette litter offenders. The program also provides portable automobile and pocket ashtrays for free. The Monofilament/Fishing Line Recovery and Recycling Program is a statewide effort to educate the public on the problems caused by fishing line/monofilament line left in the environment, to encourage recycling through a network of line recycling bins and drop-off locations, and to conduct volunteer monofilament line cleanup events. The Sarasota County program is a component of the Sarasota County Manatee Protection Plan adopted in 2003 and updated in 2011.

Sarasota County has developed a program for NEST, which is a voluntary association of County residents (neighbors, civic groups, student organizations, and others) who want to better understand and improve the environmental conditions in the watershed. The public purpose is two-fold: to provide constructive and meaningful activities to help residents improve the environmental quality of the watershed and their neighborhoods and to develop education of and advocacy for watershed improvement policies and management strategies. NEST's activities address issues such as water quality, natural system preservation, neighborhood drainage, landscaping, and other water-related issues. NEST activities may include water quality or biological monitoring, volunteer restoration, research, and planning input. NEST provides individual and community awareness of appropriate fertilizer usage, buffer zones, Low Impact Design (LID) practices, and conservation. Additional public outreach includes developing web/email campaigns and educational materials.

5.6.1 Estimated Load Reduction Methodology

Based on SIMPLE model results, the average annual TN load from residential land use in the watershed is over 34,000 lb. Jones Edmunds assumed that by continuing and improving public outreach efforts, 10% of residents will take action, which could reduce the residential TN load by 5% across 10% of the residential area in the watershed. Therefore, continuing to provide education to residents may yield a TN load reduction of about 170 lb.

5.6.2 Recommendation

Jones Edmunds recommends that the County continue to fund and implement public education programs and activities.

The implementation of these recommendations would further the goals and intent described in the Environmental Objective 4.7; Environmental Policies 4.7.5, 4.7.7 and 4.9.2; and Management Guideline Principle IV.A.2.e of the Sarasota County Comprehensive Plan.

5.7 TEACHER TRAINING/CAMPUS PROJECTS*

Implementing an Environmental Education Teacher Training Program would lead to campus projects that would result in improved natural systems and water quality. The program will teach teachers about their environment, how their individual actions and campus practices can affect the environment, and what they can do to improve it. Teachers will learn to link the outside world to their classrooms while providing instruction in line with the curriculum through campus projects. Projects could include planting buffers, testing water quality, and using rain barrels for irrigation. Incorporating campus projects will foster higher-level thinking and environmental stewardship, so that students can make informed decisions in the future. In addition to the educational component, campus aesthetics, natural systems, and water quality would be improved. The Environmental Education Teacher Training Program should be an approved Florida master in-service program.

5.7.1 Estimated Load Reduction Methodology

Jones Edmunds assumed that teacher training programs will lead to implementation of on-site projects, which will reduce TN loading from DRO by 2% across 25% of campuses. An additional 5% TN load and volume reduction is estimated across 10% of campuses for captured rainfall. The average annual TN load and volume across school parcels was estimated with SIMPLE. Implementing this program could reduce TN loading from ATM and DRO by over 11 lb and provide 4 ac-ft of rainwater for irrigation per year.

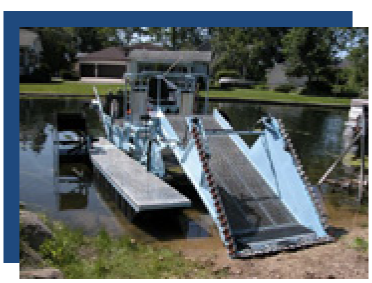
5.7.2 Recommendation

Jones Edmunds recommends that the Sarasota County School Board implement and fund teacher training and campus projects.

The implementation of these recommendations would further the goals and intent described in the Environmental Objective 4.7 of the Sarasota County Comprehensive Plan.

5.8 AQUATIC HARVESTER*

Applying herbicide to aquatic vegetation and leaving the decaying organic debris in place are detrimental to the County's efforts to improve water quality. With the vast channel system throughout the County, removing the decaying vegetation is somewhat prohibitive with a limited maintenance staff. Aquatic harvesters mechanize the process and reduce the time required for maintenance crews to perform this task. Additionally, mechanical harvesters offer an alternative to herbicides in controlling aquatic vegetation.



Harvesters are large machines that cut and collect aquatic plants. Cut plants are removed from the water by a conveyor belt system and temporarily stored on the harvester. Once the material dries, its volume will be significantly less, making transport and disposal of the material easier. Harvesters can cut and collect several acres per day depending on weed type, plant density, and equipment features, such as storage capacity. Evaluating physical characteristics and uses of the water body, plant species, and harvested material disposal options play an important role in choosing the most appropriate type of harvester.

Jones Edmunds recommends that the County purchase an aquatic harvester to use as a maintenance tool across the County. The harvester should be used on navigable waterways in the Sarasota Bay watershed.

Implementing aquatic harvesting can open waterway conveyance and reduce pollutant loading. Mechanical harvesters offer an alternative to herbicides in controlling aquatic vegetation. Eliminating herbicides in the waterways eliminates associated chemicals from entering the environment. Harvesters also remove organic debris, which would otherwise decay, and could lower dissolved oxygen and contribute nitrogen and phosphorus to the system. Additionally, harvested weeds may have a beneficial reuse as compost (USACE, 2012).

5.8.1 Estimated Load Reduction Methodology

Based on an assumed 40 hours of harvester use per month County-wide at a rate of 1 acre per hour, we have estimated, approximately 20,000 lb of TN are contributed by plants that could be removed with an aquatic harvester (Jones Edmunds, 2010). The Sarasota Bay watershed comprises about 3% of the County. Therefore 3% of 20,000 lb could be removed by implementing aquatic harvesting in the watershed, yielding a 600-lb reduction in TN load in Sarasota Bay Watershed per year.

5.8.2 Recommendation

Jones Edmunds recommends that the County purchase an aquatic harvester to use as a maintenance tool across the County. The harvester should be used on navigable water bodies in the Sarasota Bay watershed.

The implementation of these recommendations would further the goals and intent described in the Environmental Objective 2.1; Environmental Policy 4.6.6; and Management Guideline Principle IV.A.2.b of the Sarasota County Comprehensive Plan.

5.9 STREET SWEEPING*

For industrial and densely-populated areas where space for additional stormwater BMPs is not available, street sweeping removes sediment and pollutants before either reaches the stormwater system. Vacuum-assisted and regenerative-air sweepers pick up fine-grained sediments that carry a large portion of the pollutant load. The amount of sediment removed by street sweeping depends on several factors. The intensity of rainfall events, the length of time between sweeping events, particle size, land use, and the location of impervious surfaces (up-gradient or down-gradient) all contribute to determining the amount of sediment available for sweeping, the efficiency of removal, and the quantity of sediment removed from the potential sediment load to stormwater runoff. The expected pollutant reduction from street sweeping also varies with the frequency of sweeping. The frequency of sweeping in wet and dry seasons impacts the overall removal rates, and the U.S. Geological Survey (Breault et al., 2005) reports that only a small fraction of the total load is removed unless intensive sweeping programs are implemented.

5.9.1 Estimated Load Reduction Methodology

Jones Edmunds applied a 37% reduction in TN from DRO over streets in several basins with high TSS, visual sedimentation downstream, or no BMPs to estimate the extent of TN reduction possible with a street sweeping program. The TN loads from the streets in each basin was estimated from the SIMPLE catchment load from DRO applied only to the streets within each area. Because the average load across the catchment is lower than the load from the actual roads, these estimates are very conservative. Jones Edmunds projects a potential TN load reduction of 2.6 lb/ac from implementing street sweeping in these areas.

5.9.2 Recommendation

Because of limited funding for street sweeping across the entire watershed, areas with high TSS and visible sedimentation downstream and without BMPs should be swept weekly in the wet season and bi-monthly during the dry season to maximize sediment and pollutants removal between rain events.

The implementation of these recommendations would further the goals and intent described in the Environmental Objectives 2.1 and 4.2 and Management Guideline Principles IV.A.2.f, V.B.2.a, and VI.A.2.b of the Sarasota County Comprehensive Plan.

5.10 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

Sarasota County is a Municipal Separate Storm Sewer System (MS4) operator and holds a National Pollutant Discharge Elimination System (NPDES) permit (Number FLS000004) from FDEP. To maintain the permit, the County has developed a stormwater management program that includes BMPs with measurable goals. Eight minimum control measures, outlined in the 2006 Comprehensive Plan, are implemented through the program to reduce pollutants to the maximum extent practicable.

5.10.1 Recommendation

Sarasota County Field Services must continue to work with the rest of the County staff to meet the overall goals of the NPDES permit, which are to improve and maintain the quality of local water bodies.

The implementation of these recommendations would further the goals and intent described in the Environmental Policy 2.1.5 and Management Guideline Principles V.A.2.2, and V.C.2.c of the Sarasota County Comprehensive Plan.

5.11 FACILITATING AGRICULTURAL RESOURCE MANAGEMENT SYSTEMS

The Florida Department of Agriculture and Consumer Services and SWFWMD have developed the Facilitating Agricultural Resource Management Systems (FARMS) program. FARMS is an agricultural BMP cost-share reimbursement program intended to expedite the implementation of production-scale agricultural BMPs that will help agriculturalists reduce groundwater use from the Upper Floridan aquifer, improve water quality, and restore and augment the area's water. The program targets the District's Southern Water Use Caution Area, which includes Sarasota County.

Jones Edmunds recommends working with SWFWMD to implement the FARMS program across the County. The County should evaluate the water use permits to determine agricultural properties with large withdrawals.

5.11.1 Recommendation

Jones Edmunds recommends working with SWFWMD to implement the FARMS program across the County. The County should evaluate the water use permits to determine agricultural properties with large withdrawals.

The implementation of these recommendations would further the goals and intent described in the Environmental Policy 4.7.9 of the Sarasota County Comprehensive Plan.

Jones Edmunds recommends that the County continue to develop digital spatial files of designated preservation areas, compile and organize them in an accessible location, and update the dataset quarterly.

5.12 PRESERVATION AREA DATA MANAGEMENT

Consistent with the Sarasota County Comprehensive Plan and the Principles for Evaluating Development Proposals in Native Habitats, the County incorporates natural resource protection measures for native habitats during the review of all development orders. For example, mesic hammocks, coastal hammocks, scrub habitats, and wetlands, and other habitat types are identified in the Comprehensive Plan as "shall be preserved." Additional requirements include 30-foot buffers of existing upland vegetation surrounding wetlands, littoral shelf standards for stormwater treatment ponds, and watercourse buffers.

Preserve areas are located throughout the County. Sarasota County has been working to comprehensively map these areas, and some preservation information in the watershed was digitized as part of this WQMP. Continuing to develop and maintain digital files for designated preservation areas will help County staff keep an inventory, determine compliance with preservation area standards, and create contiguous preserves as adjacent parcels with native habitats are developed.

5.12.1 Recommendation

Jones Edmunds recommends that the County continue to develop digital spatial files of designated preservation areas, compile and organize them in an accessible location, and update the dataset quarterly.

The implementation of these recommendations would further the goals and intent described in the Environmental Policies 4.5.1 and 4.5.4; and Management Guideline Principles III.A.2.a, IV.A.2.a, IV.B.2.a, VII.A.2.a, and VIII.B.2.a of the Sarasota County Comprehensive Plan.

5.13 MANGROVE MONITORING

Much of large contiguous mangrove acreage loss in Sarasota Bay occurred before legislation and regulations that protect wetlands from dredging and filling were implemented. In July 2004 the County initiated a mangrove trimming study in limited portions of Sarasota Bay to assess the state of mangrove trimming within the County. The study was greatly expanded in 2007 and documented that 96% of parcels containing trimmed mangroves were trimmed in accordance with Florida Statutes (Resource Protection, 2009). The study noted that a substantial number of mangrove trimming events occur each year within Sarasota County. This County-led study provides extremely valuable information on the distribution, health, and extent of mangroves in Sarasota Bay and identifies incorrect trimming that could lead to mangrove mortality.

A 2010 dataset created by Jones Edmunds which , estimated that 367 acres of mangroves were in the Sarasota County portions of Sarasota Bay (See Appendix D – Natural Systems, Section 5.2.3 f or information on 2010 dataset). The County must work closely with local municipalities to maintain the existing acreage of mangroves. More importantly, the County must work closely with municipalities to enforce and monitor mangrove trimming, which if not done in compliance with Sections 403.9321 through 403.9333, FS (referred to as the 1996 Mangrove Trimming and Preservation Act) can result in mangrove mortality. Additionally, SBEP adopted a goal of restoring 18 acres of saltwater wetlands per year, which could assist in increase mangrove acreage.

5.13.1 Recommendation

The following recommendations will help maintain the existing mangrove acreage and LOS that this critical habitat provides:

- Continue to conduct the mangrove trimming surveys County-wide to identify non-compliant mangrove trimming and to qualitatively assess mangrove health.

- Identify HOAs and individual property owners in locations identified in Resource Protection (2009) willing to plant mangroves.

- ❖ Hold mangrove planting workshop.

- ❖ Present the importance of mangroves and planting methodologies at HOAs where mangrove opportunities were identified in Resource Protection (2009).

- ❖ Promote, in educational materials and at presentations, additional benefits of untrimmed mangroves.

- ❖ Schedule and hold tours with property owners who have trimmed and untrimmed mangroves to show homeowners the expected results.

- ❖ Contact and coordinate with the IFAS Sarasota County Extension Office for grant funding and participation.

The implementation of these recommendations would further the goals and intent described in the Environmental Policy 4.5.6; and Management Guideline Principle IV.A.2 of the Sarasota County Comprehensive Plan.

5.14 SHORELINE SOFTENING

Much of the shoreline hardening in Sarasota County occurred before wetland dredge-and-fill regulations were implemented. Despite over 50% of naturally occurring shoreline in Sarasota Bay being hardened, existing County, State, and Federal regulations should limit additional hardening. The goal for natural shoreline should be to maintain existing extents while working to increase extents over time, even at a parcel-by-parcel level. Where shoreline protection is warranted, the County should strongly promote soft, non-structural, or hybrid shoreline protection alternatives to dissuade the applicants from constructing bulkheads or armoring. These “living shorelines” use a suite of bank stabilization techniques to stabilize the shoreline, minimize future erosion, and maintain coastal processes.

5.14.1 Recommendations

The following recommendations will maintain or reduce shoreline hardening in Sarasota Bay:

- ❖ Continue Building Department and Resource Protection coordination to present applicants with living shoreline or soft alternatives to bulkheads and armoring.

- ❖ Work with SBEP to develop a living shoreline brochure that is available to the public at the Building Department and other County offices.

- ❖ Solicit opportunities to present living shoreline concepts and projects (e.g., Herb Dolan Park) to HOAs.

- Incorporate a living shoreline presentation into any neighborhood outreach being conducted.

- Continue to encourage shoreline softening for developments proposing shoreline hardening per Sarasota County Comprehensive Plan (Environment Plan, ENV Goal 4, Policy 4.2.1).

- Schedule and lead tours with SBEP to public project sites and private property owners where examples of living shorelines exist.

The implementation of these recommendations would further the goals and intent described in the Environmental Policies 1.1.2 and 4.2.1; and Management Guideline Principles IV.A.2.d, IV.A.2.f, IV.B.2.d, IV.C.2.e, VI.A.2.d, and VI.B.2.g of the Sarasota County Comprehensive Plan.

5.15 SEPTIC REPLACEMENT PROGRAM

Septic systems have the potential to contribute significant pollutant loads to the primary receiving waters in the Sarasota Bay watershed. In April 1997, the Sarasota County Board of County Commissioners (BOCC) found that septic systems and small package wastewater treatment plants were contributing to documented pollution problems in Phillippi Creek. The BOCC directed staff to initiate a program (Phillippi Creek Septic Tank Replacement Program) to replace or upgrade septic systems in this area. This program will result in approximately 14,000 new wastewater connections implemented over 8 to 10 years. The BOCC further recognized the need for septic system replacement in other areas and expanded the program to include the south portions of the County. This project is known as the South County Wastewater Improvement Program (SCWIP) and includes the area west of I-75 from Clark Road south to the County’s south perimeter in Englewood, excluding the Englewood Water District service area.

SCWIP evaluated whether existing wastewater treatment practices affect water quality in the project area and recommended that Sarasota County provide central sewers for those sub-areas with average acreage sizes less than 0.5 acre. The SCWIP recommendation to replace septic systems in certain areas is based on their analysis of the design, construction, installation, utilization, operation, maintenance, and repair of septic tank systems. SCWIP found that only 24% of all developed parcels have been permitted since 1983 and meet current code separation requirements. Pathogens released from improperly functioning septic tanks may pose a special health risk for infants, young children, and people with severely compromised immune systems. Septic systems not properly installed or maintained can increase bacteria in the bay and its tributaries. The continued replacement of septic systems reduces human health risk for exposure to fecal coliforms and may improve water quality; both are beneficial to the residents of Sarasota County and the environment.

5.15.1 Recommendation

Jones Edmunds recommends that the County continue to expand its central sewer lines and continue offering rebates to ease the transition of residents from septic to sewer.

The implementation of these recommendations would further the goals and intent described in the Water Goal 1, Water Policy 1.1.4; and Management Guideline Principles IV.A.2.b of the Sarasota County Comprehensive Plan.

5.16 SEPTIC TO CISTERN

In June 2009 the County Health Department implemented a procedure for converting abandoned septic tanks into cisterns based on Rule 64E-6.011, FAC. This conversion allows a single-family residence to convert an abandoned septic tank to a cistern by permit within 90 days of connecting the building plumbing to sanitary sewer. Laboratory sampling and health department inspection are required for this procedure, and the water collected in the tank must be used for non-potable irrigation purposes only.

5.16.1 Recommendation

Jones Edmunds recommends that the County target areas identified in its septic replacement program. The County should educate residents on the benefits of stormwater harvesting and provide support and instructions on the process. Direct targeting will engage homeowners and continue to show a return on the outreach investment.

The implementation of these recommendations would further the goals and intent described in the Water Objective 1.3 of the Sarasota County Comprehensive Plan.

5.17 STRATEGIC MAINTENANCE MANUAL

Stormwater maintenance has traditionally played an active role in maintaining the flood capacity of the stormwater system throughout the County. A more robust maintenance program will play a larger role in improving the quality of the runoff reaching the estuaries and bays of Sarasota County. The recommendations below are intended to expand and enhance the existing stormwater maintenance process to include water quality in addition to flood protection as part of the focus. Updating the Strategic Maintenance Plan and adopting several non-structural BMPs and source control practices may also provide the best opportunities for increased awareness and implementation of maintenance improvements aimed at improving water quality. The modifications, additions, or removal of maintenance practices listed below will help the County meet its water quality goals.

5.17.1 Recommendation

Jones Edmunds recommends that the County:

- Implement the 1999 Strategic Maintenance Plan.
- Achieve the inspection and maintenance frequency required in the MS4 Permit.
- Update the Strategic Maintenance Plan.
- Adopt practices listed below when fiscally feasible:
  - Inspection and Permit Compliance
    - NPDES Inspection
    - Asset Management
  - FEMA Community Rating System
  - Facility Maintenance and BMPs
    - Facilities: Scheduling
    - Facilities: Denuding Conveyance Features
    - Non-Structural BMPs: Buffer Zones
    - Non-Structural BMPs: Low-Impact-Development
    - Source Control: Street Sweeping
    - Source Control: Herbicides
    - Source Control: Fertilizer Management
    - Source Control: Harvesters

The implementation of these recommendations would further the goals and intent described in the Water Policy 2.1.1; and Management Guideline Principles V.C.2.f of the Sarasota County Comprehensive Plan.

5.18 STORMWATER MANUAL FOR SITE, DEVELOPMENT, SUBDIVISION, AND CAPITAL IMPROVEMENT PROJECTS REVIEW SUBMITTALS

The Stormwater Manual describes the review process and standards for capital improvement projects and land development projects. The Manual is designed to assist the applicant with the submittal process and is consistent with the most current (2001) LDRs. The Manual has not been presented to or adopted into the LDRs by the BOCC. Many developers follow the formatting and use the Manual as a reference, and adopting the Manual would provide a formal template for consistency.

5.18.1 Recommendation

Jones Edmunds recommends that the County adopt the Stormwater Manual to streamline the County's submittal and review process.

The implementation of these recommendations would further the goals and intent described in the Environmental Objective 4.8; and Management Guideline Principles V.A.2.d, V.C.2.f, VI.A.2.e, and VI.B.2.h of the Sarasota County Comprehensive Plan.

5.19 COMPOSTING PILOT STUDY

Composting is a beneficial reuse of grass clipping and vegetation debris and offers several benefits:

- ❖ Removing products before decay will reduce the potential for nitrogen and phosphorus to enter the waterways.
- ❖ Using compost material as a soil amendment on eroding banks will provide structure and moisture capacity to the soil matrix.

Maintenance staff and contracted vendors can bag grass clippings during the mowing specifically along waterways and transport the debris to a designated composting facility. The compost would then be worked into the soil by maintenance staff on stream banks that need to be stabilized or vegetated.

5.19.1 Recommendation

Jones Edmunds recommends that the County develop and implement a composting pilot study in conjunction with a capital improvement project requiring soil amendment or bank stabilization.

5.20 LOW-IMPACT DESIGN (LID)

LID is a stormwater management approach that uses a suite of hydrologic controls (structural and non-structural) distributed throughout the site and integrated as a treatment train (i.e., in series) to replicate the natural hydrologic function of the landscape. A County manual to assist in incorporating LID projects into new development and infrastructure retrofit projects was developed in 2008. Consistently implementing LID concepts, design, and practice will improve the overall effectiveness and efficiency of stormwater management relative to conventional systems, reducing runoff and improving water quality.

5.20.1 Recommendation

Jones Edmunds recommends that the County continue to update the LID Manual to include new BMP types and that the County encourage LID for new developments and retrofit projects.

The implementation of these recommendations would further the goals and intent described in the Environmental Objective 4.8; and Management Guideline Principles V.C.2.f, VI.A.2.e and VII.A.2.g of the Sarasota County Comprehensive Plan.

5.21 EXOTIC SPECIES MANAGEMENT PROGRAM

The tropical climate in Sarasota County provides an ideal setting for aquatic invasive/exotic plant species to flourish. The undesirable vegetation, if left unchecked, may out-compete native plant species, cause public health risks, and impede flood conveyance. Only 11 herbicides are approved to use in plant management in Florida waters. Education and training are essential to balancing the environmental risk associated with chemicals versus the potential degradation of an ecosystem where invasive plants prosper. The NEST program provides an opportunity to expand education for individuals and the community on the benefits of using native plant species in landscaping and identifying and removing nuisance species. A formal exotic species management program would expand on what is being done through the NEST Program.

5.21.1 Recommendation

Jones Edmunds recommends that the County seek funding for and initiate an exotic species management program on County owned lands to focus on those non-native plant species that cause or may cause significant negative impacts to a system without providing benefit.

The implementation of these recommendations would further the goals and intent described in the Environmental Policy 4.6.6 of the Sarasota County Comprehensive Plan.

5.22 BOAT RAMP BMP PROGRAM

Operation and maintenance of recreational boating facilities can negatively impact water quality, habitat areas, and natural systems. Boat ramps are usually near riparian and tidal habitat and are a direct connection between land and water. These environmentally sensitive areas generally consist of riparian and aquatic vegetation, shellfish beds, fish habitats, waterfowl nesting grounds, and diverse marine life. Pollutants including sediment and chemicals from launch areas and boats wash directly down boat ramps into creeks and the bay without treatment. Implementing BMPs at boat ramps across the County will reduce impacts to habitat and water quality. Erosion repair, waterbar and trench systems, bioswales, and buffers should be considered at boat ramps to reduce pollutant loading to the bay.

5.22.1 Recommendation

Jones Edmunds recommends that the County implement a boat ramp BMP program to incorporate BMPs at boat ramps across the County.

The implementation of these recommendations would further the goals and intent described in the Environmental Policy 1.3.5; and Management Guideline Principles V.A.2.f and V.A.2.g of the Sarasota County Comprehensive Plan.

5.23 IRRIGATION UTILITIES FOR NEW DEVELOPMENT

Sarasota County has successfully worked with several communities to establish an irrigation utility at the beginning of a new development, construct a central irrigation system, and limit or prohibit individual groundwater wells through deed restrictions. This structure requires an active management strategy and resource management to ensure that the type of water used follows the principles and hierarchy established by Water Policy 3.3.4. Demand management strategies include limitations on the amount of water and time of day for irrigation, appropriate plant placement, and drought-tolerant plant selections. Also, demands have been adjusted by the changing community perspective with a general shift away from traditional lawns to a more natural landscape.

As examples, Palmer Ranch, Lakewood Ranch, Stonybrook of Venice, and the Grand Paradiso communities were planned and developed with sustainable community principles. A development-wide piping system designed to supply reclaimed water and use stormwater harvesting to irrigate yards and common areas was installed during construction. A private irrigation utility was set up to administer and maintain the system and serve the customers. Community wells are used to supplement supplies when demands cannot be met through other means. The community wells also have meters to track the amount of groundwater used. Grand Paradiso has a development-wide restriction that does not allow private wells. Encouraging the establishment of private utilities and following the prioritization and hierarchy for supplies as outlined in Water Policy 3.3.4 will help the County achieve its sustainability goals as well as offset potable water demand.

5.23.1 Recommendation

Jones Edmunds recommends continuing to work with developers to implement irrigation utilities and sustainable community practices.

The implementation of these recommendations would further the goals and intent described in the Water Policy 3.3.4 of the Sarasota County Comprehensive Plan.

5.24 PUBLIC EDUCATION ON WATER CONSERVATION PRACTICES

Public education is an important component to water supply planning. The County should continue to educate residents on water conservation practices, such as those listed on its website: http://www.scgov.net/EnvironmentalServices/Water/Conservation/TopWaterUsers.asp

What can you do to save water indoors:
- *Search for and fix leaks.*
- *Install low-flow toilets, faucets, and showerheads.*
- *Flush less (do not use the toilet as a trash can).*
- *Turn off water while brushing your teeth.*
- *Take shorter showers.*
- *Use less water for baths.*
- *Operate appliances only when full.*
- *Purchase water-efficient appliances.*

What can you do to save water outdoors:

Search for and fix leaks:
- *Faucets, hoses, and connections.*
- *Sprinkler systems.*
- *Swimming pools.*
- *Service connection lines.*

Irrigate properly:
- *Check local water restrictions.*
- *Water only when needed.*
- *Water in morning or evening.*
- *Evaluate alternative methods such as micro-irrigation.*

5.24.1 Recommendation

Jones Edmunds recommends that the County continue its public education practices related to water conservation and enforce the Landscape Efficiency Ordinance (No. 2001-081), which focuses on irrigation system efficiency, limiting plants requiring the most supplemental irrigation for new developments and horizontal additions to residential buildings. (Sarasota County Ordinance 2001-181, 2001).

The implementation of these recommendations would further the goals and intent described in the Water Policy 3.3.1 of the Sarasota County Comprehensive Plan.

5.25 POTABLE WATER DEMAND-SIDE MANAGEMENT ANALYSIS

Evaluating water supply savings potential from customer or demand-side measures requires understanding how water is used in homes and businesses served by the County utilities. Once the end uses are accounted for, the more cost-effective conservation measures can be selected and incentivized by the County to reduce water demands. The County should evaluate demand-side water savings for the following future development conditions:

- Existing development—This scenario defines the current potential for demand-side management and will be used to estimate the potable water reductions that can be realized through retrofits and programs directed at the existing customer base. This scenario will include estimates of water savings from projects being implemented by the County.

- In-fill of existing development—This scenario will estimate the potential water reductions possible from approved developments that have infrastructure in place with vacant lots to be built on.

- Approved development without buildings—This scenario will estimate the long-term potential for demand-side management in the County from developments that have been approved but do not have active demands.

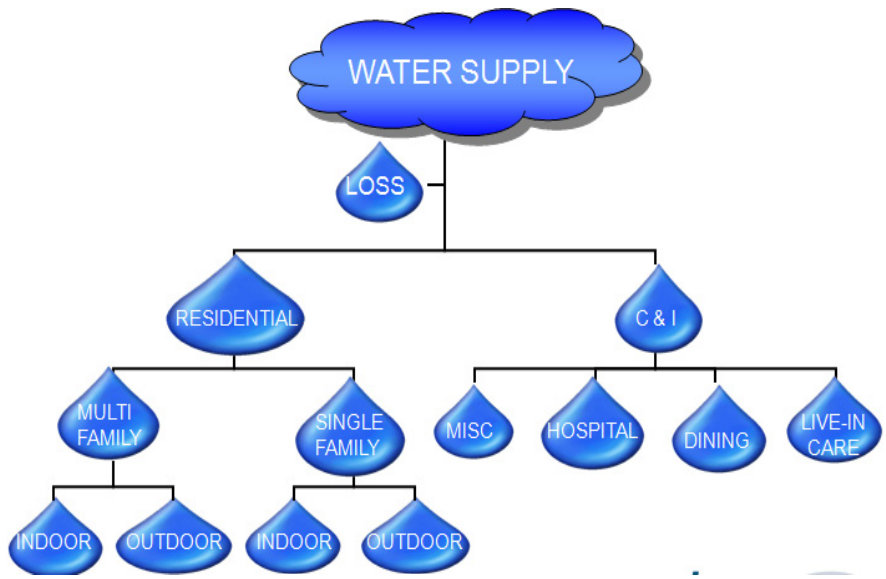
- Conditions at end of planning horizon—This scenario will estimate the long-term potential for demand-side management in the County from developments that have yet to be planned.

The costs and benefits from County demand management programs can be compared against other alternative water supplies.

5.25.1 Recommendation

Jones Edmunds recommends that the County partner with the potable water utilities to perform a Demand-Side Management Analysis. SWFWMD has several programs available to analyze this information, such as the Conserve Florida and Utility Service Programs. The Analysis should include the following components:

- Data Collection.
- Profile Water Use and Users.
- Estimate Water Use for Four Scenarios.
- Identify Potential Demand-side Management Measures.
- Estimate Potable Water Demand Reductions and Costs.
- Report Findings.



Profile Water Use and Users

The implementation of these recommendations would further the goals and intent described in the Water Policy 3.3.1 of the Sarasota County Comprehensive Plan.

5.26 FLORIDA WATER STAR℠

Florida Water Star℠ in Sarasota County
(picture courtesy of SWFWMD)

Florida Water Star℠ is a voluntary certification program for builders and developers designed to increase water efficiency in landscapes, irrigation systems, and indoors. SWFWMD is encouraging good water stewardship to the building industry by offering this recognition program that focuses on water efficiency and water quality protection. Florida Water Star℠ is tailored to the needs of Florida's water resources and is easily integrated into other green certification programs such as Energy Star®, the Florida Green Building Coalition's green standards, and the U.S. Green Building Council's LEED® program.

What are some of the features of Florida Water Star℠?

- ❖ Requires micro-irrigation and mulch in plant beds.
- ❖ Limits high-volume irrigation system to 50 to 60% of planted landscape area.
- ❖ Requires high-performance water-conserving appliances and fixtures.

- Requires points related to water quality issues for homes built near water bodies.
- Requires landscapes for the right plant in the right place.

How does Florida Water Star[SM] certification benefit new homebuyers?

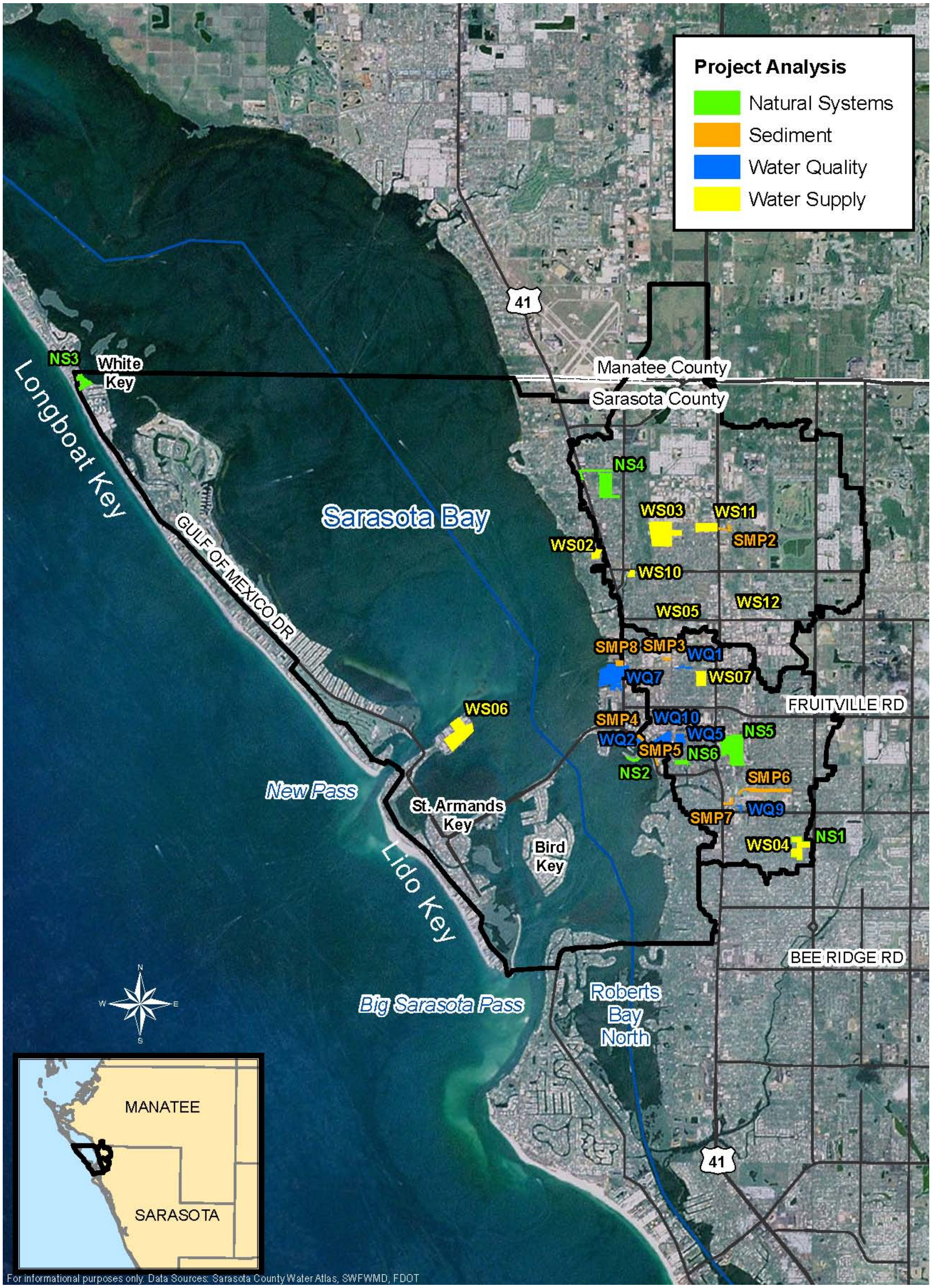
- Answers their interest in being "green."
- Saves them money on utilities.
- Decreases landscape maintenance costs.
- Increases resale value.

5.26.1 Recommendation

Jones Edmunds recommends that the County continue to work with SWFWMD to encourage participation in the Water Star[SM] Program.

The implementation of these recommendations would further the goals and intent described in the Water Policy 3.3.1 of the Sarasota County Comprehensive Plan.

6.0 CONCEPTUAL-LEVEL PROJECT SHEETS AND COST ESTIMATES


Project Analysis
Natural Systems
Sediment
Water Quality
Water Supply
41
NS3
White Key
Manatee County
Sarasota County
Longboat Key
GULF OF MEXICO DR
Sarasota Bay
NS4
WS03
WS11
SMP2
WS02
WS10
WS05
WS12
SMP8
SMP3
WQ1
WQ7
WS07
FRUITVILLE RD
WS06
SMP4
WQ10
WQ5
NS5
WQ2
SMP5
NS6
NS2
SMP6
New Pass
St. Armands Key
SMP7
WQ9
NS1
WS04
Bird Key
Lido Key
BEE RIDGE RD
Big Sarasota Pass
Roberts Bay North
MANATEE
SARASOTA
For informational purposes only. Data Sources: Sarasota County Water Atlas, SWFWMD, FDOT

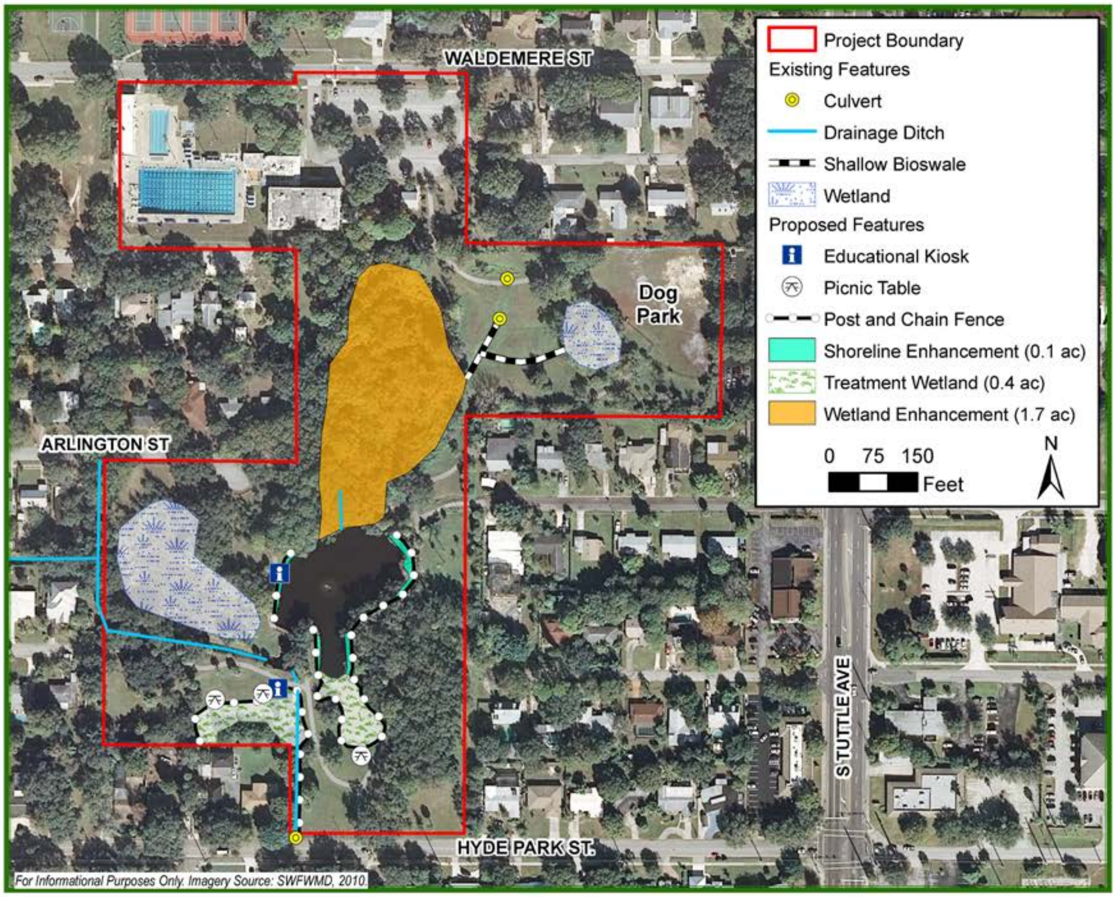
Sarasota County

JONES EDMUNDS

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

NS1 - Arlington Park



Site Evaluation

Untreated stormwater from large areas of residential land use drain to Arlington Park. There is a large pond in the center of the park which has little or no littoral vegetation, bank erosion, and appears to have very poor water quality. A large weir impounds the pond at a drainage ditch to the southwest. There is an isolated Mixed Hardwood Wetland to the west of the pond, comprised primarily of native vegetation, with a mostly native vegetative buffer surrounding it. A large Mixed Hardwood Wetland in the center of the park, consisting of a mixture of native and invasive vegetation, connects to the north end of the pond. A third wetland connects to the larger central wetland via a shallow swale.

Proposed Project Elements

- Wetland enhancement
- Construct treatment wetlands
- Shoreline enhancement
- Addition of park features (picnic benches, education kiosk)

Benefits

Wetland enhancement will help restore native vegetation and improve wildlife utilization. The addition of treatment wetlands will add beneficial habitat and enhance water quality. A littoral shelf in the pond will assimilate additional nutrients, reduce bank erosion, and provide forage and refugia for urban vertebrate and invertebrate wildlife species. Adding park features will provide an educational experience and recreational amenities for residents.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 6,487
- TP (lb/yr): 54
- TN (lb/yr): 61
- UMAM Credits (Herbaceous Wetlands): 0.12
- UMAM Credits (Forested Wetlands): 0.17

Opinion of Probable Cost ***(Conceptual Level Estimate)***

- $83,195

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

NS1 - Arlington Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**BJB**
PROJECT TITLE:	APPROVED BY:
Arlington Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/19/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 4,079.60	$ 4,080
Clearing and Grubbing	AC	0.5	$ 8,000.00	$ 4,000
Silt Fence	LF	250	$ 2.00	$ 500
Floating Turbidity Barrier	LF	500	$ 12.00	$ 6,000
Excavation	CY	1,685	$ 8.00	$ 13,480
Prepared Soil Layer (12")	SY	2,420	$ 2.50	$ 6,050
Wetlands	LS	1	$ 2,875.00	$ 2,875
Plant Material and Install for Shoreline Enhancement	LS	1	$ 719.00	$ 719
Sod	SY	100	$ 2.50	$ 250
Post and Chain Fence	LF	1,361	$ 2.00	$ 2,722
Picnic Table	EA	3	$ 400.00	$ 1,200
Educational Kiosk	EA	2	$ 1,500.00	$ 3,000
Contingency (25%)	LS	1	$ 11,218.90	$ 11,219
			SUBTOTAL	$ 56,095
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 20,000.00	$ 20,000
Maintenance of Exotic Species (Biannual for 2 years, then annually for 2 years)	LS	6	$ 850.00	$ 5,100
			SUBTOTAL	$ 27,100
			OPINION OF PROBABLE COST (ROUNDED)	**$ 83,195**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Note: All slopes assumed to be 4:1 with 2.5 feet of excavation for Bioretention and Treatment Wetland.

Sarasota County

JONES EDMUNDS

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan
NS2 - Bayfront Park and Marina

Site Evaluation

The south portion of the park contains a partially armored shoreline with a concrete walking path, benches, grass, and large trees. Several very small areas of mangroves are along this shoreline. Much of the shoreline is armored with stone of various sizes as there is considerable fetch within Sarasota Bay that can direct waves to this shore. This park offers beautiful views of Sarasota Bay and experiences significant tourist and local resident pedestrian traffic due to the marina, restaurants, children's water park, and proximity to downtown.

Proposed Project Elements

- Create living shoreline*
- Add educational features (kiosks on restoration and the planting of native vegetation)

*Note: Living Shoreline should be constructed in accordance with Sarasota County Comprehensive Plan Management Guidelines for Bay Waters which promotes shoreline softening and prohibits filling in bay waters.

Benefits

Due to the large number of visitors to this park, Jones Edmunds expects the living shoreline enhancement to be a very successful public education opportunity. This enhancement includes several small planting areas in strategically placed locations and will help minimize impacts to the current landscape while providing viewing opportunities of Sarasota Bay from the pedestrian trail.

.Pollutant Removal Estimate (Avg)

- Erosion Prevention and Sediment Control (CY): 2,270
- UMAM Credits (Herbaceous Wetlands): 0.04

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $20,055

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

NS2 - Bayfront Park Shore

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**BJB**
PROJECT TITLE:	APPROVED BY:
Bayfront Park and Marina	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/19/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Plant Material and Install	LS	1	$ 9,044	$ 9,044
Educational Kiosk	EA	2	$ 1,500	$ 3,000
Contingency (25%)	LS	1	$ 3,011	$ 3,011
			SUBTOTAL	$ 15,055
Design	LS	1	$ 5,000.00	$ 5,000
			SUBTOTAL	$ 5,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 20,055**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

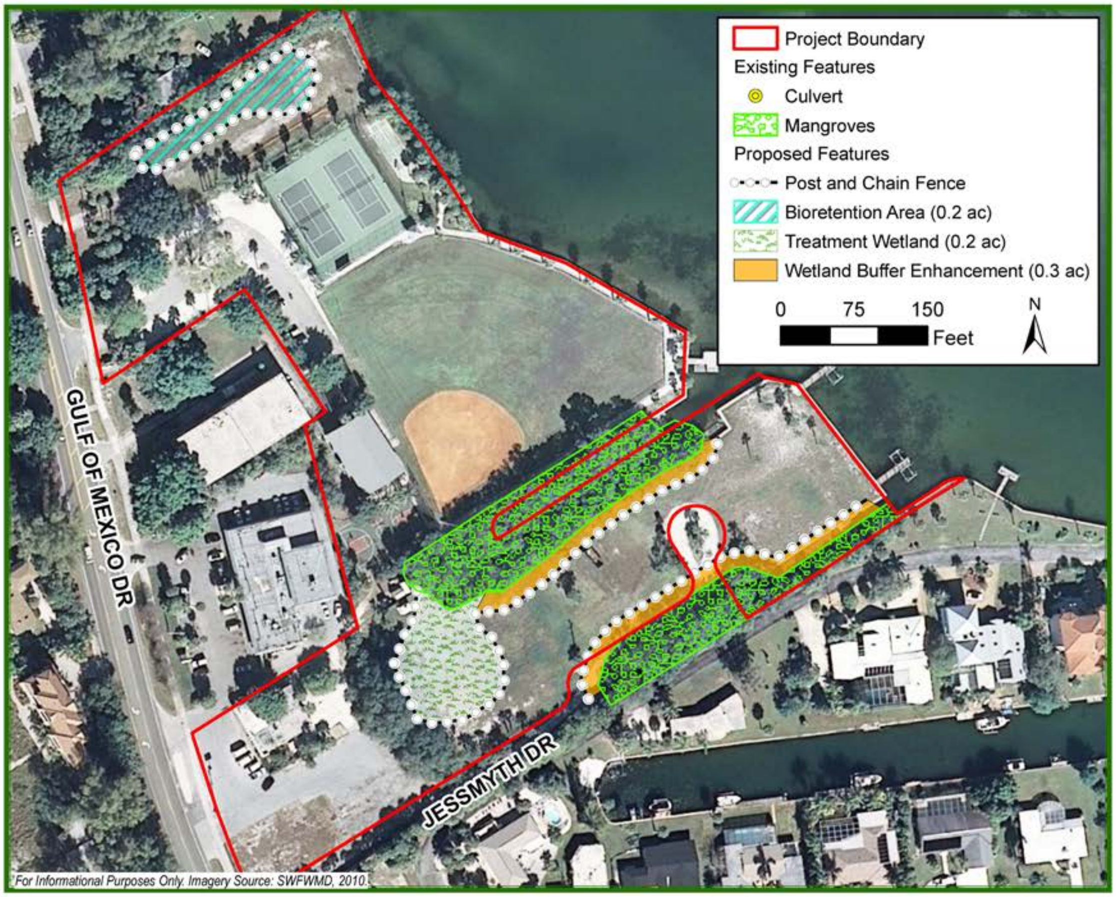
Sarasota County

Jones Edmunds

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

NS3 - Longboat Key - Bayfront Park



Site Evaluation

Longboat Key Bayfront Park is bound by the Sarasota Bay to the east and commercial properties and Gulf of Mexico Drive to the west. The park contains parking lots, a maintained field, tennis courts, a baseball field, and a park area. Two dredged inlets occur within the park which are lined with red mangroves. The mangroves in the southern inlet transition to a shallow upland cut swale. The park is mowed to the edge of the mangroves. A grassed field occupies the northern portion of the park.

Proposed Project Elements

- Construct bioretention treatment wetland at north end
- Enhance uplands next to mangrove wetlands
- Construct a treatment wetland in southern portion of park

Benefits

The bioretention and treatment wetland areas will provide habitat and capture, attenuate, and treat stormwater runoff from the adjacent commercial properties, SR-789, and the impervious parking lot on the west side of the site. Buffers will provide habitat and slow runoff, which will reduce sediment and nutrient load to the bay. A post-and-chain fence along the top of the banks will protect against mowing and pedestrian damage to vegetation.

.Pollutant Removal Estimate *(Avg)*

- TSS (lb/yr): 696
- TP (lb/yr): 6
- TN (lb/yr): 17
- UMAM Credits (Herbaceous Wetlands): 0.18

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $101,621

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

NS3 - Longboat Key Bayfront Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**BJB**
PROJECT TITLE:	APPROVED BY:
Longboat Key Bayfront Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/19/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 5,717.90	$ 5,718
Clearing and Grubbing	AC	0.7	$ 8,000.00	$ 5,600
Silt Fence	LF	250	$ 2.00	$ 500
Floating Turbidity Barrier	LF	700	$ 12.00	$ 8,400
Excavation	CY	2,060	$ 8.00	$ 16,480
Prepared Soil Layer (12")	SY	3,390	$ 2.50	$ 8,475
Pipe Culvert	LF	100	$ 40.00	$ 4,000
Outfall Structure with Skimmer	EA	1	$ 3,000.00	$ 3,000
Plant Material and Install for Bioretention Areas	LS	1	$ 2,130	$ 2,130
Plant Material and Install for Treatment Wetland Buffer	LS	1	$ 2,130	$ 2,130
Plant Material and Install for Wetland Buffer	LS	1	$ 3,194	$ 3,194
Sod	SY	100	$ 2.50	$ 250
Post and Chain Fence	LF	1,510	$ 2.00	$ 3,020
Contingency (25%)	LS	1	$ 15,724	$ 15,724
			SUBTOTAL	$ 78,621
Survey	LS	1	$ 3,000.00	$ 3,000
Design and Permitting	LS	1	$ 20,000.00	$ 20,000
			SUBTOTAL	$ 23,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 101,621**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Note: All slopes assumed to be 4:1 with 2.5 feet of excavation for Bioretention and Treatment Wetland.

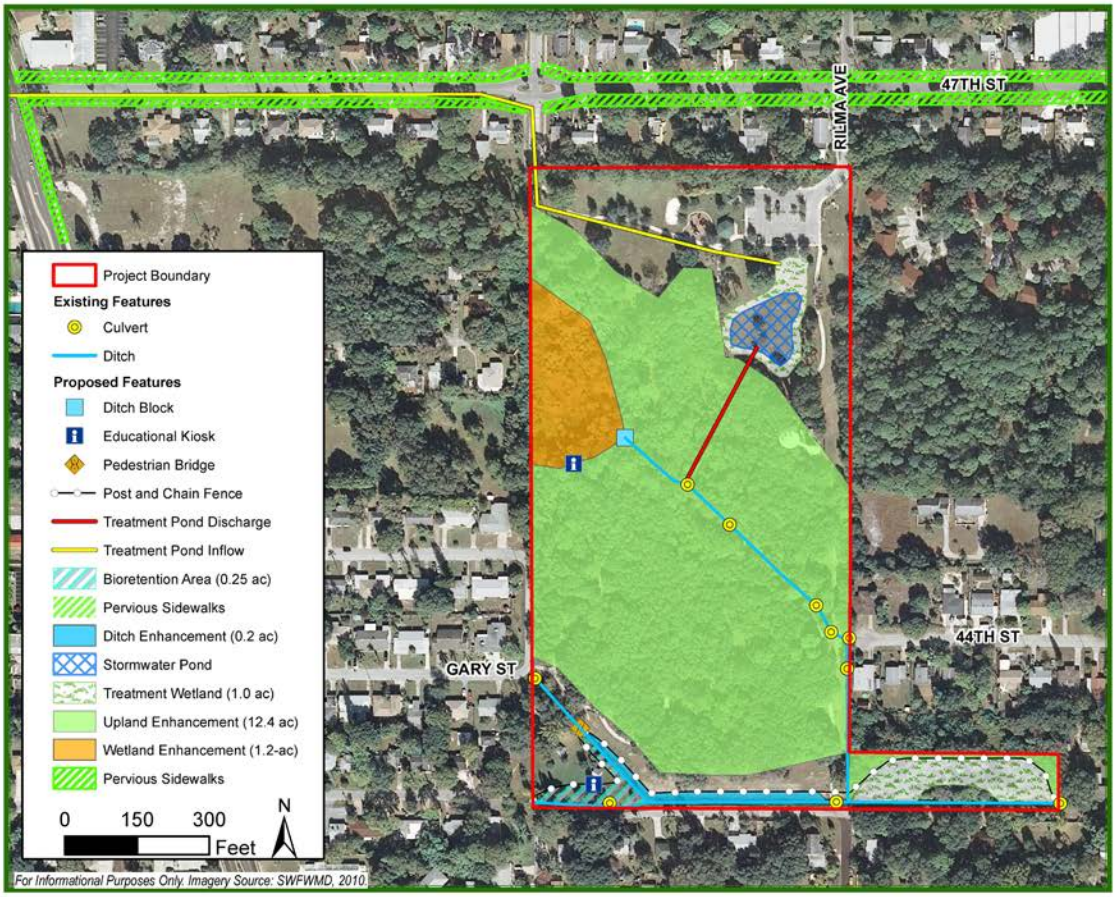
Sarasota County

Sarasota Bay Water Quality Management Plan

NS4 - North Water Tower Park

JONES EDMUNDS

Janicki Environmental, Inc.



Site Evaluation

North Water Tower Park consists primarily of a mature Temperate Hardwood community traversed with paved sidewalks. There is an isolated wetland comprised of native and exotic vegetation. A shallow, excavated swale connects the wetland to an east/west ditch at the south end of the park. Residential runoff enters the park and flows east via a large ditch which has very steep and eroding side slopes.

Proposed Project Elements

- Enhance on-site wetland & uplands
- Create treatment wetlands
- Create a bioretention area
- Add a ditch block to existing natural wetland
- Add wet detention pond
- Divert stormwater from U.S. 41 to treatment pond and wetlands
- Replace sidewalks with pervious pavement or pavers
- Add park features (kiosk(s), pedestrian bridge, fence)

Benefits

Bioretention area and treatment wetlands will provide habitat and treat stormwater runoff from untreated developed areas. Ditch enhancement will stabilize side slopes, slow and treat runoff, which will reduce sediment and nutrient load to the bay. Ditch plug will restore on-site wetland hydrology. Upland enhancement will improve habitat quality. A post-and-chain fence will protect side slope vegetation from mowing and pedestrian damage.

.Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 14,421
- TP (lb/yr): 171
- TN (lb/yr): 775
- UMAM Credits (Herbaceous Wetlands): 0.35
- UMAM Credits (Forested Wetlands): 0.99

Opinion of Probable Cost (Conceptual Level Estimate)

- $653,738

Sarasota Bay Water Quality Management Plan
Conceptual Level Cost Estimate
NS4 - North Water Tower Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**BJB**
PROJECT TITLE:	APPROVED BY:
North Water Tower Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/19/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 39,748.20	$ 39,748
Clearing and Grubbing/Remove Concrete	AC	2.5	$ 10,000.00	$ 25,000
Silt Fence	LF	500	$ 2.00	$ 1,000
Floating Turbidity Barrier	LF	500	$ 12.00	$ 6,000
Geotextile Fabric	SF	8,715	$ 8.00	$ 69,720
Excavation	CY	8,500	$ 8.00	$ 68,000
Embankment	CY	250	$ 12.00	$ 3,000
Ditch Block	EA	1	$ 500.00	$ 500
Prepared Soil Layer (12")	SY	7,020	$ 2.50	$ 17,550
Plant Material and Install for Ditch Enhancement	LS	1	$ 2,130.00	$ 2,130
Plant Material and Install for Treatment Wetlands	LS	1	$ 7,187.00	$ 7,187
Plant Material and Install for Treatment Wetlands	LS	1	$ 1,797.00	$ 1,797
Pipe Culvert	LF	72	$ 55.00	$ 3,960
Outfall Structure with Skimmer	EA	1	$ 4,000.00	$ 4,000
Mitered End Section	EA	3	$ 1,000.00	$ 3,000
Pervious Sidewalk Pavement (4")	SF	24,000	$ 6.00	$ 144,000
Riprap	TN	128	$ 75.00	$ 9,600
Bedding Stone with Geotextile	TN	46	$ 90.00	$ 4,140
Sod	SY	2,500	$ 2.50	$ 6,250
Post and Chain Fence	LF	3,624	$ 2.00	$ 7,248
Pedestrian Bridge	EA	1	$ 10,000.00	$ 10,000
Picnic Benches	EA	2	$ 200.00	$ 400
Educational Kiosk	EA	2	$ 1,500.00	$ 3,000
Contingency (25%)	LS	1	$ 109,307.55	$ 109,308
			SUBTOTAL	$ 546,538
Survey	LS	1	$ 10,000.00	$ 10,000
Design and Permitting	LS	1	$ 60,000.00	$ 60,000
Maintenance of Exotic Species (Biannual for 2 years, then annually for 2 years)	YR	6	$ 6,200.00	$ 37,200
			SUBTOTAL	$ 107,200
			OPINION OF PROBABLE COST (ROUNDED)	**$ 653,738**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.
Note: All slopes assumed to be 4:1 with 2.5 feet of excavation for Bioretention and Treatment Wetland.

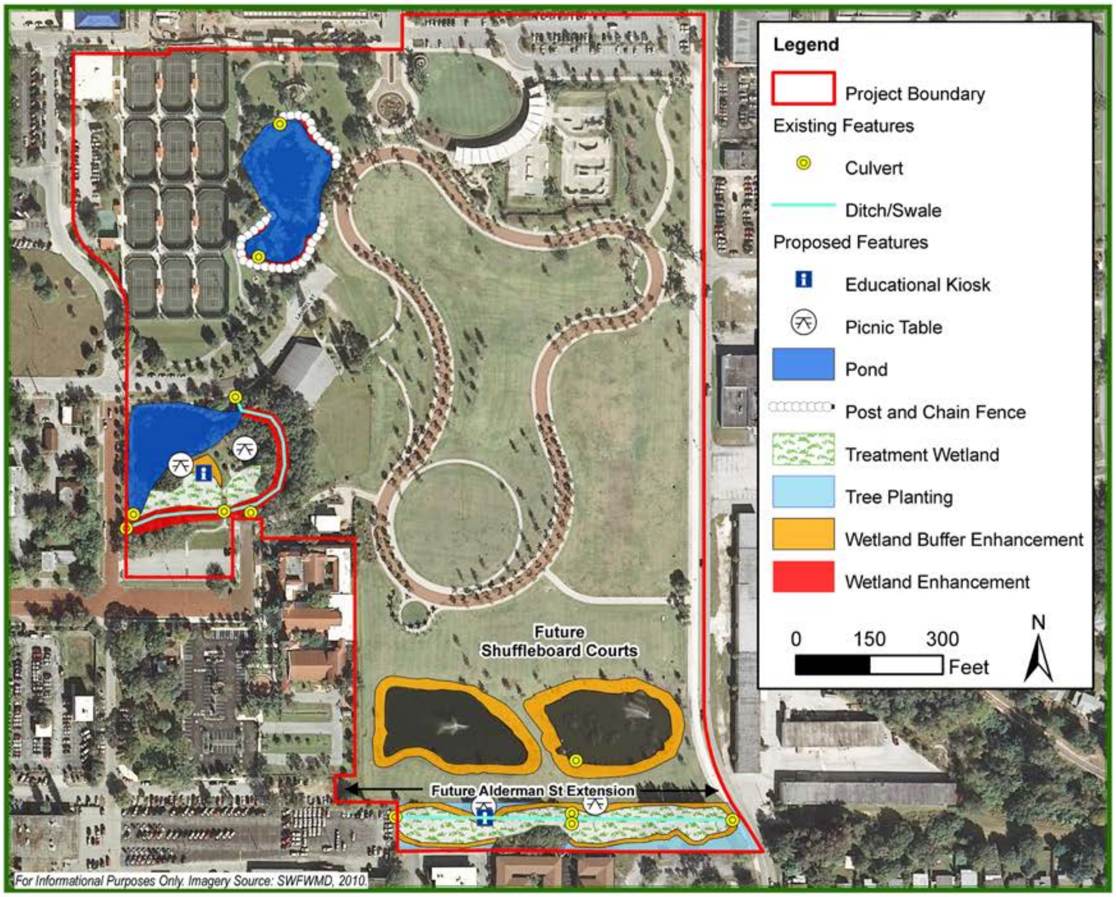
Sarasota County

Sarasota Bay Water Quality Management Plan

NS5 - Payne Park

Jones Edmunds

Janicki Environmental, Inc.



Site Evaluation

The majority of Payne Park consists of developed facilities ranging from walking pathways, a skate park, amphitheatre, and large expanses of open grassy areas. Several ponds, or water features, are in the northwest and south portions of the park. Most of the pond banks are mowed to the water's edge and the southern ponds are lacking littoral vegetation. The northern ponds receive untreated stormwater from roads to the north and discharge via drop structures to the west. The southern ponds receive stormwater from a commercial area to the west and the park itself. The ponds are connected with a pipe and discharge via the easternmost pond's drop structure into an east-west ditch on the southern park boundary.

Proposed Project Elements

- Wetland & upland enhancement(s)
- Create a treatment wetland
- Tree planting
- Install educational kiosks and picnic tables

Benefits

Planting pond edges will protect the water quality of the pond from dog waste and overland flow that carries nutrients. A post-and-chain fence will help protect against mowing and damage to vegetation. The addition of wetlands will detain and treat untreated stormwater flows. Wetland buffer enhancements will stabilize side slopes and reduce sedimentation. Planting trees will shade treatment wetland and provide areas for residents to enjoy.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 9,228
- TP (lb/yr): 66
- TN (lb/yr): 74
- UMAM Credits (Herbaceous Wetlands): 0.19
- UMAM Credits (Forested Wetlands): 0.05

Opinion of Probable Cost (Conceptual Level Estimate)

- $162,152

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

NS5 - Payne Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**BJB**
PROJECT TITLE:	APPROVED BY:
Payne Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/19/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 9,538.30	$ 9,538
Clearing and Grubbing	AC	1.4	$ 8,000.00	$ 11,200
Silt Fence	LF	250	$ 2.00	$ 500
Floating Turbidity Barrier	LF	500	$ 12.00	$ 6,000
Excavation	CY	4,365	$ 8.00	$ 34,920
Prepared Soil Layer (12")	SY	7,040	$ 2.50	$ 17,600
Plant Material and Install for Wetland Buffer	LS	1	$ 13,358.00	$ 13,358
Plant Material and Install for Tree Enhancement Area	LS	1	$ 1,258.00	$ 1,258
Plant Material and Install for Treatment Wetland	LS	1	$ 5,750.00	$ 5,750
Plant Material and Install for Wetland Enhancement Area	LS	1	$ 719.00	$ 719
Sod	SY	100	$ 2.50	$ 250
Post and Chain Fence	LF	564	$ 2.00	$ 1,128
Picnic Table	EA	3	$ 400.00	$ 1,200
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Contingency (25%)	LS	1	$ 26,230.33	$ 26,230
			SUBTOTAL	$ 131,152
Survey	LS	1	$ 6,000.00	$ 6,000
Design and Permitting	LS	1	$ 25,000.00	$ 25,000
			SUBTOTAL	$ 31,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 162,152**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Note: All slopes assumed to be 4:1 with 2.5 feet of excavation for Bioretention and Treatment Wetland.

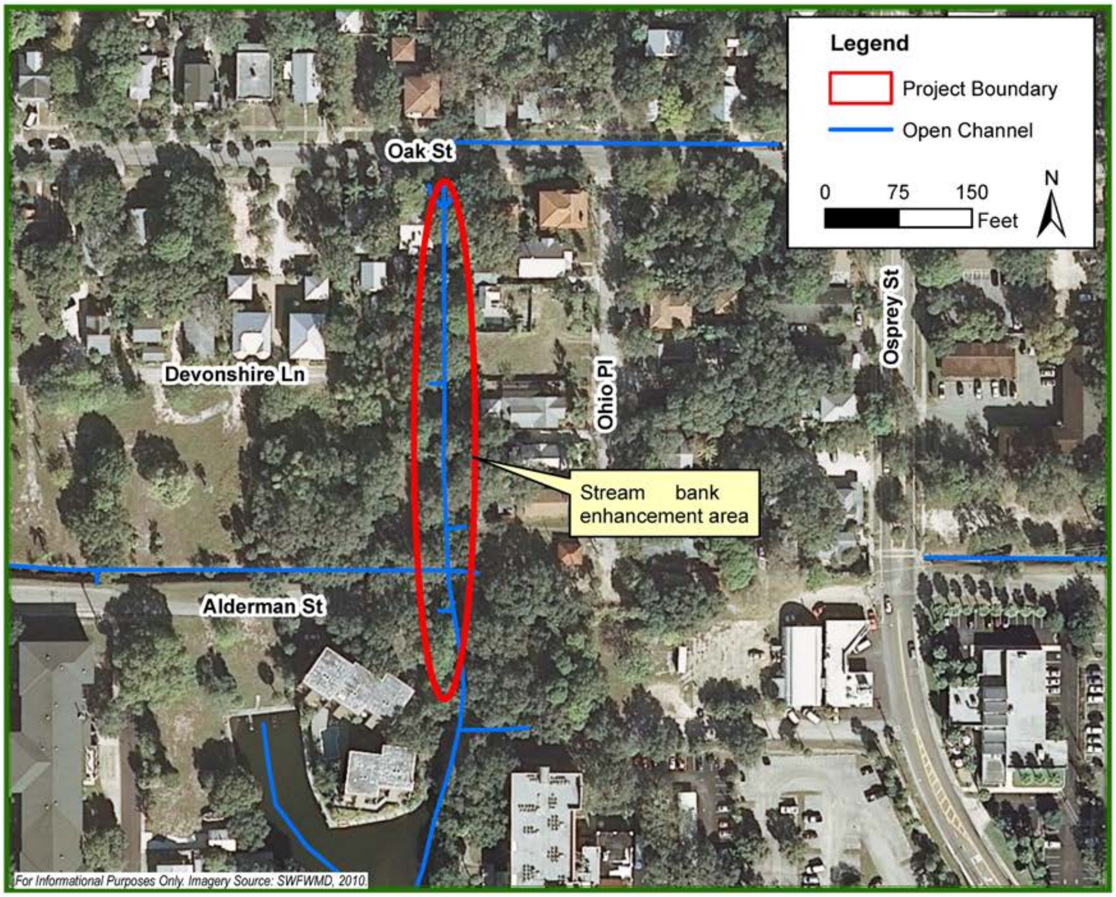
Sarasota County

Jones Edmunds

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

NS6 - Hudson Bayou Oak Street Canal



Site Evaluation

This site is a channelized tributary of Hudson Bayou that flows south within a narrow 12- to 15-foot-wide drainage easement between residential properties. Almost the entire reach of this channelized tributary is armored or has vertical or near vertical side slopes and much of the bank is dominated by dense exotic vegetation. This system receives untreated stormwater that discharges directly to the creek via pipes or ditches.

Proposed Project Elements

- Remove and treat exotic vegetation
- Stabilize banks with native vegetation
- Install logs/large branches in channel

Benefits

The banks will be enhanced by removing exotic invasive vegetation and planting desirable native species from the toe to top of slope. Enhancement of the side slope will be challenging in several locations due to the vertical bank and the potential for bank failure if large exotic invasive trees and shrubs are removed. Installing several logs and thick-diameter branches in two or three locations of this stream reach will trap sediments and provide benthic habitat.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 1,148
- TP (lb/yr): 2
- TN (lb/yr): 9
- UMAM Credits (Forested Wetlands): 0.02

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $33,094

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

NS6 - Hudson Bayou Oak Street Canal

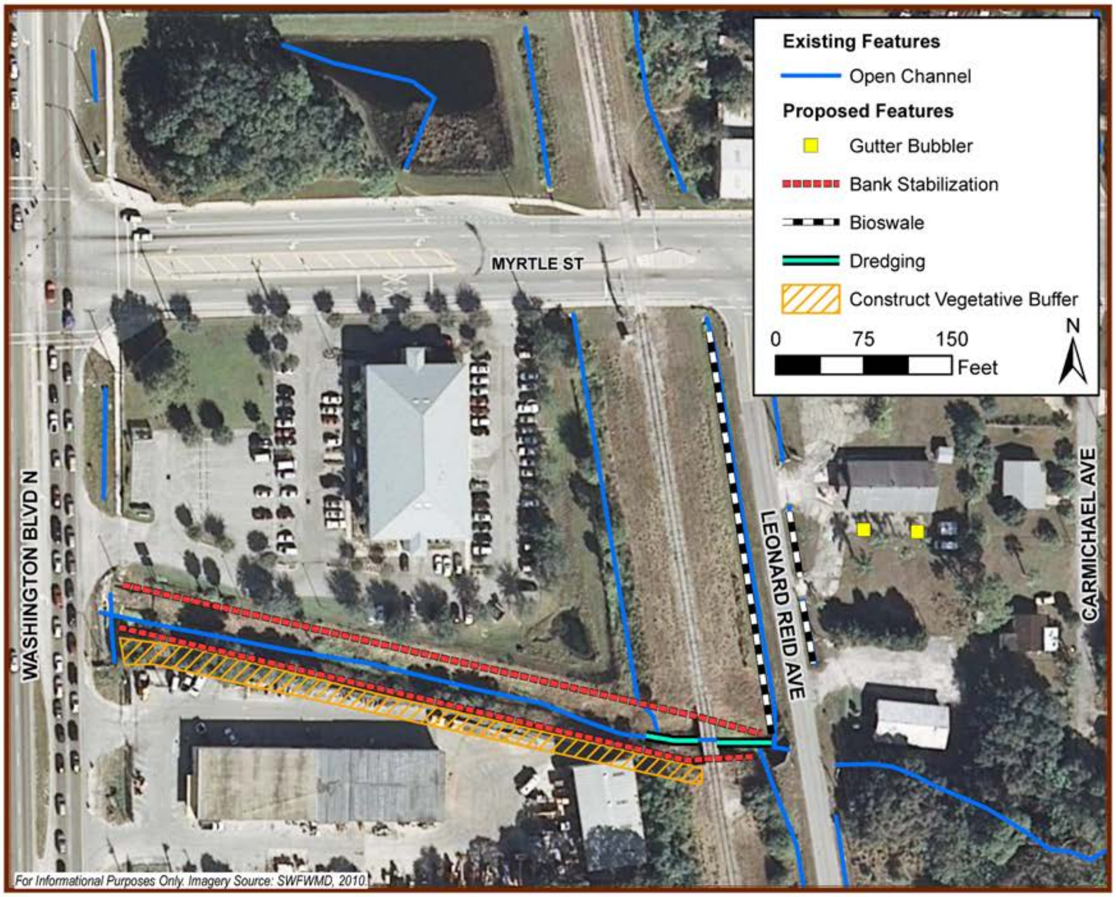
OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**BJB**
PROJECT TITLE:	APPROVED BY:
Hudson Bayou Oak Street Canal	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/19/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 1,425.00	$ 1,425
Floating Turbidity Barrier	LF	500	$ 12.00	$ 6,000
Installation of Wood Debris	LS	1	$ 2,500.00	$ 2,500
Plant Material and Install for Banks	LS	1	$ 5,750.00	$ 5,750
Contingency (25%)	LS	1	$ 3,918.75	$ 3,919
			SUBTOTAL	$ 19,594
Survey	LS	1	$ 3,000.00	$ 3,000
Design and Permitting	LS	1	$ 7,500.00	$ 7,500
Maintenance of Exotic Species (Biannual for 2 years, then annually for 2 years)	YR	6	$ 500.00	$ 3,000
			SUBTOTAL	$ 13,500
			OPINION OF PROBABLE COST (ROUNDED)	**$ 33,094**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota Bay Water Quality Management Plan

SMP2 - Whitaker Canal at Leonard Reid Ave



Site Evaluation

The banks of the waterway are eroded between Leonard Reid Ave. and Washington Bvd. Runoff from Hertz Equipment Rental to the south appears to discharge to the stream without any treatment. There is sediment accumulation in the waterway, primarily under the railroad piers. A grassed swale parallel to Leonard Reid Ave. from Myrtle St. drains to the waterway. There is also erosion along the banks of the waterway on the east side of Leonard Reid Avenue. A small church has a gutter downspout discharging directly to the stream. Erosion at the top of bank has occurred at the outflow from the gutter.

Proposed Project Elements

- Stabilize banks with native vegetation
- Add a sediment sump
- Create buffer
- Retrofit existing swale to a biofiltration/bioretention swale
- Add gutter bubblers
- Construct bioswale to treat runoff from the church property

Benefits

Bank stabilization will reduce erosion and retain sediment thereby improving flood control conditions. The addition of a sediment sump will reduce flow velocities and promote settling of sediment in an area that will not adversely impact flood control or habitats. A buffer will capture contaminants from the equipment rental facility. The bioswales will capture and treat untreated runoff from the surrounding roads and church property. Gutter bubblers or rain barrels will reduce erosion and sedimentation.

Pollutant Removal Estimate *(Avg)*

- TSS (lb/yr): 4,355
- TP (lb/yr): 35
- TN (lb/yr): 157
- Erosion Prevention and Sediment Control (CY): 1,400

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $189,200

JONES EDMUNDS Sarasota County

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP2 - Whitaker Canal at Leonard Reid Ave

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Whitaker Canal at Leonard Reid Ave.	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 11,578.20	$ 11,578
Clearing and Grubbing	AC	1.4	$ 4,000.00	$ 5,600
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	3,000	$ 8.00	$ 24,000
Embankment	CY	100	$ 12.00	$ 1,200
Prepared Soil Layer (12")	SY	6,650	$ 2.50	$ 16,625
Riprap	TN	130	$ 75.00	$ 9,750
Bedding Stone with Geotextile Fabric	TN	46	$ 90.00	$ 4,140
Concrete Sediment Basin	EA	1	$ 40,000.00	$ 40,000
Gutter Bubbler Assembly	EA	2	$ 2,500.00	$ 5,000
Sod	SY	2,000	$ 2.50	$ 5,000
Planting for Stream Banks	LS	1	$ 2,175.00	$ 2,175
Planting for Bioswale	LS	1	$ 892.00	$ 892
Contingency (25%)	LS	1	$ 31,840.05	$ 31,840
			SUBTOTAL	$ 159,200
Survey	LS	1	$ 5,000.00	$ 5,000
Design and Permitting	LS	1	$ 25,000.00	$ 25,000
			SUBTOTAL	$ 30,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 189,200**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

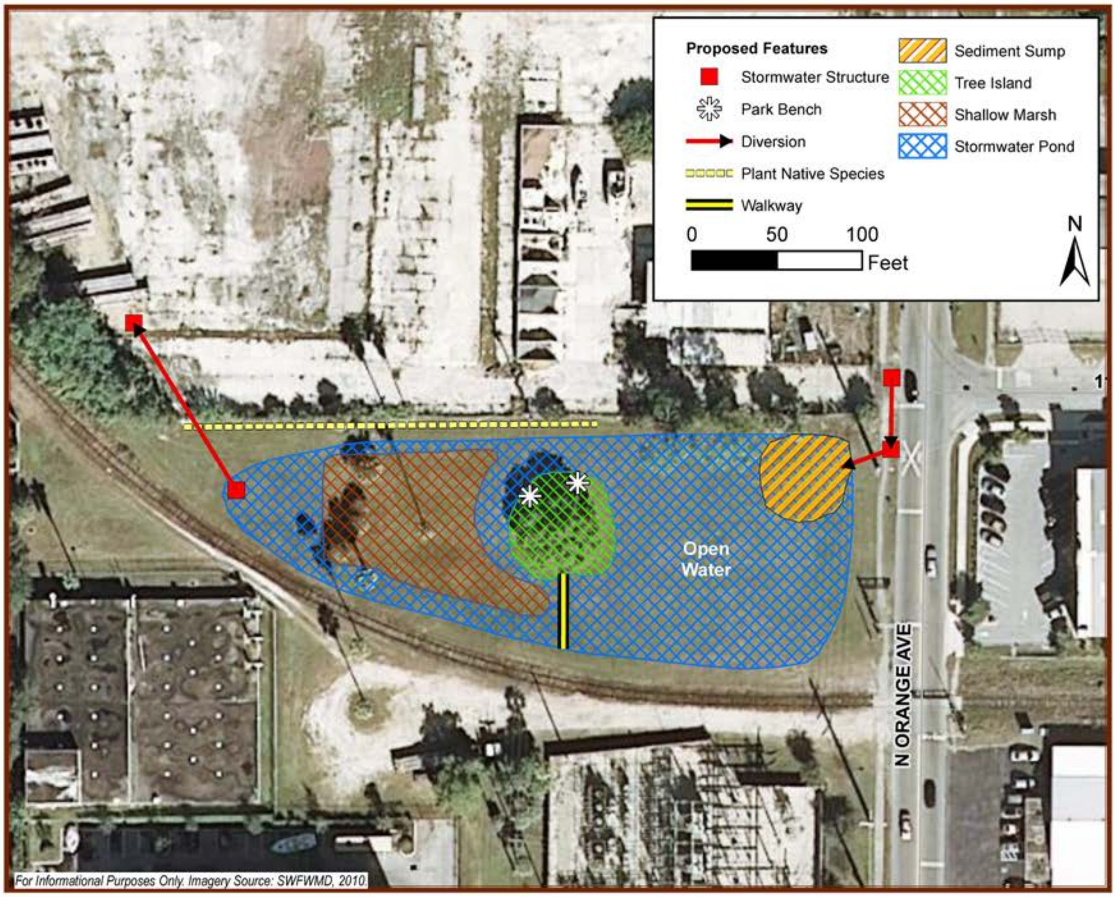
Sarasota County

JONES EDMUNDS

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

SMP3 - Orange Avenue



Site Evaluation

The area has elevated SIMPLE TSS loads and is adjacent to a large area of bare earth. Stormwater from 12th Street and an adjacent wastewater treatment plant flows via pipes down Orange Avenue, continues west along the northern bounds of the project area, and eventually discharges at Pioneer Park.

Proposed Project Elements

- Create Diversion
- Plant native species
- Install stormwater structure
- Create a stormwater pond (+/-0.5 acre)
- Create a shallow marsh
- Add a sediment sump
- Add park features (park benches, walkway, tree island)

Benefits

A diversion through the proposed treatment system at this site will improve water quality before it discharges to the bay. Planting native vegetation will reduce maintenance requirements. The addition of a sediment sump will reduce flow velocities and promote settling of sediment in an area that will not adversely impact flood control or habitats. The park- like setting will be valuable to the community as well.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 14,045
- TP (lb/yr): 77
- TN (lb/yr): 90
- Erosion Prevention and Sediment Control (CY): 85

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $226,500

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP3 - Orange Avenue

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Orange Avenue	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

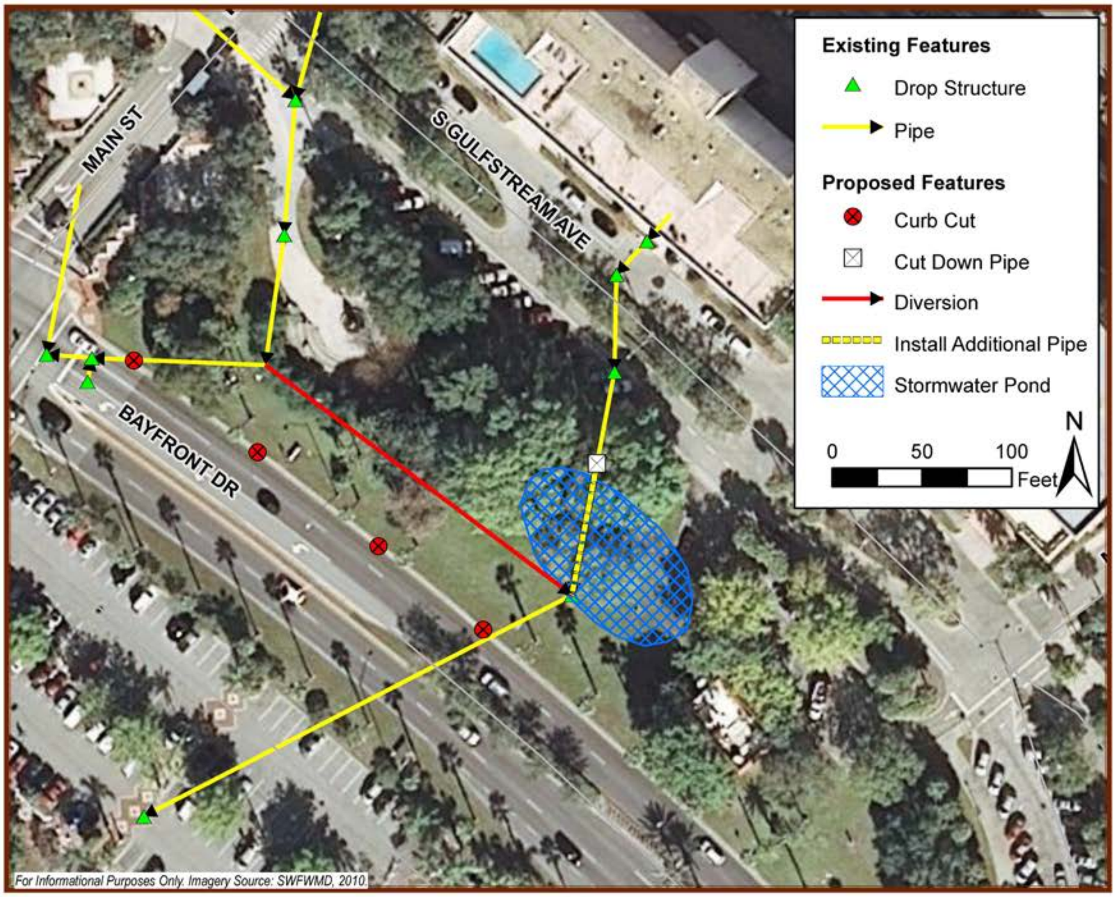
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 13,392.20	$ 13,392
Maintenance of Traffic (5%)	LS	1	$ 6,696.10	$ 6,696
Clearing and Grubbing	AC	1.0	$ 4,000.00	$ 4,000
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	2,020	$ 8.00	$ 16,160
Embankment	CY	200	$ 12.00	$ 2,400
Prepared Soil Layer (12")	SY	880	$ 2.50	$ 2,200
Pipe Culvert	LF	200	$ 105.00	$ 21,000
Ditch Bottom Inlet/Manhole	EA	4	$ 6,000.00	$ 24,000
Mitered End Section	EA	1	$ 3,000.00	$ 3,000
Riprap	TN	64	$ 75.00	$ 4,800
Bedding Stone with Geotextile Fabric	TN	23	$ 90.00	$ 2,070
Concrete Sediment Basin	EA	1	$ 40,000.00	$ 40,000
Boardwalk	LF	50	$ 100.00	$ 5,000
Picnic Benches	EA	2	$ 200.00	$ 400
Sod	SY	2,500	$ 2.50	$ 6,250
Planting for Native Species	LS	1	$ 475.00	$ 475
Planting for Shallow Marsh	LS	1	$ 767.00	$ 767
Contingency (25%)	LS	1	$ 38,502.58	$ 38,503
			SUBTOTAL	$ 192,513
Survey	LS	1	$ 4,000.00	$ 4,000
Design and Permitting	LS	1	$ 30,000.00	$ 30,000
			SUBTOTAL	$ 34,000
OPINION OF PROBABLE COST (ROUNDED)				**$ 226,500**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

SMP4 - Bayfront Park and Marina North



Site Evaluation

This area is a grassed buffer between Bayfront Drive and the businesses and residences in downtown Sarasota. The stormwater inventory shows underground infrastructure discharging untreated stormwater directly to the bay. This site has a public restroom at the south end and a curb inlet unusually positioned in the center of the parcel.

Proposed Project Elements

- Create wet detention pond
- Create diversion
- Cut down pipe
- Install additional pipe
- Retrofit curb inlet as pond outfall
- Create curb cuts

Benefits

Creating a stormwater pond and diverting untreated stormwater to the pond will provide treatment for urban runoff before it reaches the bay. Curb cuts would allow runoff to enter the grassed area for infiltration and provide treatment along the roadway corridor.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 2,505
- TP (lb/yr): 13
- TN (lb/yr): 14

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $124,000

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP4 - Bayfront Park and Marina North

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Bayfront Drive North	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 5,998.25	$ 5,998
Maintenance of Traffic (10%)	LS	1	$ 5,998.25	$ 5,998
Clearing and Grubbing	AC	0.5	$ 8,000.00	$ 4,000
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	900	$ 8.00	$ 7,200
Embankment	CY	50	$ 12.00	$ 600
Prepared Soil Layer (12")	SY	225	$ 2.50	$ 563
Drainage Flume\Curb Cut	EA	4	$ 1,200.00	$ 4,800
Pipe Culvert	LF	300	$ 55.00	$ 16,500
Outfall Structure with Skimmer	EA	1	$ 4,000.00	$ 4,000
Ditch Bottom Inlet	EA	2	$ 3,000.00	$ 6,000
Mitered End Section	EA	2	$ 1,000.00	$ 2,000
Riprap	TN	64	$ 75.00	$ 4,800
Bedding Stone with Geotextile Fabric	TN	23	$ 90.00	$ 2,070
Sod	SY	2,420	$ 2.50	$ 6,050
Contingency (25%)	LS	1	$ 17,994.75	$ 17,995
			SUBTOTAL	$ 89,974
Survey	LS	1	$ 4,000.00	$ 4,000
Design and Permitting	LS	1	$ 30,000.00	$ 30,000
			SUBTOTAL	$ 34,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 124,000**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

JONES EDMUNDS

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

SMP5 - Bayfront Park and Marina South

Site Evaluation

This site is narrow and slopes down from the northwest toward Gulf Stream Avenue. The area is grassed and has several large trees. Untreated stormwater runoff flows into a major stormwater inlet at the northwest corner of the site and curb inlets around the site. This runoff discharges to the bay.

Proposed Project Elements

- Construct bioswale
- Create stormwater diversion
- Create curb cuts
- Add park features (benches, walkways, and educational kiosks)

Benefits

Creating a bioretention swale and diverting untreated stormwater through it will provide treatment for urban runoff before it reaches the bay. Curb cuts would allow runoff to enter the grassed area and swale for infiltration and provide treatment along the roadway corridor.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 1,564
- TP (lb/yr): 24
- TN (lb/yr): 31

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $137,500

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP5 - Bayfront Park and Marina South

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Bayfront Drive South	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 6,899.90	$ 6,900
Maintenance of Traffic (10%)	LS	1	$ 6,899.90	$ 6,900
Clearing and Grubbing	AC	1.0	$ 8,000.00	$ 8,000
Silt Fence	LF	300	$ 2.00	$ 600
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	1,720	$ 8.00	$ 13,760
Embankment	CY	70	$ 12.00	$ 840
Prepared Soil Layer (12")	SY	800	$ 2.50	$ 2,000
Drainage Flume\Curb Cut	EA	15	$ 1,200.00	$ 18,000
Pipe Culvert	LF	50	$ 55.00	$ 2,750
Outfall Structure with Skimmer	EA	1	$ 4,000.00	$ 4,000
Ditch Bottom Inlet	EA	1	$ 3,000.00	$ 3,000
Mitered End Section	EA	1	$ 1,000.00	$ 1,000
Riprap	TN	32	$ 75.00	$ 2,400
Bedding Stone with Geotextile Fabric	TN	12	$ 90.00	$ 1,080
Sod	SY	2,420	$ 2.50	$ 6,050
Picnic Benches	EA	10	$ 200.00	$ 2,000
Planting for Bioswale	LS	1	$ 2,319.00	$ 2,319
Contingency (25%)	LS	1	$ 20,699.70	$ 20,700
			SUBTOTAL	$ 103,499
Survey	LS	1	$ 4,000.00	$ 4,000
Design and Permitting	LS	1	$ 30,000.00	$ 30,000
			SUBTOTAL	$ 34,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 137,500**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

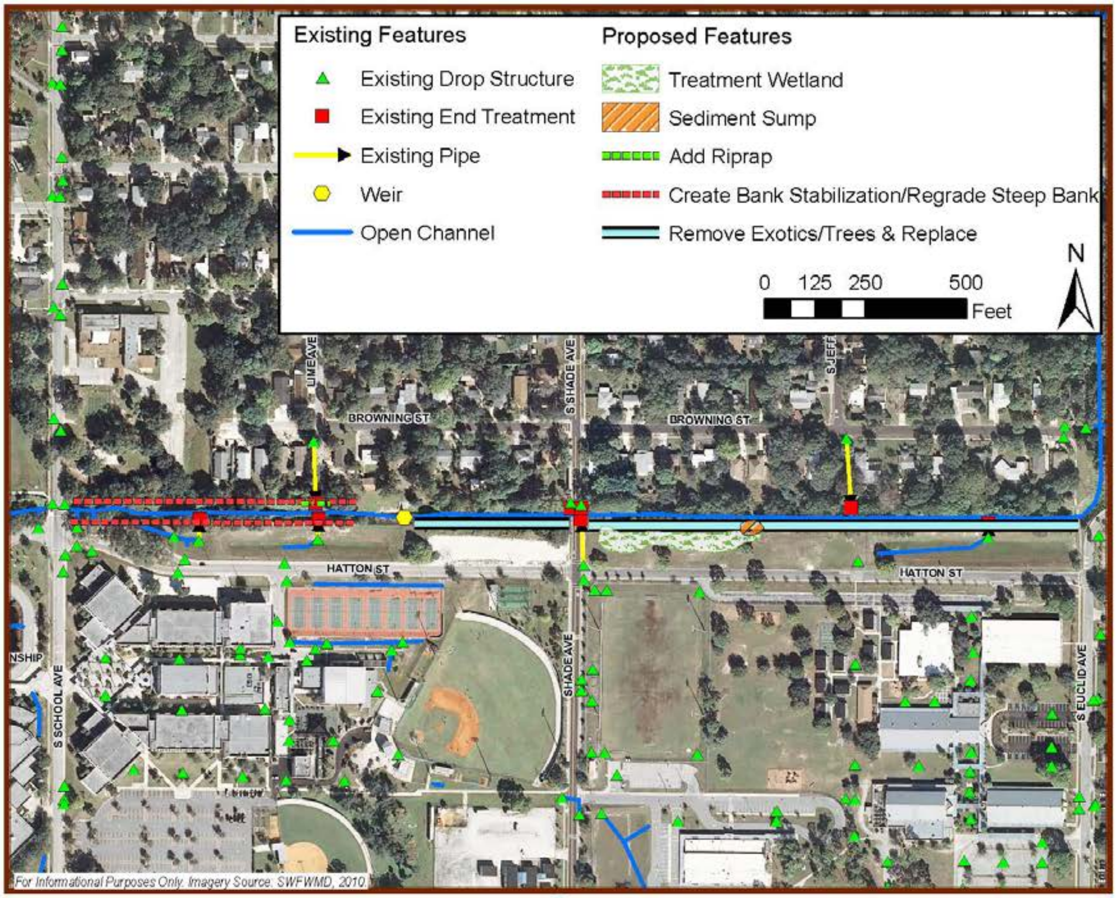
Sarasota County

Sarasota Bay Water Quality Management Plan

SMP6 - Sarasota High School at Hatton Street

Jones Edmunds

Janicki Environmental, Inc.



Site Evaluation

Hatton Street ditch has very steep banks, erosion, and sedimentation. There are multiple discharges without erosion-control measures, and a large weir west of Shade Avenue controls flow through the ditch. On the south side of the Hatton Street ditch are two stormwater ponds for the high school.

Proposed Project Elements

- Remove exotic, invasive plants
- Create bank stabilization, using geoweb and articulating blocks
- Lower berm; regrade north bank
- Install LID components
- Widen waterway
- Create a sediment sump
- Create a wetland area

Benefits

Bank stabilization will reduce erosion and retain sediment thereby improving flood control conditions. Widening the channel will reduce flow velocity and erosion. The addition of a sediment sump will also reduce flow velocities and will promote settling of sediment in an area that will not adversely impact flood control or habitats. Wetland creation will aid in reducing the pollutant load and will provide habitat. Informational kiosks enhance educational opportunities at the school.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 11,208
- TP (lb/yr): 93
- TN (lb/yr): 105
- Erosion Prevention and Sediment Control (CY): 21,574

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $368,600

JONES EDMUNDS   Sarasota County

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP6 - Sarasota High School at Hatton Street

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Sarasota High School at Hatton Street Ditch	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

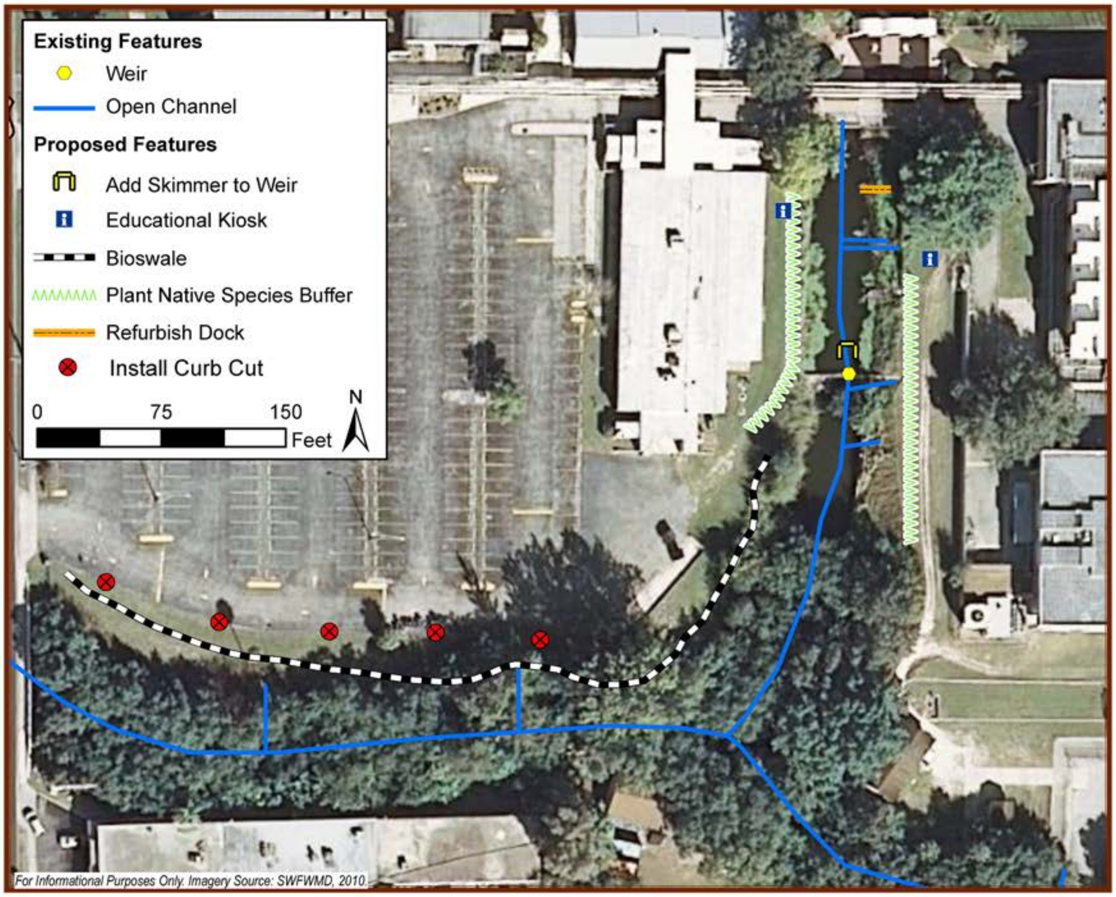
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 22,036.30	$ 22,036
Clearing and Grubbing	AC	4.0	$ 8,000.00	$ 32,000
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	3,500	$ 8.00	$ 28,000
Embankment	CY	100	$ 12.00	$ 1,200
Prepared Soil Layer (12")	SY	1,840	$ 2.50	$ 4,600
Concrete Sediment Basin	EA	1	$ 40,000.00	$ 40,000
Fabric Formed Concrete Filter Points	SY	1,800	$ 55.00	$ 99,000
Riprap	TN	64	$ 75.00	$ 4,800
Bedding Stone with Geotextile Fabric	TN	23	$ 90.00	$ 2,070
Sod	SY	2,270	$ 2.50	$ 5,675
Planting for Wetland	LS	1	$ 1,618.00	$ 1,618
Tree Planting (1 gal on 20ft centers)	LS	1	$ 3,080.00	$ 3,080
Contingency (25%)	LS	1	$ 60,599.83	$ 60,600
			SUBTOTAL	$ 306,079
Survey	LS	1	$ 15,000.00	$ 15,000
Design and Permitting	LS	1	$ 45,000.00	$ 45,000
Maintenance of Exotic Species (5 Years)	YR	7	$ 365.00	$ 2,555
			SUBTOTAL	$ 62,555
			OPINION OF PROBABLE COST (ROUNDED)	**$ 368,600**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

SMP7 - Sarasota High School at Tamiami Trail



Site Evaluation

A waterway between the school maintenance building and the school has erosion on both banks, and herbicide has been applied on the west bank. A large weir controls the flow through this site. There is significant algae growth north of the weir and non-native vegetation in the waterway on the south side of the weir. There is an ARMS station with a small dock in disrepair onsite.

Proposed Project Elements

- Eliminate herbicide use on banks
- Add skimmer to weir
- Pull back top of bank on the west side
- Regrade eroded slopes and plant native vegetation
- Relocate dumpsters and trash cans away from waterway
- Install LID components
- Add curb cuts
- Create bioswale

Benefits

Adding curb cuts and a bioswale will decrease the sediment and pollutants washing from the lot directly into the bayou. Pulling back the bank and regrading eroded slopes will reduce erosion and downstream sedimentation. Incorporating native vegetation will reduce maintenance costs and eliminate the need for herbicides. Adding a skimmer and relocating dumpsters will reduce pollution. Refurbishing the dock and incorporating LID components will provide educational opportunities on campus.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 400
- TP (lb/yr): 4
- TN (lb/yr): 16

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $48,100

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP7 - Sarasota High School at Tamiami Trail

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Sarasota High School at Tamiami Trail	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 2,549.30	$ 2,549
Clearing and Grubbing	AC	0.5	$ 8,000.00	$ 4,000
Silt Fence	LF	600	$ 2.00	$ 1,200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	500	$ 8.00	$ 4,000
Embankment	CY	50	$ 12.00	$ 600
Prepared Soil Layer (12")	SY	890	$ 2.50	$ 2,225
Concrete Curb Cut	EA	5	$ 75.00	$ 375
Weir Skimmer	EA	1	$ 1,000.00	$ 1,000
Sod	SY	900	$ 2.50	$ 2,250
Planting for Bioswale	LS	1	$ 1,029.00	$ 1,029
Planting for Buffer	LS	1	$ 614.00	$ 614
Dock	LF	20	$ 200.00	$ 4,000
Educational Kiosk	EA	2	$ 1,500.00	$ 3,000
Contingency (25%)	LS	1	$ 7,010.58	$ 7,011
			SUBTOTAL	$ 35,053
Survey	LS	1	$ 3,000.00	$ 3,000
Design and Permitting	LS	1	$ 10,000.00	$ 10,000
			SUBTOTAL	$ 13,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 48,100**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

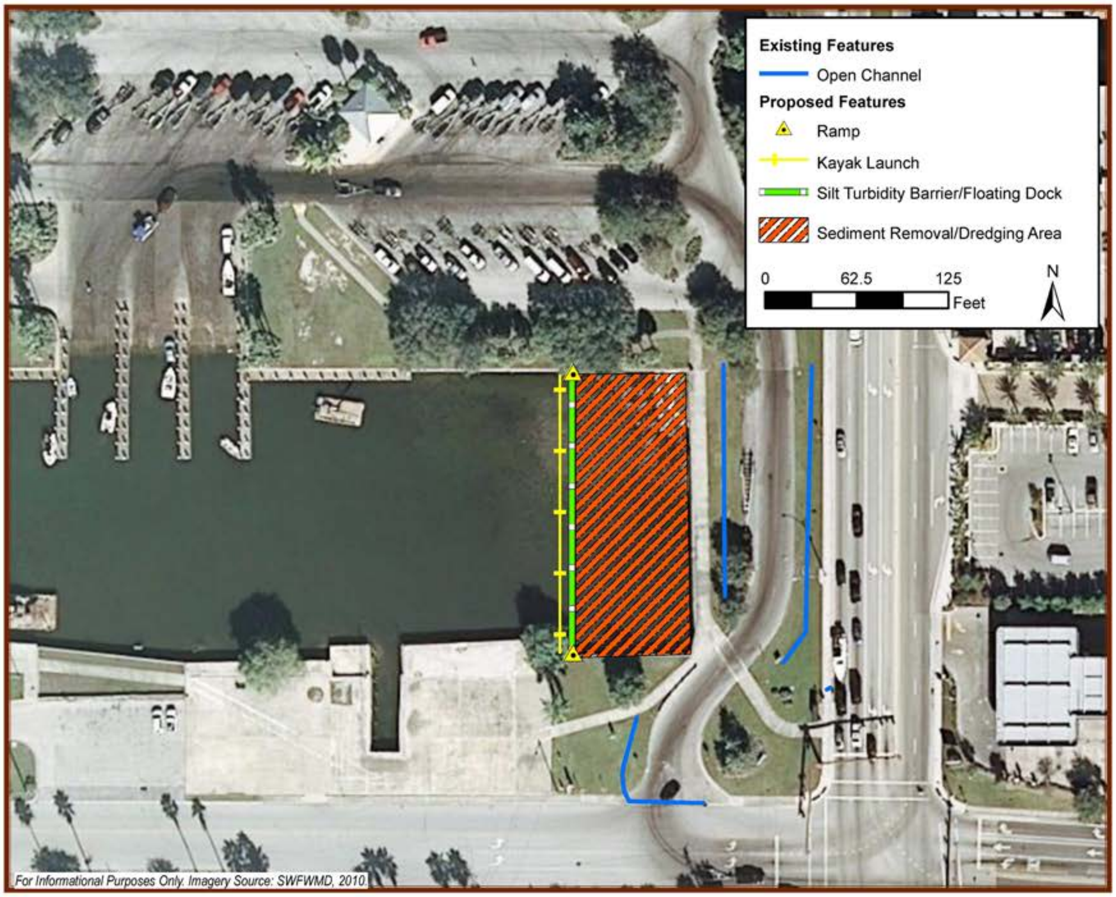
Sarasota County

JONES EDMUNDS

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

SMP8* - 10th Street Boat Basin Dock



Site Evaluation

The 10th Street boat basin is adjacent to Tamiami Trail at the west end of 10th Street. The area draining to this site has high TN, TP, TSS, BOD, and fecal coliform SIMPLE pollutant loads. The 10th Street Outfall discharges untreated runoff from a large contributing area into the boat basin. Stakeholders and County employees have expressed concern about the amount of garbage and debris that enters the bay from the outfall. There is also a large area of sedimentation in the northeast corner of the site.

Proposed Project Elements

- Two Options:
  - 1- Concrete Cinderblock Wall Structure w/ ~2'x2' open notches @ top
  - 2 - Floating Turbidity Silt Barrier (Type III) -low cost alternative
- Annual dredging behind barrier

Benefits

Project will reduce the amount of debris and sediment entering Sarasota Bay from the 10th Street outfall. A cinderblock wall structure or a turbidity barrier will confine settling to a discrete, maintainable area. Adding a kayak launch will add a recreational component to this project.

Pollutant Removal Estimate (Avg)

- Erosion Prevention and Sediment Control (CY): 630

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $476,400

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

SMP8 - 10th Street Boat Basin Dock

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
10th Street Silt Barrier	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

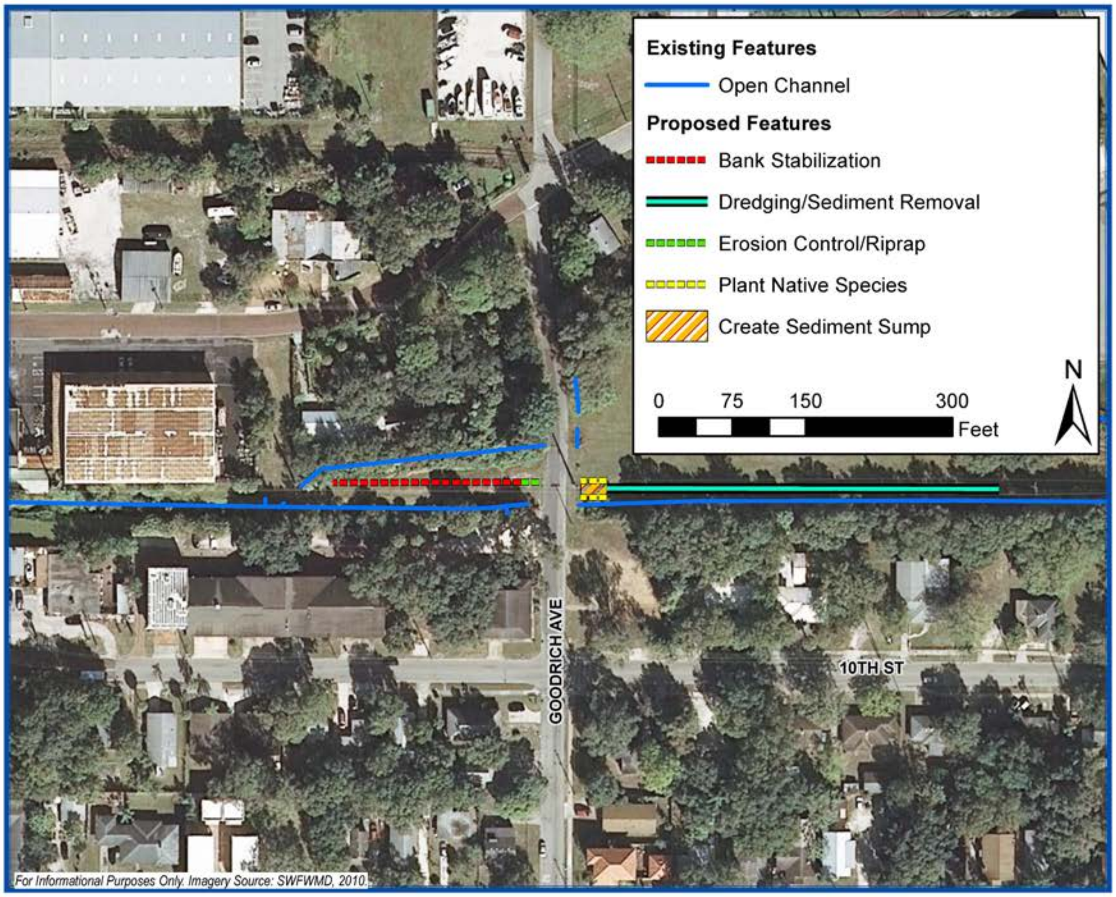
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 32,317.50	$ 32,318
Clearing and Grubbing	AC	0.5	$ 4,000.00	$ 2,000
Silt Fence	LF	400	$ 2.00	$ 800
Floating Turbidity Barrier	LF	400	$ 12.00	$ 4,800
Excavation	CY	1,850	$ 8.00	$ 14,800
Embankment	CY	50	$ 12.00	$ 600
Concrete Ramps with Handrails	EA	2	$ 75,000.00	$ 150,000
Sediment Basin	EA	1	$ 150,000.00	$ 150,000
Sod	SY	70	$ 2.50	$ 175
Contingency (25%)	LS	1	$ 88,873.13	$ 88,873
			SUBTOTAL	$ 444,366
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 30,000.00	$ 30,000
			SUBTOTAL	$ 32,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 476,400**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

WQ1 - North Gillespie Park



Site Evaluation

A channel runs east-west north of 10th Street. The banks on the north and south side have loose sands and are eroded. Multiple pipes are discharging to the stream without signs of erosion control or water quality treatment. Several property owners have tried to stabilize the top of bank with bricks and sandbags. A small ditch carries flow parallel to the stream from Goodrich Avenue west approximately 200 feet.

Proposed Project Elements

- Bank stabilization
- Add sediment sump
- Add public education (partner with children's garden and kiosk)

Benefits

Bank stabilization will reduce erosion and retain sediment thereby protecting adjacent properties and improving flood control conditions. The addition of a sediment sump will reduce flow velocities and promote settling of sediment in an area that will not adversely impact flood control or habitats. Adding informational kiosks will provide learning opportunities to students at the adjacent school.

Pollutant Removal Estimate (Avg)

- Erosion Prevention and Sediment Control (CY): 460

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $103,700

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WQ1 - North Gillespie Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
North Gillespie Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 6,306.85	$ 6,307
Clearing and Grubbing	AC	0.5	$ 4,000.00	$ 2,000
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	250	$ 8.00	$ 2,000
Embankment	CY	20	$ 12.00	$ 240
Prepared Soil Layer (12")	SY	75	$ 2.50	$ 188
Riprap	TN	128	$ 75.00	$ 9,600
Bedding Stone with Geotextile Fabric	TN	46	$ 90.00	$ 4,140
Concrete Sediment Basin	EA	1	$ 40,000.00	$ 40,000
Sod	SY	650	$ 2.50	$ 1,625
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Planting for Stream Banks	LS	1	$ 376.00	$ 376
Contingency (25%)	LS	1	$ 17,343.84	$ 17,344
			SUBTOTAL	$ 86,719
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 15,000.00	$ 15,000
			SUBTOTAL	$ 17,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 103,700**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

JONES EDMUNDS

Janicki Environmental, Inc.

Southwest Florida Water Management District

Sarasota Bay Water Quality Management Plan

WQ2 - Bayfront Parking Lot

Site Evaluation

This site is adjacent to Sarasota Bay along the west side of Bayfront Drive near Ringling Blvd. Untreated stormwater from Bayfront Drive and the parking lot flows through curb inlet and grates that lead to several pipes that discharge into Sarasota Bay. Large pipes also discharge untreated runoff from the urbanized area to the east. The drainage area just upstream of this project site contains high TN, TSS, BOD, and fecal coliform SIMPLE loads. Additionally, stakeholders and County employees have expressed concern about the amount of garbage and debris that comes out of these outfalls.

Proposed Project Elements

- Install pervious pavement to parking lot*
- Install baffle boxes and grate baskets
- Install ashtray stands
- Install curb cuts and LID to medians
- Create motorcycle/fuel efficient car parking

*Note: High traffic and turn areas need to be analyzed for suitable pavement type.

Benefits

Adding a dedicated motorcycle and smart car parking area with pervious pavement and replacing foot traffic areas with pervious pavement will facilitate stormwater infiltration. Adding curb cuts and LID components to existing parking lot medians will provide water quality treatment before the flow enters the bay. Incorporating baffle boxes in the easement between the parking lot and Bayfront Boulevard will help to intercept litter and sediment from the downtown area before it reaches the outfall.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 14,958
- TP (lb/yr): 12
- TN (lb/yr): 217

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $1,007,300

Sarasota Bay Water Quality Management Plan
Conceptual Level Cost Estimate
WQ2 - Bayfront Parking Lot

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Bayfront Parking Lot	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 67,437.00	$ 67,437
Clearing and Grubbing	AC	1.3	$ 8,000.00	$ 10,000
Silt Fence	LF	2,000	$ 2.00	$ 4,000
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	960	$ 8.00	$ 7,680
Embankment	CY	10	$ 12.00	$ 120
Pervious Pavement (6")	SF	53,615	$ 8.00	$ 428,920
Pavement Striping/Signage	LS	1	$ 8,000.00	$ 8,000
Grate Basket	EA	2	$ 5,000.00	$ 10,000
Baffle Box	EA	4	$ 50,000.00	$ 200,000
Sod	SY	980	$ 2.50	$ 2,450
Ashtray Stand	EA	4	$ 500.00	$ 2,000
Contingency (25%)	LS	1	$ 185,451.75	$ 185,452
			SUBTOTAL	$ 927,259
Survey	LS	1	$ 5,000.00	$ 5,000
Design and Permitting	LS	1	$ 75,000.00	$ 75,000
			SUBTOTAL	$ 80,000
OPINION OF PROBABLE COST (ROUNDED)				**$ 1,007,300**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

WQ5 - Hudson Bayou North Branch

Site Evaluation

This site includes the Sarasota County Administration building and parking lots. Runoff from the south parking lot flows through a rock-lined retention swale that runs the length of the lot on the south side of Morrill Street and into a large outfall at the northwest corner. The outfall connects to a 48-inch pipe that discharges to Hudson Bayou. Untreated runoff from Morrill Street and the north parking lot flows into the Ringling Boulevard drainage system. In addition to runoff from the parking lot, a steady flow of water from the cooling system in the County building is also being discharged to the Ringling Boulevard system.

Proposed Project Elements

- Install LID components and curb cuts
- Raise the bleed-down elevation in the control structure
- Install cistern on the building
- Create bioretention swale

Benefits

The proposed biofiltration swale will provide pollutant removal for the impervious area and will decrease surface runoff rate. The cistern will facilitate irrigation and maintenance of the biofiltration vegetation. Adding LID components and curb cuts to the parking lot medians will treat the stormwater before it reaches the outfall structures.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 213
- TP (lb/yr): 2
- TN (lb/yr): 9

Stormwater Harvesting Yield *(Avg)*:

- 1 acre-feet/year

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $52,900

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WQ5 - Hudson Bayou North Branch

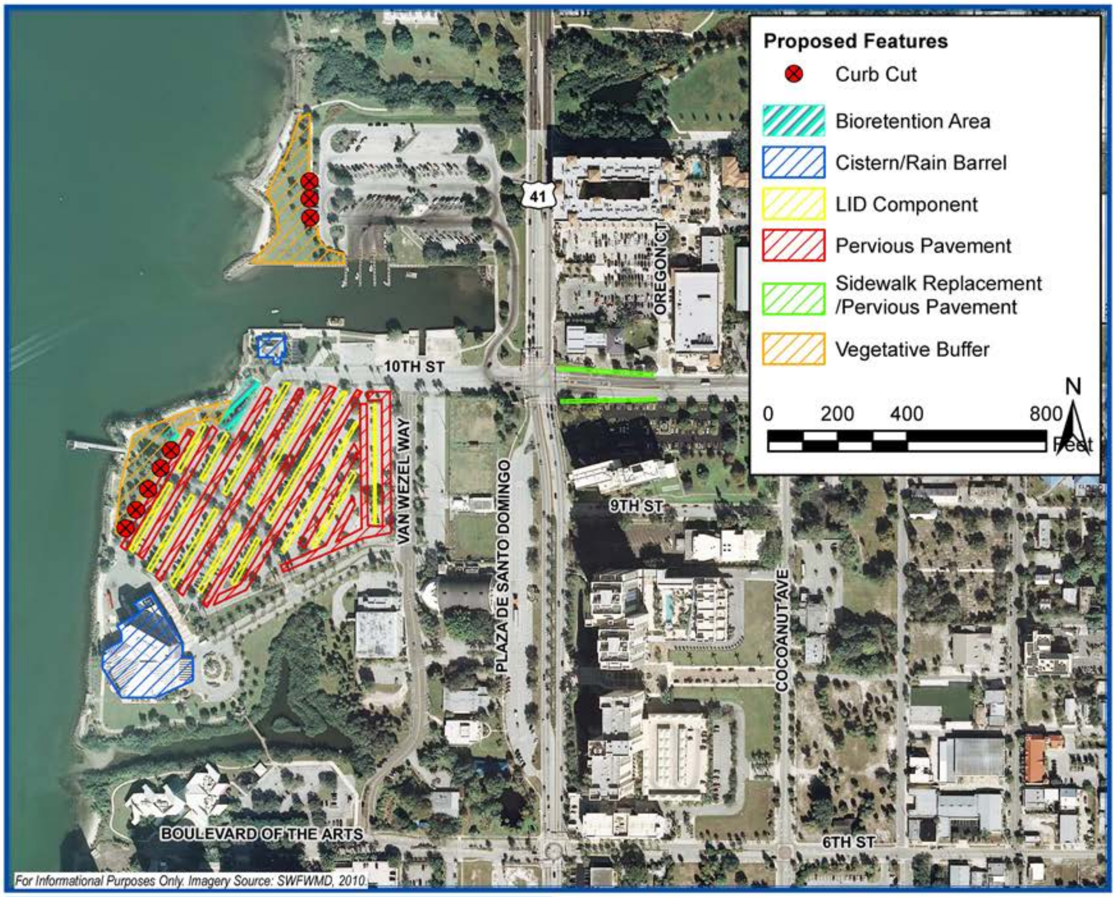
OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Hudson Bayou North Branch	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 2,612.10	$ 2,612
Clearing and Grubbing	AC	0.2	$ 4,000.00	$ 800
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	50	$ 12.00	$ 600
Excavation	CY	335	$ 8.00	$ 2,680
Embankment	CY	5	$ 12.00	$ 60
Prepared Soil Layer (12")	SY	400	$ 2.50	$ 1,000
Modify Outfall Structure	EA	1	$ 250.00	$ 250
Concrete Curb Cuts	EA	6	$ 75.00	$ 450
Sod	SY	600	$ 2.50	$ 1,500
Cistern	EA	3	$ 6,000.00	$ 18,000
Planting for Bioretention Swale	LS	1	$ 581.00	$ 581
Contingency (25%)	LS	1	$ 7,183.28	$ 7,183
			SUBTOTAL	$ 35,916
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 15,000.00	$ 15,000
			SUBTOTAL	$ 17,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 52,900**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota Bay Water Quality Management Plan

WQ7 - 10th Street Outfall



Site Evaluation

A U.S. Coast Guard station and the Van Wezel Performing Arts Hall are at the northwest and southwest corners of this site. There are small grassed treatment areas between the parking lot and the bay. The sidewalks on either side of 10th Street, east of Tamiami Trail, are cracked and broken. Untreated stormwater from nearby streets and the parking lot flows through curb inlet and grates that lead to several pipes that discharge into Sarasota Bay. The drainage area just upstream of this project site contains high load volumes according to SIMPLE.

Proposed Project Elements

- Install curb cuts and LID practices
- Install pervious pavement in the parking lot*
- Construct vegetative buffers between parking lot and grassed waterfront areas
- Install rain barrels at all onsite buildings
- Install pervious sidewalk along 10th Street

*Note: High traffic and turn areas need to be analyzed for suitable pavement type.

Benefits

The proposed bioretention areas and buffer will provide pollutant removal for the impervious area and will decrease surface runoff rate. The cistern and/or rain barrels will facilitate irrigation and maintenance of the onsite vegetation. Cistern use will reduce also the surface-water runoff from areas that do not currently receive stormwater treatment. Adding LID components and curb cuts to the parking lot medians will treat the stormwater before it reaches the outfall structures.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 4,913
- TP (lb/yr): 22
- TN (lb/yr): 192

Opinion of Probable Cost (Conceptual Level Estimate)

- $1,362,400

JONES EDMUNDS

Sarasota County

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WQ7 - 10th St Outfall

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
10th Street Outfall	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 91,760.40	$ 91,760
Clearing and Grubbing	AC	5.0	$ 6,000.00	$ 30,000
Silt Fence	LF	1,000	$ 2.00	$ 2,000
Floating Turbidity Barrier	LF	500	$ 12.00	$ 6,000
Excavation	CY	2,270	$ 8.00	$ 18,160
Embankment	CY	5	$ 12.00	$ 60
Prepared Soil Layer (12")	SY	1,220	$ 2.50	$ 3,050
Pervious Sidewalk Pavement (4")	SF	4,580	$ 6.00	$ 27,480
Pervious Pavement (6")	SF	100,400	$ 8.00	$ 803,200
Pavement Markings/Signage	LS	1	$ 1,500.00	$ 1,500
Concrete Curb Cuts	EA	8	$ 75.00	$ 600
Sod	SY	4,500	$ 2.50	$ 11,250
Cistern	EA	2	$ 4,000.00	$ 8,000
Planting for Vegetative Buffer	LS	1	$ 6,304.00	$ 6,304
Planting for Bioretention Area	LS	1	$ 724.00	$ 724
Contingency (25%)	LS	1	$ 252,341.10	$ 252,341
			SUBTOTAL	$ 1,262,430
Survey	LS	1	$ 20,000.00	$ 20,000
Design and Permitting	LS	1	$ 80,000.00	$ 80,000
			SUBTOTAL	$ 100,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 1,362,400**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

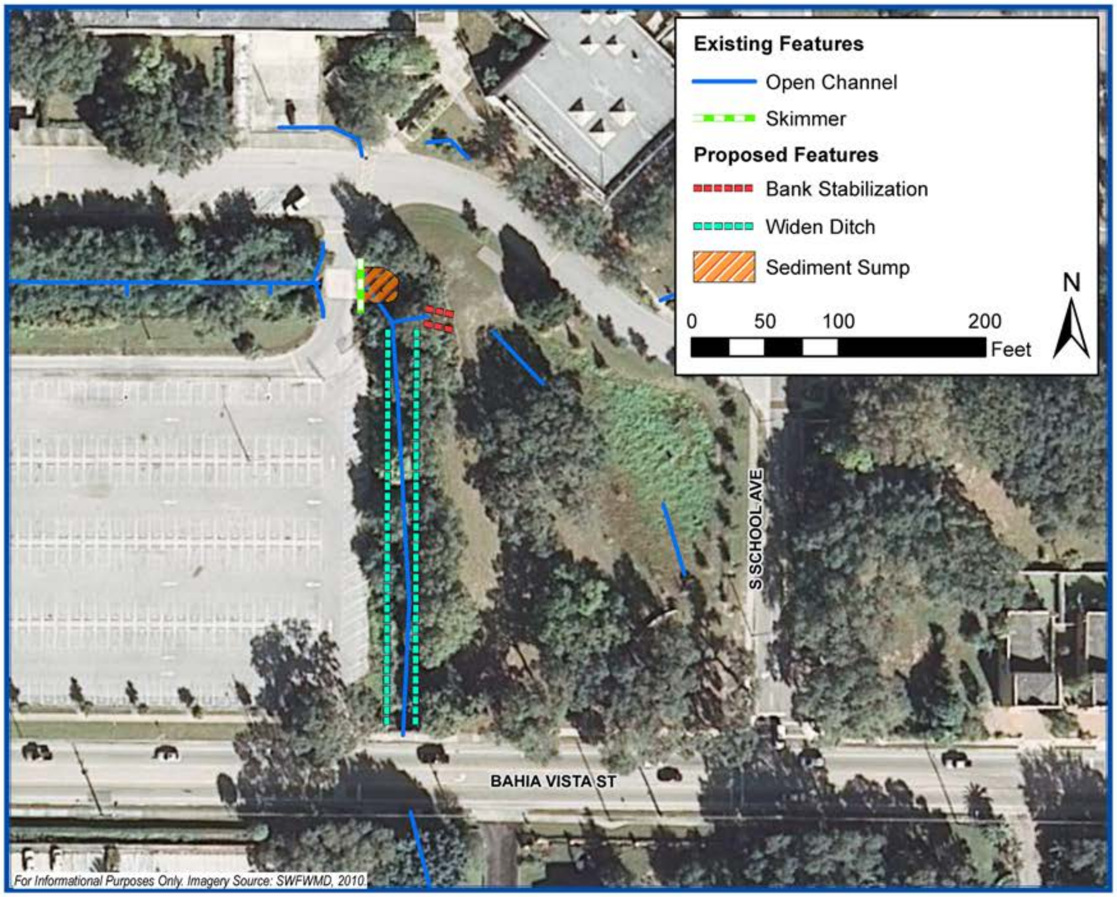
Sarasota County

Sarasota Bay Water Quality Management Plan

WQ9 - Hudson Bayou East Branch

Jones Edmunds

Janicki Environmental, Inc.



Site Evaluation

The south-to-north ditch from Bahia Vista Street is full of muck and trash. A 10-inch pipe discharges from a retention area to the north end of the ditch. The bank around the pipe is eroded, and the ditch is sedimented and heavily vegetated at this point. Approximately a meter north of this, the ditch bends 90 degrees to the west to a skimmer and 82-inch square culvert. The skimmer is full of debris, and both sides of the culvert contain muck and garbage.

Proposed Project Elements

- Clean out the existing skimmer bimonthly
- Dredge ditch
- Stabilize the ditch banks
- Widen the ditch
- Create sediment sump

Benefits

Widening the ditch will facilitate pollutant removal and stabilizing the banks will help to alleviate further erosion. The sediment sump will provide a settling area for suspended solids that is easily accessible for maintenance and cleanout.

Pollutant Removal Estimate (Avg)

- Erosion Prevention and Sediment Control (CY): 92

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $112,900

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WQ9 - Hudson Bayou East Branch

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Hudson Bayou East Branch	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 6,607.90	$ 6,608
Clearing and Grubbing	AC	0.2	$ 4,000.00	$ 800
Silt Fence	LF	100	$ 2.00	$ 200
Floating Turbidity Barrier	LF	100	$ 12.00	$ 1,200
Excavation	CY	650	$ 8.00	$ 5,200
Embankment	CY	5	$ 12.00	$ 60
Prepared Soil Layer (12")	SY	70	$ 2.50	$ 175
Riprap	TN	128	$ 75.00	$ 9,600
Bedding Stone with Geotextile Fabric	TN	64	$ 90.00	$ 5,760
Concrete Sediment Basin	EA	1	$ 40,000.00	$ 40,000
Sod	SY	780	$ 2.50	$ 1,950
Planting for Stream Bank	LS	1	$ 1,134.00	$ 1,134
Contingency (25%)	LS	1	$ 18,171.73	$ 18,172
			SUBTOTAL	$ 90,859
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 20,000.00	$ 20,000
			SUBTOTAL	$ 22,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 112,900**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

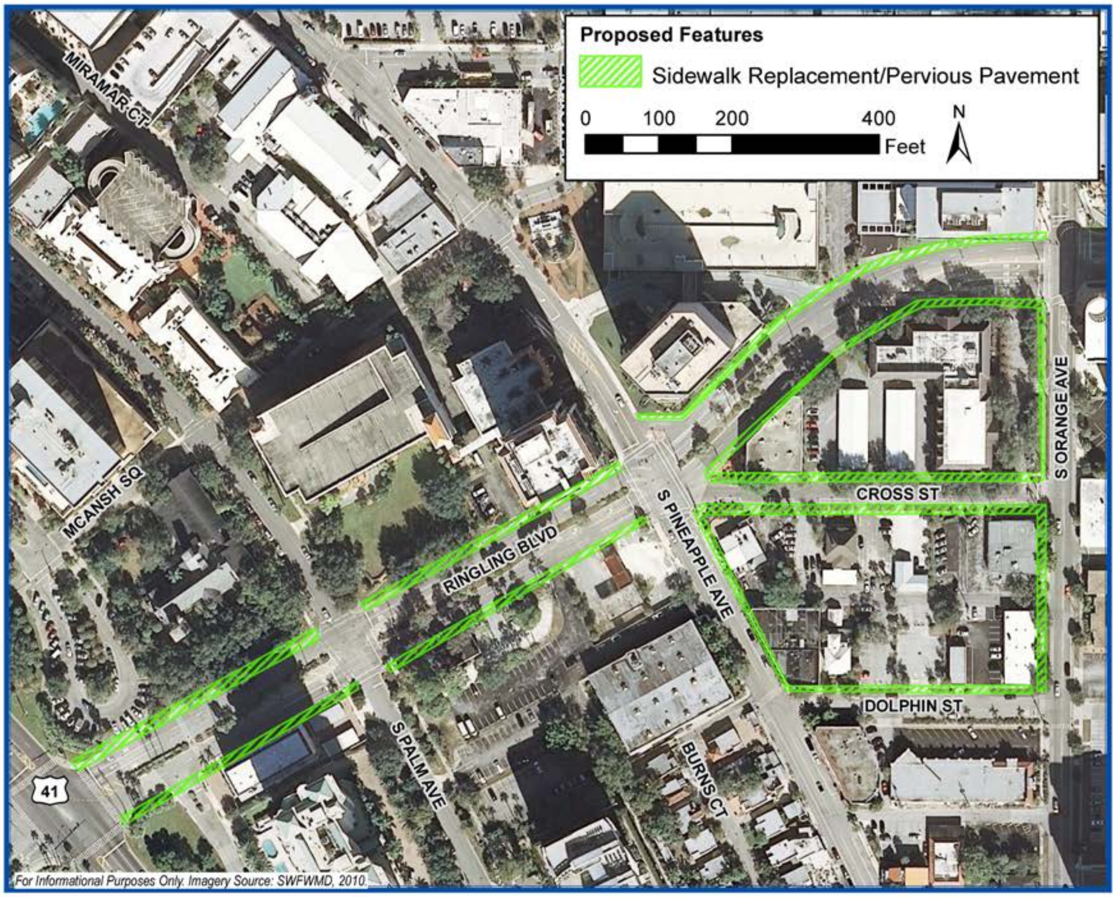
Jones Edmunds

Janicki Environmental, Inc.

Southwest Florida Water Management District

Sarasota Bay Water Quality Management Plan

WQ10 - Ringling Blvd Sidewalks



Site Evaluation

This site includes the length of Ringling Boulevard through downtown Sarasota. The area has high TN, TSS, BOD, and fecal coliform SIMPLE pollutant-load results. Untreated stormwater from Ringling Boulevard and surrounding developed areas enters the stormwater conveyance along Ringling Boulevard via curb inlets. A large pipe drains directly to Sarasota Bay. The area is highly urbanized and consists mostly of DCIA. There is very little space for infiltration to occur.

Proposed Project Elements

- Replace concrete sidewalks with pervious concrete or pavers

Benefits

Replacing the traditional sidewalks with pervious concrete or pervious pavers along Ringling Boulevard from US 41 east to S. Orange Avenue will increase infiltration of runoff in this highly urbanized area.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 913
- TP (lb/yr): 3
- TN (lb/yr): 20

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $396,400

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WQ10 - Ringling Blvd. Sidewalks

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Ringling Boulevard Sidewalks	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**4/24/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 27,447.80	$ 27,448
Silt Fence	LF	100	$ 2.00	$ 200
Remove Concrete (Phase 1)	AC	0.23	$ 8,000.00	$ 1,840
Pervious Sidewalk Pavement (4") (Phase 1)	SF	10,003	$ 6.00	$ 60,018
Remove Concrete (Phase 2)	AC	0.21	$ 8,000.00	$ 1,680
Pervious Sidewalk Pavement (4") (Phase 2)	SF	9,092	$ 6.00	$ 54,552
Remove Concrete (Phase 3)	AC	0.58	$ 8,000.00	$ 4,640
Pervious Sidewalk Pavement (4") (Phase 3)	SF	25,258	$ 6.00	$ 151,548
Contingency (25%)	LS	1	$ 75,481.45	$ 75,481
			SUBTOTAL	$ 377,407
Survey	LS	1	$ 4,000.00	$ 4,000
Design and Permitting	LS	1	$ 15,000.00	$ 15,000
			SUBTOTAL	$ 19,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 396,400**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

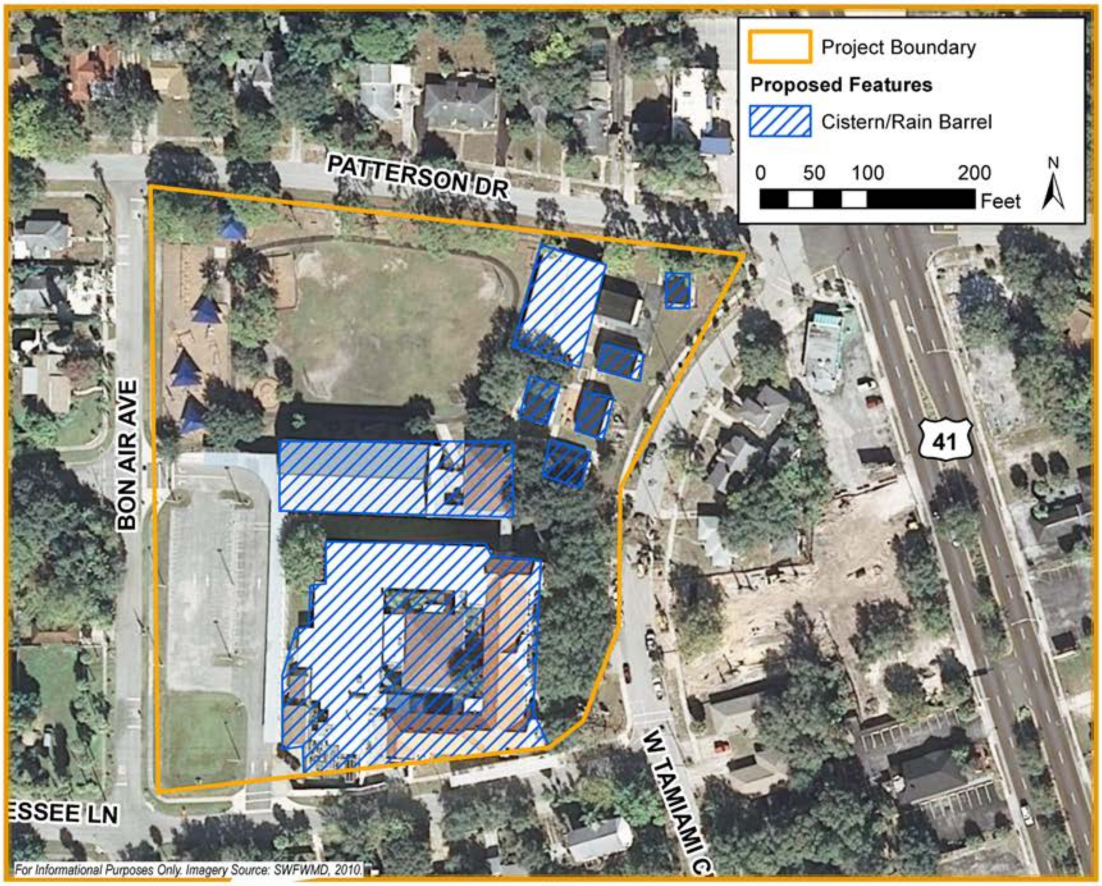
Sarasota County

Jones Edmunds

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

WS02 - Bay Haven Elementary



Site Evaluation

This site is at Bay Haven Elementary School, just west of US 41 and south of Patterson Drive. This school is an appropriate site for a cistern as there are large building onsite and the school currently irrigates its grounds using potable water. Runoff volumes at Bay Haven Elementary are slightly higher than historical conditions, and the area is not served by reclaimed lines.

Proposed Project Elements

- Install cisterns
- Irrigate with harvested rainwater (before potable water)
- Install rain barrels
- Create educational program

Benefits

A cistern will reduce the amount of stormwater runoff which is currently higher in this area than it was in the 1950s. Stormwater collected in the cisterns could be used to water the school grounds, which will reduce the school's use of potable water.

Implementing an education outreach program with faculty and students where they monitor rainfall, install rain barrels, and maintain rain barrels and cisterns will teach students to conserve stormwater and will facilitate shared learning in their communities.

Stormwater Harvest Yield *(Avg):* 3 Acre-feet/year

Pollutant Removal Estimate *(Avg):* TN: 4 lb/yr

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $80,800

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS02 - Bay Haven Elementary School

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Bay Haven Elementary School	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

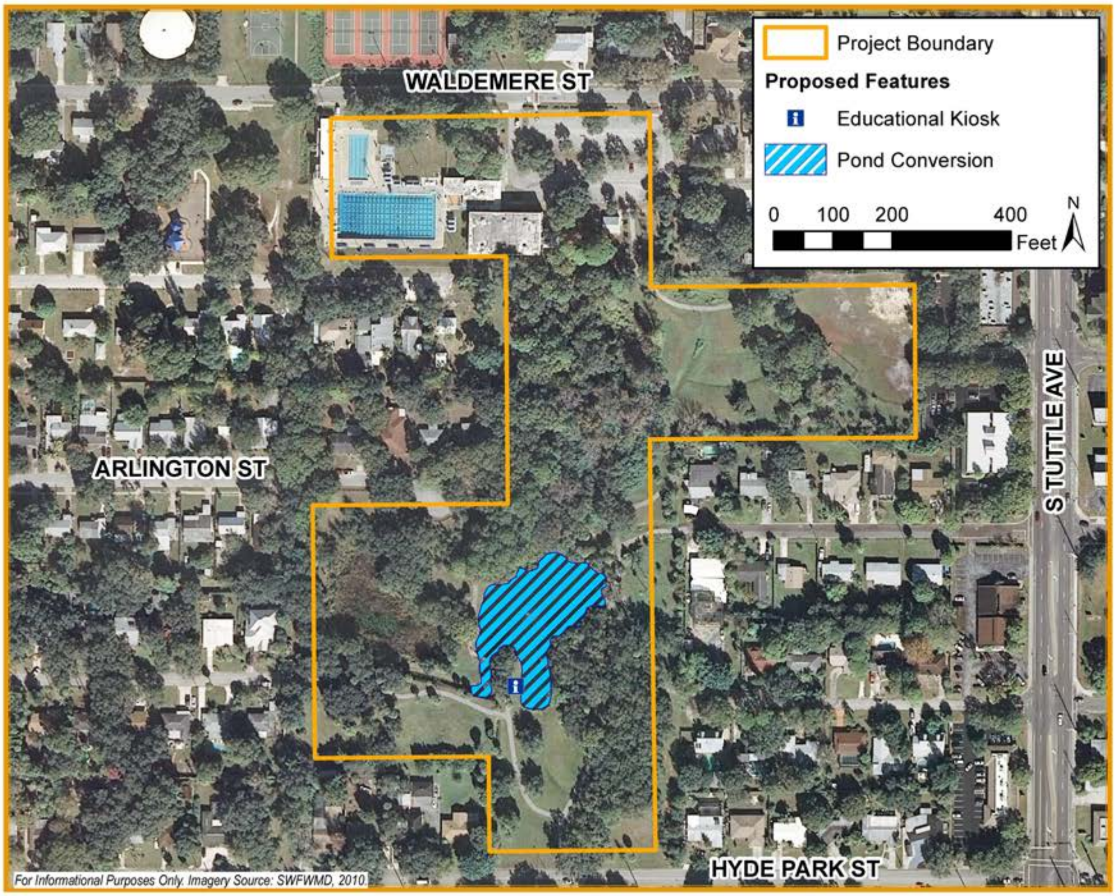
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 5,221.25	$ 5,221
2500 gallon Cistern	EA	7	$ 6,000.00	$ 42,000
Irrigation Pump	EA	2	$ 1,000.00	$ 2,000
Fittings, Supplies, and Electrical	LS	1	$ 8,000.00	$ 8,000
Sod	SY	85	$ 2.50	$ 213
Contingency (25%)	LS	1	$ 14,358.44	$ 14,358
			SUBTOTAL	$ 71,792
Survey	LS	1	$ 1,000.00	$ 1,000
Design and Permitting	LS	1	$ 8,000.00	$ 8,000
			SUBTOTAL	$ 9,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 80,800**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

WS04 - Arlington Park and Aquatic Complex



Site Evaluation

The Arlington Park and Aquatic Complex is an approximately 15-acre site that is owned by the City of Sarasota and operated by Sarasota County. The complex is east of Tamiami Trail between Waldemere and Hyde Park Streets. The complex offers recreational as well as aquatic services such as multiple pools, basketball, tennis, and racquetball courts, playground, walking trail, and gymnasium.

The site is partially irrigated with potable water. Stormwater runoff from the site and adjacent areas drain to a large on-site stormwater pond via swales and open ditches. The pond discharges off site to the west via an open channel to the Hudson Canal. Stormwater runoff in this area is higher than the 1950s.

Proposed Project Elements

- Convert on-site ponds to stormwater-harvesting ponds
- Install a public education kiosk (how to/benefits of stormwater-harvesting ponds)

Benefits

Converting the existing pond to a stormwater-harvesting pond will supply irrigation to the complex which will reduce runoff from the site as well as potable water use.

Installing public education kiosks will provide the public with an explanation of the stormwater harvesting pond and the benefits of water conservation.

Stormwater Harvest Yield (Avg): 33 acre-feet/year

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $39,200

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS04 - Arlington Park and Aquatic Complex

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Arlington Park and Aquatic Complex	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

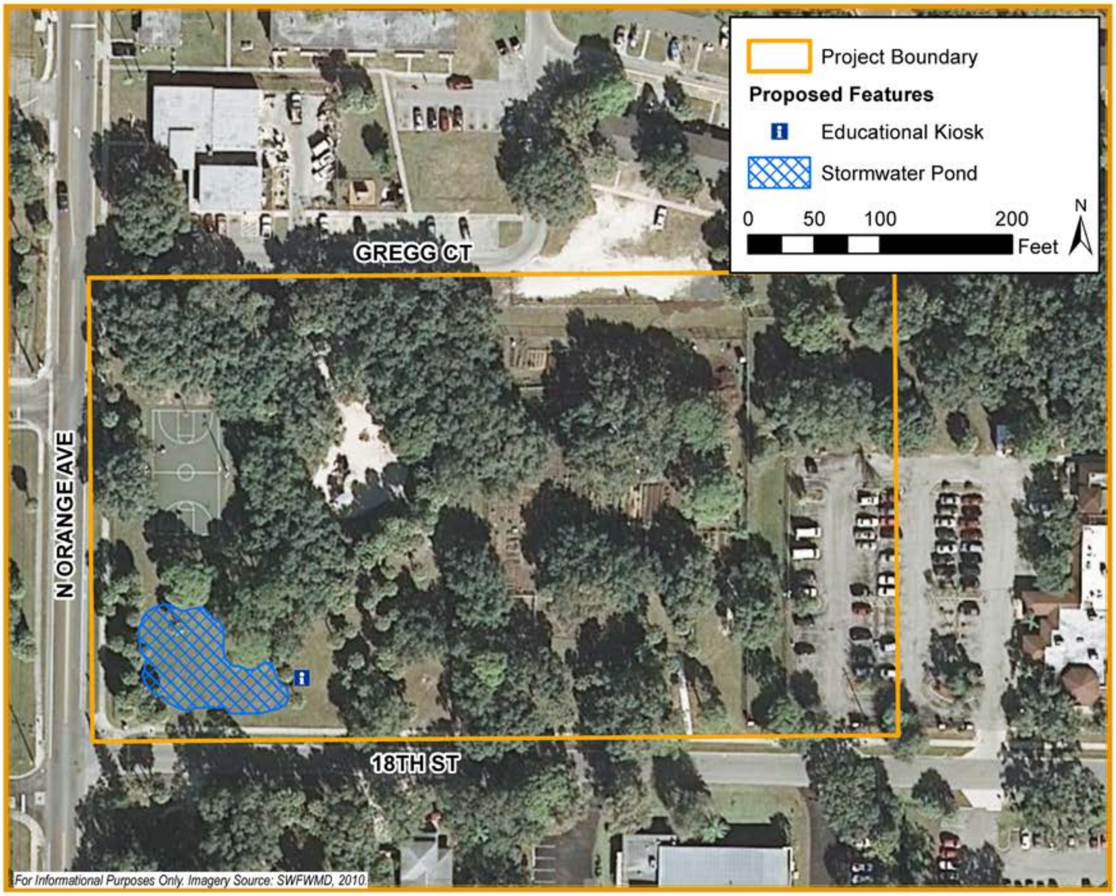
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 2,052.50	$ 2,053
Irrigation Pump	EA	4	$ 1,000.00	$ 4,000
Fittings, Supplies, and Electrical	LS	1	$ 15,000.00	$ 15,000
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY	10	$ 2.50	$ 25
Contingency (25%)	LS	1	$ 5,644.38	$ 5,644
			SUBTOTAL	$ 28,222
Survey	LS	1	$ 1,000.00	$ 1,000
Design and Permitting	LS	1	$ 10,000.00	$ 10,000
			SUBTOTAL	$ 11,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 39,200**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

WS05 - Orange Avenue Park



Site Evaluation

Orange Avenue Park is a City-owned, County-operated park at the northeast corner of 18th Street and Orange Avenue. The park is a small community park (approximately 5 acres) within walking distance to neighborhoods and features a basketball court, playground, and picnic areas.

Stormwater runoff from the site has increased from historical conditions and the site is irrigated by potable water. The nearest reclaimed lines are more than a mile from the park.

Proposed Project Elements

- Install a stormwater-harvesting pond
- Irrigate the park with harvested water
- Install a public education kiosk

Benefits

Installing a stormwater harvesting pond will reduce the runoff leaving the site which will reduce the amount of pollutants leaving the site. Irrigating the park landscaping and facilities with harvested water will reduce the parks demands on potable water.

Installing a public education kiosk will explain the purpose of the pond to the residents and will facilitate shared learning about water conservation in their communities.

Stormwater Harvest Yield *(Avg):* 6 acre-ft/year

Pollutant Removal Estimate *(Avg)*

- TSS (lb/yr): 1,343
- TP (lb/yr): 5
- TN (lb/yr): 18

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $103,100

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS05 - Orange Avenue Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Orange Avenue Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 5,532.00	$ 5,532
Clearing and Grubbing	AC	0.2	$ 4,000.00	$ 800
Irrigation Pump	EA	2	$ 1,000.00	$ 2,000
Fittings, Supplies, and Electrical	LS	1	$ 8,000.00	$ 8,000
Excavation	CY	875	$ 8.00	$ 7,000
Embankment	CY	45	$ 12.00	$ 540
Pipe Culvert	LF	400	$ 55.00	$ 22,000
Ditch Bottom Inlet	EA	3	$ 3,000.00	$ 9,000
Mitered End Section	EA	1	$ 1,000.00	$ 1,000
Riprap	TN	32	$ 75.00	$ 2,400
Bedding Stone with Geotextile Fabric	TN	12	$ 90.00	$ 1,080
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY		$ 2.50	$ -
Contingency (25%)	LS	1	$ 15,213.00	$ 15,213
			SUBTOTAL	$ 76,065
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 25,000.00	$ 25,000
			SUBTOTAL	$ 27,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 103,100**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Jones Edmunds

Janicki Environmental, Inc.

Sarasota Bay Water Quality Management Plan

WS06 - Ken Thompson Park

Site Evaluation

Ken Thompson Park is a 92-acre waterfront park on City Island that is City-owned and County-operated. The park has boardwalks through mangroves, tidal marsh restoration areas, and features a boat ramp, kayak launch, fishing pier, playground, bait shop, and rest rooms. The park is in an area with more stormwater runoff than historical conditions. The southwest portion of the park is irrigated by potable water. Large buildings exist on site which would be ideal for capturing rainfall via greenroofs, cisterns, or rain barrels. Buildings on the west portion of the site are leased to Mote Marine Laboratories or others. Educational signs could be posted around the site.

Proposed Project Elements

- Install greenroofs, cisterns, or rain barrels on park buildings
- Replace parking lot asphalt with pervious pavement
- Install a public education kiosk
- Partner with Mote on educational opportunities [water conservation]

Benefits

Installing cisterns, rain barrels, and greenroofs will reduce the amount of stormwater runoff leaving the site which will also reduce the amount of pollutants directly entering the bay. Greenroofs provide additional water benefit. Replacing parking lot asphalt with pervious pavers will further reduce pollutants and stormwater leaving the site. Using the stormwater onsite will reduce the park's potable water demand. Installing public information kiosks will explain how water is harvested and re-used and the benefits of a greenroof. The County should partner with Mote Marine on education opportunities related to stormwater conservation.

Stormwater Harvest Yield *(Avg):* 4 acre-feet/year

Pollutant Removal Estimate *(Avg):*

- TSS (lb/yr): 294 TP (lb/yr): 1 TN (lb/yr): 11

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $884,900

JONES EDMUNDS Sarasota County

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS06 - Ken Thompson Park Preserve

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	
PROJECT TITLE:	APPROVED BY:
Ken Thompson Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

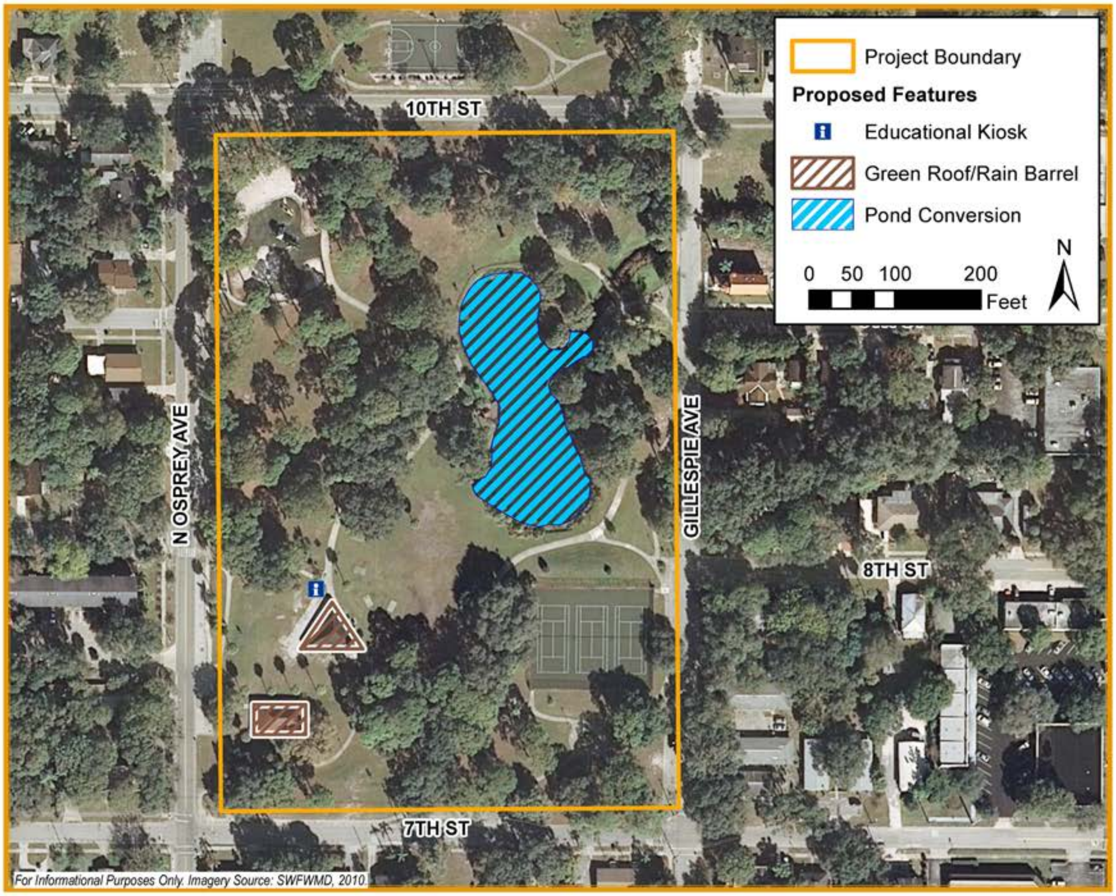
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 62,463.50	$ 62,464
Clearing and Grubbing	AC	1.6	$ 4,000.00	$ 6,400
425 gallon Cistern	EA	2	$ 2,000.00	$ 4,000
2500 gallon Cistern	EA	8	$ 6,000.00	$ 48,000
Irrigation Pump	EA	4	$ 1,000.00	$ 4,000
Fittings, Supplies, and Electrical	LS	1	$ 10,000.00	$ 10,000
Pervious Pavement (6")	SF	67,520	$ 8.00	$ 540,160
Excavation	CY	1,250	$ 8.00	$ 10,000
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY	230	$ 2.50	$ 575
Contingency (25%)	LS	1	$ 171,774.63	$ 171,775
			SUBTOTAL	$ 858,873
Survey	LS	1	$ 1,000.00	$ 1,000
Design and Permitting	LS	1	$ 25,000.00	$ 25,000
			SUBTOTAL	$ 26,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 884,900**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

WS07 - Gillespie Park



Site Evaluation

Gillespie Park is a 10-acre park that is City-owned and County-operated. The park features a Gallery of Patriots, lawn bowling, tennis courts, playgrounds, walking trails, and picnic areas.

Stormwater runoff in the area has increased from historical conditions and although the park does not irrigate with potable water, adjacent residents do and this could be an opportunity to partner with them to reduce local demands on potable water. Buildings and a large stormwater pond are onsite which could be used to capture rainfall before it leaves the site.

Proposed Project Elements

- Install greenroofs and rain barrels on the park buildings
- Convert the existing stormwater pond to a stormwater-harvesting pond
- Install a public education kiosk - [SW harvesting/benefits of a greenroof]

Benefits

Installing rain barrels and greenroofs will reduce the amount of stormwater runoff leaving the site which will also reduce the amount of pollutants entering downstream waterbodies. Converting the stormwater pond to a harvesting pond will provide additional storage during the rainy season allowing more stormwater to be beneficially used as irrigation or other non-potable water source. Using the stormwater onsite or partnering with adjacent residents will help reduce the park's potable water demand.

Installing public information kiosks will explain the purpose of cisterns, rain barrels, and green roofs and will facilitate shared learning about water conservation. The County should partner with Mote Marine on education opportunities related to stormwater conservation.

Stormwater Harvesting Yield *(Avg)*: 9 acre-feet/year

Opinion of Probable Cost *(Conceptual Level Estimate)*

- $32,300

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS07 - Gillespie Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Gillespie Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 1,552.50	$ 1,553
425 gallon Cistern	EA	2	$ 2,000.00	$ 4,000
Irrigation Pump	EA	2	$ 1,000.00	$ 2,000
Fittings, Supplies, and Electrical	LS	1	$ 8,000.00	$ 8,000
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY	10	$ 2.50	$ 25
Contingency (25%)	LS	1	$ 4,269.38	$ 4,269
			SUBTOTAL	$ 21,347
Survey	LS	1	$ 1,000.00	$ 1,000
Design and Permitting	LS	1	$ 10,000.00	$ 10,000
			SUBTOTAL	$ 11,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 32,300**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

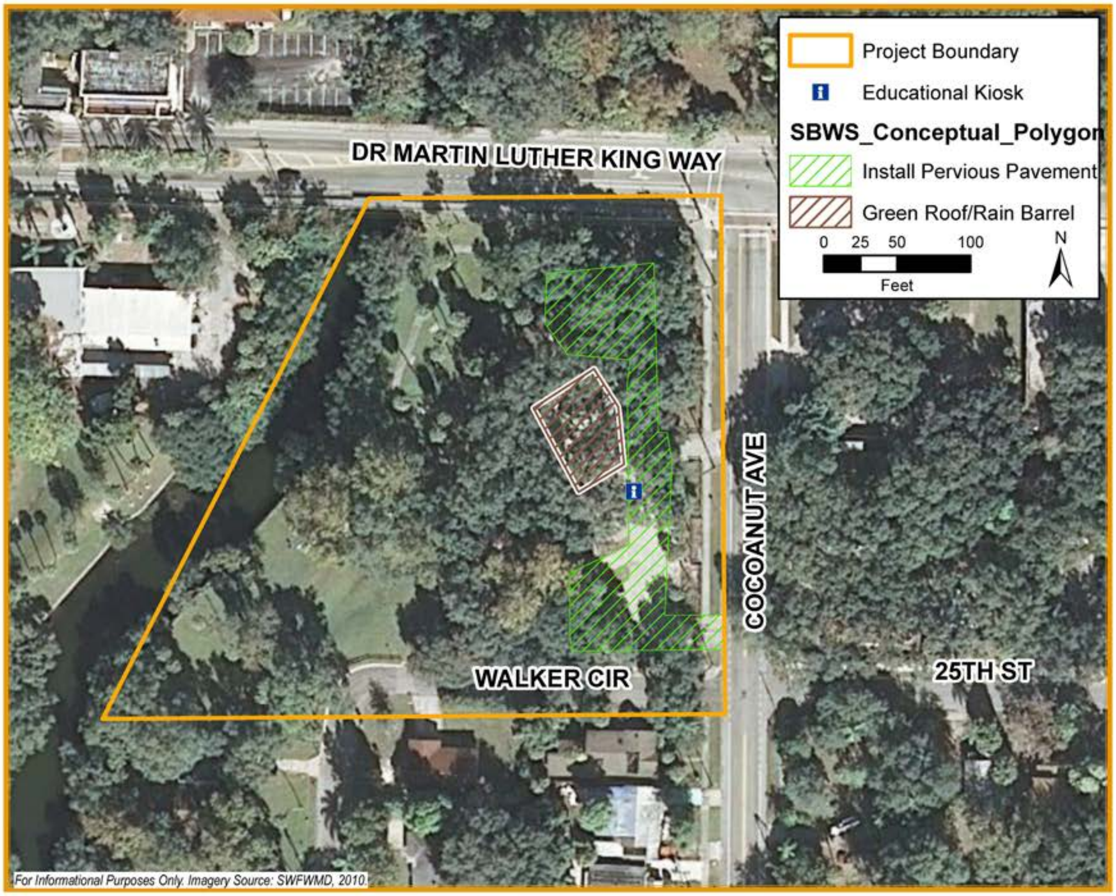
JONES EDMUNDS

Janicki Environmental, Inc.

Southwest Florida Water Management District

Sarasota Bay Water Quality Management Plan

WS10 - Martin Luther King Park



Site Evaluation

Martin Luther King Park is on the southwest corner of Dr. Martin Luther King Jr. Way and Coconut Avenue. This small neighborhood park features picnic areas and a rest room. Whitaker Bayou runs along the west boundary of the park.

The park is in an area with an increase in stormwater runoff from historical conditions which drains untreated directly to Whitaker Bayou.

Proposed Project Elements

- Install a greenroof on the park building
- Install rainbarrels on the park building
- Install a public education kiosk [benefits of green roof]
- Replace parking lot asphalt with pervious pavers*

*Note: High traffic and turn areas need to be analyzed for suitable pavement type.

Benefits

Installing rain barrels and greenroofs reduce the amount of stormwater runoff leaving the site which will also reduce the amount of pollutants directly entering the bay. Replacing parking lot asphalt with pervious pavers will further reduce pollutants and stormwater leaving the site.

Installing public information kiosks will explain the purpose of the rain barrels and green roofs and will facilitate shared learning about water conservation.

Pollutant Removal Estimate (Avg)

- TSS (lb/yr): 50
- TN (lb/yr): 1

Stormwater Harvesting Yield *(Avg):*

- Negligible

Opinion of Probable Cost *(Conceptual Level Estimate)*

- *$187,200*

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS 10 - Martin Luther King Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Martin Luther King Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

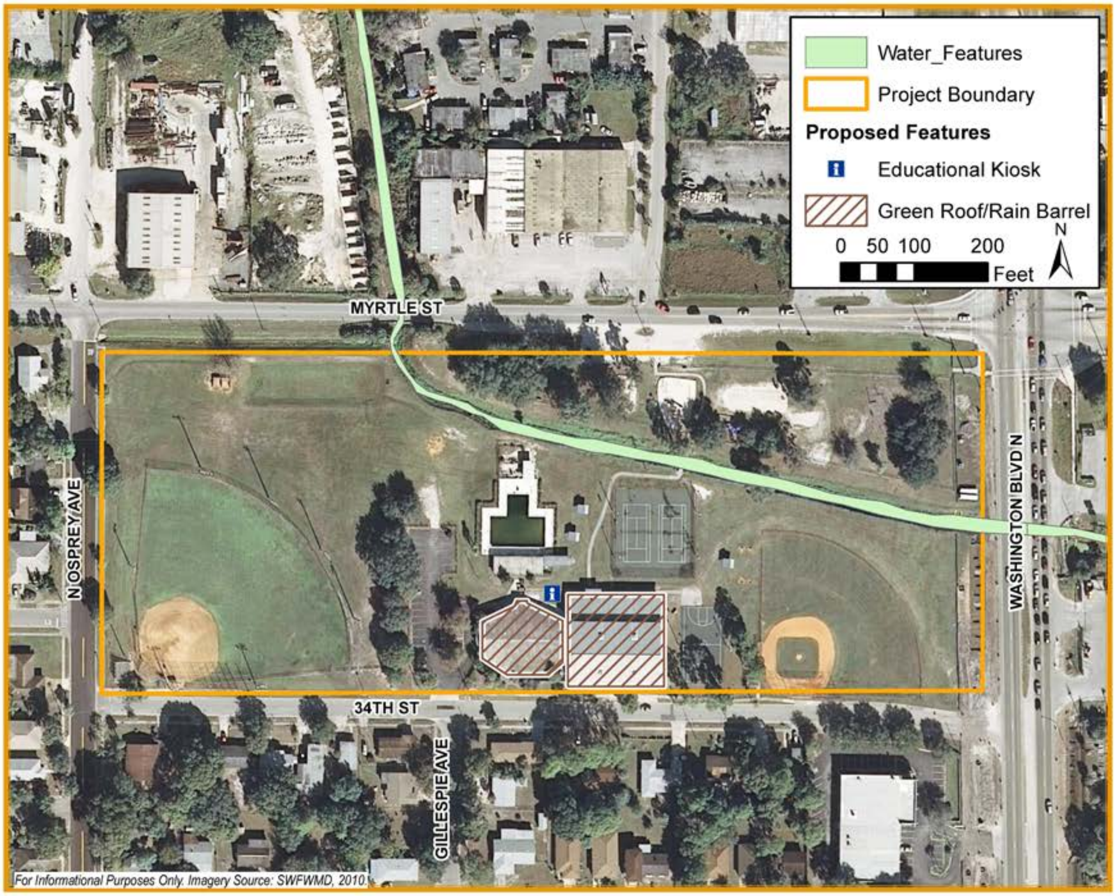
DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 12,016.70	$ 12,017
Clearing and Grubbing	AC	0.3	$ 4,000.00	$ 1,200
325 gallon Cistern	EA	2	$ 1,000.00	$ 2,000
Irrigation Pump	EA	2	$ 1,000.00	$ 2,000
Fittings, Supplies, and Electrical	LS	1	$ 8,000.00	$ 8,000
Pervious Pavement (6")	SF	12,834	$ 8.00	$ 102,672
Excavation	CY	240	$ 8.00	$ 1,920
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY	350	$ 2.50	$ 875
Contingency (25%)	LS	1	$ 33,045.93	$ 33,046
			SUBTOTAL	$ 165,230
Survey	LS	1	$ 2,000.00	$ 2,000
Design and Permitting	LS	1	$ 20,000.00	$ 20,000
			SUBTOTAL	$ 22,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 187,200**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

Sarasota Bay Water Quality Management Plan

WS11 - Robert Taylor Community Complex



Site Evaluation

Robert Taylor Community Complex is a historical community center with a 13-acre campus at the southwest corner of US 301 and Myrtle Street. The complex houses a 44,000 square-foot facility which features indoor and outdoor amenities such as a fitness center, childcare, computer lab, recording studio, aquatic center, amphitheater, and basketball courts.

The Complex is in an area with an increase in stormwater runoff from historical conditions which drains untreated to the Whitaker Canal that runs through the site.

Proposed Project Elements

- Install cisterns/rain barrels
- Wash recreational areas with harvested water
- Start educational program
- Install a public education kiosk

Benefits

Installing rain barrels and cisterns will reduce the amount of stormwater runoff leaving the site and directly entering the Whitaker Canal.

Implementing an education outreach program with staff and residents where they monitor rainfall, install rain barrels and maintain rain barrels and cisterns will teach residents to conserve stormwater and will facilitate shared learning in their communities. Installing public information kiosks will explain the purpose of the rain barrels and cisterns to community members visiting the complex and will facilitate shared learning about water conservation.

Stormwater Harvesting Yield ***(Avg):*** 1 acre-feet/year
Pollutant Removal Estimate ***(Avg):*** TN: 1 lb/yr
Opinion of Probable Cost ***(Conceptual Level Estimate)***

- $77,200

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS11 - Robert Taylor Community Complex

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Robert Taylor Community Complex	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 4,452.50	$ 4,453
2500 gallon Cistern	EA	4	$ 6,000.00	$ 24,000
Irrigation Pump	EA	4	$ 1,000.00	$ 4,000
Fittings, Supplies, and Electrical	LS	1	$ 15,000.00	$ 15,000
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY	10	$ 2.50	$ 25
Contingency (25%)	LS	1	$ 12,244.38	$ 12,244
			SUBTOTAL	$ 61,222
Survey	LS	1	$ 1,000.00	$ 1,000
Design and Permitting	LS	1	$ 15,000.00	$ 15,000
			SUBTOTAL	$ 16,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 77,200**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

Sarasota County

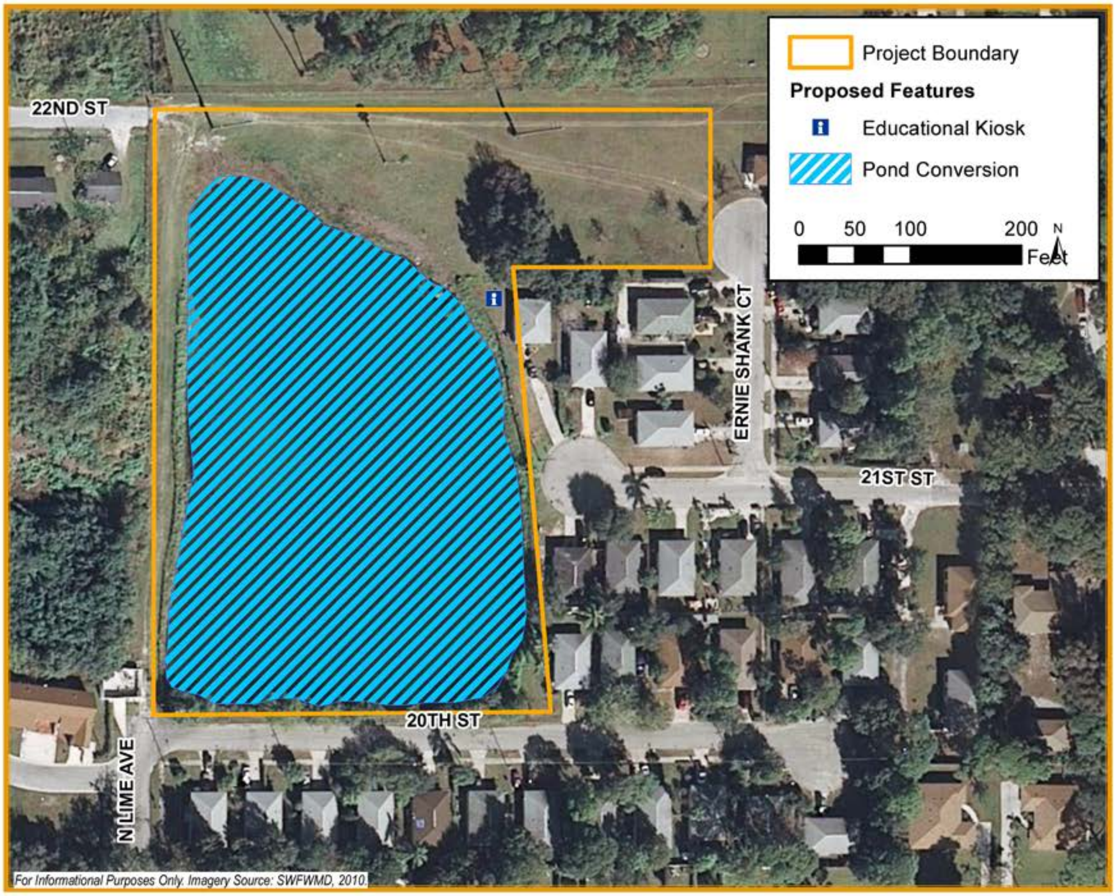
JONES EDMUNDS

Janicki Environmental, Inc.

Southwest Florida Water Management District

Sarasota Bay Water Quality Management Plan

WS12 - Lime Lake Park



Site Evaluation

Lime Lake Park is east of US 301, between 22nd and 20th Streets at the end of Lime Avenue. The park is a small neighborhood park that was recently renovated to include a walking trail around the perimeter of the lake, a fishing pier, gazebo, solar-powered aerator in the middle of the lake (for filtration and aesthetics), benches, picnic tables, ADA parking spaces, areas for shoreline plantings/ restoration, and educational signage. Lime Lake Park is in an area with an increase in stormwater runoff from historical conditions. The park does not appear to have an on-site irrigation system, but local residents irrigate with potable water. Storage is available in the on-site 3-acre pond.

Proposed Project Elements

- Convert the on-site ponds to stormwater-harvesting pond*
- Install a public education kiosk
- Partner with local residents to offset their potable irrigation

*Note: Stormwater harvesting should be designed so that the frequency and drawdown does not impact the Littoral Zone vegetation.

Benefits

Converting the pond to a stormwater harvesting pond will reduce the amount of stormwater runoff leaving the site if the water can be beneficially used. The harvested water could be used to irrigate or hand water the landscaping. The pond is large enough offset local resident's potable demand for irrigation during the wet season. Beneficial yield will vary depending on how much the harvested water is used.

Installing public information kiosks will explain the purpose of cisterns, rain barrels, and green roofs and will facilitate shared learning about water conservation. The County should partner with Mote Marine on education opportunities related to stormwater conservation.

***Stormwater Harvesting Yield** (Avg):* 10 acre-feet/year

***Opinion of Probable Cost** (Conceptual Level Estimate)*

- $25,500

Sarasota Bay Water Quality Management Plan

Conceptual Level Cost Estimate

WS12 - Lime Lake Park

OWNER:	ESTIMATED BY:
Sarasota County	**MOB**
CLIENT:	CHECKED BY:
Sarasota County	**DTJ**
PROJECT TITLE:	APPROVED BY:
Lime Lake Park	**CAM**
JONES EDMUNDS PROJECT NUMBER:	DATE:
19006-034-01	**5/8/2012**
ESTIMATE TYPE (ROM, BUDGET, DEFINITIVE):	CONSTRUCTION OR PROJECT ESTIMATE:
ROM	**Construction Cost Estimate**

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	LS	1	$ 1,052.50	$ 1,053
Irrigation Pump	EA	1	$ 1,000.00	$ 1,000
Fittings, Supplies, and Electrical	LS	1	$ 8,000.00	$ 8,000
Educational Kiosk	EA	1	$ 1,500.00	$ 1,500
Sod	SY	10	$ 2.50	$ 25
Contingency (25%)	LS	1	$ 2,894.38	$ 2,894
			SUBTOTAL	$ 14,472
Survey	LS	1	$ 1,000.00	$ 1,000
Design and Permitting	LS	1	$ 10,000.00	$ 10,000
			SUBTOTAL	$ 11,000
			OPINION OF PROBABLE COST (ROUNDED)	**$ 25,500**

Note: Unit prices are based on FDOT area and statewide prices, and recent bids received by Jones Edmunds.

ATTACHMENT 1 RANGE OF REMOVAL EFFICIENCIES (%) OF STRUCTURAL AND SOURCE CONTROL BMPS

Study	Year	Dry Retention			Wet Detention			Dry Retention w Filtration			Offline Systems/ Constructed Wetlands			Porous Pavement			Grassed Swales			Bioretention			Other Filtration			Buffer Zones			Street Sweeping			Catch Basin/Baffle Box			Green Roof			Stream Restoration/ Enhancement (lb/lf/yr)		
		TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
Evaluation of Current Stormwater Design Criteria within the State of Florida	2007	80–99	61–99	80–99	55–94	20–91	4–63	77–98	0–92	0–80	89–95	76–92	30–85																											
The Cost Effectiveness of Stormwater Management Practices	2005		15–45			30–65			50–80			15–45			30–65			15–45						30–80																
Technical Memorandum: The Runoff Reduction Method	2008					50–75	30–40		25	15		50–75	25–55		25	25		15	20		20–40	40–60		60–65	30–45	50–85														
Urban Pollutant Loads and General BMP Cost Analysis	2005	50	30		90	90																																		
Effective Use of BMPs in Stormwater Management	2005	61	19	21	58–78	48–62	21–43	75	60–70	55–60	36–96	21–89	19–48	82–95	65	80–85	7–69	14–37	14–55	80	65–87	49							37–50	9–28		10–25								
Permeable Pavement Summary Fact Sheet	2005																																							
Stormwater Pollutant Removal Criteria	2004	40–60	20	20	50–90	50	30				90	50	30	0–80	60	50				90	60	30	60–80	30–50	30–35		30	30												
Stormwater Management Program for Nutrient Control	2004					40	25					35	40					20	20		35	40		45	35															
Riparian Forest Buffer Practice and Riparian Grass Buffer Practice	2007																										45–65	65–85												
Final Report of the Statewide Task Force on Riparian Forest Buffers	2000																									37–99	6–97	7–95												

Study	Year	Dry Retention			Wet Detention			Dry Retention w Filtration			Offline Systems/ Constructed Wetlands			Porous Pavement			Grassed Swales			Bioretention			Other Filtration			Buffer Zones			Street Sweeping			Catch Basin/Baffle Box			Green Roof			Stream Restoration/ Enhancement (lb/lf/yr)		
		TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping	2008																												18–72	10–30	15–45	39–75	3–6	14–27						
Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts	2002	62	46		62	46		78	56											45	32								25–95	5–90										
Residential Street Dirt Accumulation Rates and Chemical Composition and Removal Efficiencies	2004																												20–92											
New Developments in Street Sweeper Technology Article 121	2002																												45–65	30–55										
Stormwater Best Management Practices in an Ultra Urban Setting: Selection and Monitoring	2006																												55–93	40–74	42–77									
East Baton Rouge Parish Stormwater BMPs Chapter 7	2007																																		80–90	20–85	30–95			
Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated	2011																																					2.55	0.0035	0.02

ATTACHMENT 2 PROJECTS FROM PREVIOUS PLANS

Project	General Description	Project Description	Status
Whitaker Bayou Greenway Park and Watershed Restoration (Sarasota County)	Planning and permitting of restoration activities, streambed restoration including dredging of contaminated soils, riparian habitat improvements, increased or improved public access, and stormwater improvements using LID technology along an 8-mile stretch from MLK Park north to 49th Street.		Whitaker Bayou Greenway Park and Stormwater LID Retrofit Pilot: Private ownership of most of the property along Whitaker Bayou makes it economically infeasible for local government or non-government, non-profit organizations to purchase land or easements to create an uninterrupted greenway corridor along the majority of the Bayou. Developing a greenway along Whitaker Bayou and/or attempting to enhance the Blueway experience within the downstream sections of the Bayou do not appear to be cost effective endeavors at this time due to a variety of limitations.
Dr. Martin Luther King, Jr. Park	Recommendation to remove the seawall along the south shoreline, remove exotic plants along the north shoreline to the bridge, and install a canoe/kayak launch.	The City of Sarasota has plans for the canoe/kayak launch and expects construction to occur in 2013.	Awaiting construction.
South of 32nd Street and north of North Riverside Drive	Installing a bio-swale, protecting trees, installing educational signs, creating a wetland treatment cell off the main channel, and regrading the main channel along the property lines to the east.		
Whitaker Bayou Greenway Park and Stormwater LID Retrofit Pilot (SBEP)	LID options to use in the watershed including installing bio-swales, baffle boxes, catch basin baskets, and pervious pavement in appropriate locations in publicly owned rights-of-way. Private property owners are encouraged to use numerous options such as installing bio-swales and rain gardens, using rain barrels and cisterns to augment landscape irrigation, planting trees, and installing green roofs.	**North Water Tower Park** – Bypass systems, bioswales, dry retention, removal of nuisance and invasive vegetation, and bank stabilization.	Developing conceptual plans.
		Dr. Martin Luther King, Jr. Park Area – Slope stabilization along the entire shoreline, bio-swale, and addition of dog waste stations in the park (add on to Dr. Martin Luther King, Jr. Park project).	Developing conceptual plans.
		32nd Street – Bio-swales in the upper reaches of the contributing drainage basin (add on to South of 32nd Street and north of North Riverside Drive project).	Developing conceptual plans.
		Cocoanut Avenue Area – Remove portions of impervious pavement between 32nd Street (just north of the 32nd Street project) and Myrtle Street to the north, reclaim the Cocoanut Avenue right-of-way to construct bio-swales and a pervious sidewalk and use some of the area for slope stabilization by regarding, and provide dog waste stations.	Developing conceptual plans.
		Spring Oaks Canal – Series of bio-swales along the west side of the main canal, slope stabilization along the west side of the main canal, bio-swales in a 50-foot-wide drainage easement along the north side of the Spring Oaks development, pervious sidewalk or trail to wind through the bio-swales, educational kiosks, and dog waste stations.	Developing conceptual plans.
		Booker Middle School and Wetland – Bio-swales at two roadway accesspoints along Seward Drive and in the Myrtle Street medians, plantings in the three dry retention areas along the north side of Myrtle Street, bio-swale along the west side of the canal at the northeast corner of the school grounds, enhance wetland, and provide signage and kiosks.	Developing conceptual plans.
		North Sarasota Sidewalk Area – Convert existing stormwater management system to bioretention areas in the constructed Sidewalks to Schools Program areas, install additional bio-swales on the south side of the main canal, and provide educational kiosks.	Developing conceptual plans.
		12th Street and North Shade Avenue Area – Series of bio-swales along the north side of 8th Street, along the north and south sides of 11th Street, and along the north and south sides of 15th Street; slope stabilization of the drainage ditch between 15th and 17^{th} Streets; bio-swales in the North Shade Avenue right-of-way between 8th and 15th Streets; and pervious sidewalk or trail along the south side of 15th Street.	Developing conceptual plans.

Project	General Description	Project Description	Status
Indian Beach/Sapphire Shores LID Retrofit Pilot	Opportunities within the watershed (including New College, the Ringling Museum, Sapphire Drive, 47th Street, 40th Street, and Virginia Drive) to retrofit existing stormwater infrastructure using LID concepts to improve the quality of the stormwater discharges into Sarasota Bay were identified.	**IBBS Outfall Improvements 1** – 45th Street and Bayshore Road baffle box/nutrient separation box.	
		IBBS Outfall Improvements 2 – 41st Street and Bayshore Road/nutrient separation box.	
		IBBS Outfall Improvements 3 – Indian Beach Lane and Indian Beach Drive baffle box/nutrient separation box.	
		IBBS Outfall Improvements 4 – Virginia Drive and Bayshore Circle baffle box/nutrient separation box.	
		IBBS Outfall Improvements 5 - 23rd Street and Alameda Ave baffle box/ nutrient separation box.	
		IBBS Outfall Improvements 6 - Alameda Way and Alameda Ave baffle box / nutrient separation box.	
		IBBS Outfall Improvements 7 – Sylvan Drive and Chippewa Place baffle box/ nutrient separation box.	
		IBSS Site 1 – Northwest corner of N. Shore Drive and Bay Shore Road bio-swales.	
		IBSS Site 2 – Northwest and the southwest corners of Sapphire Drive and Bay Shore Road bio-swales.	
		IBSS Site 3 – West end of Ringling Point Drive bio-swale.	
		IBSS Site 4 – Northwest corner of S. Shore Drive and Sun Circle bio-swale.	
		IBSS Site 6 – Windsor Drive in the center of a roundabout bio-swale.	
		IBSS Site 7 – North and south sides of Patterson Drive adjacent to the Bay Haven Elementary School bio-swale.	
		IBSS Site 8 – North and south side of 23rd Street at N. Tamiami Trail bio-swale.	
		Demonstration Project – Lift Station No. 9 bio-swales.	Completed
City of Sarasota Deep Well Injection	Deep well injection system to remove runoff from Hog Creek and wastewater effluent from Whitaker Bayou; the City discharge is about 8 MGD at AWT about 50% of the time and the reverse osmosis discharge is about 5 MGD continuously.		
School Avenue MURT (Multi-Use Recreational Trail)	This trail would use a City right-of-way that is atop a covered County-maintained stormwater drainage pipe. The trail extends from the south at Siesta Drive to Hillview Street to the north. This project is a partnership between the City of Sarasota and the National Park Service, Rivers and Trails Program.		

Project	General Description	Project Description	Status
Hudson Bayou Urban Greenspace and Trail located within the Laurel Park Neighborhood	SBEP (City of Sarasota) is developing preliminary conceptual plans and designs for restoration activities for this project. The plans include designs for restoration activities at A.B. Smith Park (next to Payne Park). The plans also include designs that explore restoration opportunities from west of Osprey Avenue using Alderman Street to Hudson Bayou. This greenspace corridor uses a City right-of-way atop a Sarasota County drainageway leading to Hudson Bayou/Alderman Street. Plans include removing exotics at the base of the Bayou, creating a primitive neighborhood canoe/kayak launch, and additional minor restoration activities. Potentially, through land acquisition efforts a pocket park (with stormwater enhancements) could be developed at the base of the greenspace corridor leading to Hudson Bayou. The parcel is now in private ownership, and the City owns the lift station area leading to the bayou where a rest area and picnic area could be located.		
Osprey Avenue Beautification/Pedestrian Sleeve located within the Gillespie Park Neighborhood	As part of the City's Walk-to-Town Neighborhoods as discussed in the Duany Master Plan, a pedestrian sleeve will be developed at the intersection of Fruitville Road and Osprey Avenue to provide a pedestrian connection to downtown. Redevelopment of Osprey Avenue from Fruitville Road to Fourth Street and from Fourth Street to Seventh Street was also recommended. This project is a partnership between the City of Sarasota and the National Park Service, Rivers and Trails Program.		Several design types of development and improvements were drafted at the design charrette, but consensus has not yet been reached with the neighborhood residents and the type of improvements and development that would occur along Osprey Avenue is still being discussed. However, a Community Development Block Grant is funding the construction of a neighborhood gateway at the intersection of Fruitville Road and Osprey Avenue. The gateway will include such improvements as brick pavers, landscaping, irrigation, sidewalks, curb and gutter, neighborhood sign, and street light. A Community Development Block Grant is also funding the installation of decorative street lights along Osprey Avenue from Fruitville Road to 10th Street.
Shade Avenue Canal Multi-Use Linear Park within the Park East Neighborhood	Creation of linear park along the drainage ditch from between 8th and 6th Streets and between 6th and Aspinwall Streets, a pocket park through the acquisition of approximately 2 acres of land at the corner of Aspinwall Street and Lime Avenue that runs along Aspinwall to Shade Avenue, and a linear park from Jefferson Avenue and Eighth Street to Tuttle Avenue		

Project	General Description	Project Description	Status
Stormwater Improvements for Hudson Bayou – 319 grant	Oak Street and Ohio Place	Nutrient Separating Baffle Box (NSBB) where major piped drainage outfalls to Hudson Bayou.	
	Brother Geenan Way and Osprey Avenue	Treatment train with pipe improvements along Brother Geenan Way, detention with biofiltration, and an NSBB at the major outfall to Hudson Bayou.	
	Lukewood Park	Treatment train with detention with biofiltration around existing canopies, a specialized NSBB, and aesthetic components.	
	Ringling Boulevard between US 301 and Lime Avenue	LID retrofit right-of-way along west section of Ringling Boulevard between Lime and Euclid Avenues and treatment train incorporating LID techniques into traditional street design using pervious systems for street parking, detention with biofiltration, and underdrains to existing stormwater pipes.	
	Ringling Boulevard between Lime and Euclid Avenues	LID techniques to treat stormwater before it enters the stormwater conveyance system and treatment train approach using detention with biofiltration in the large right-of-way.	
	County Parking Garage on Ringling Boulevard	LID testing facility within the garage.	
Stormwater Improvements for Hudson Bayou – 60% plans on 7/2011	Ringling Boulevard BMPs		
	Lukewood Park BMPs		
	Novus BMPs		
	Dolphin Street BMPs		
	Ringling Boulevard Paving Grading and Drainage		
	Lukewood Park Paving Grading and Drainage		
	Dolphin Street Paving Grading and Drainage	Suntree nutrient baffle box.	
	Novus Paving Grading and Drainage		
Whitaker Bayou Flood Attenuation Alternatives Analysis	Drainage improvement alternatives	16-acre storage area with liner.	The 2004 report stated that the County would determine how to proceed with implementation of the options based on the Board's decision.
		16-acre storage area with berm.	
		Box culvert in Tri-Par Estates.	
		160-cfs pump station in Tri-Par Estates.	
		116-acre storage area with liner.	
		116-acre storage area with berm.	
		Drop structure in Tributary D.	
		Four stormwater pump stations along 17th Street.	
		Five stormwater pump stations along Dr. MLK Jr. Way.	
		Drop structure in Tributary B.	
		Box culvert under Myrtle Street.	
		40-cfs stormwater pump station.	
Arlington Canal at Euclid	This project has been identified in the Hudson Bayou Basin Study as one of the projects that will reduce flooding and provide increased water quality benefits to the bay.	The project involves widening the north side of the existing canal from US 41 upstream to the confluence of the Euclid Canal, replacing an existing 72-inch corrugated metal pipe (CMP) with a double 72-inch reinforced concrete pipe (RCP), and developing alternatives for the existing drainage system between Sarasota High School and Bahia Vista Street.	Completed
Arlington Canal at Hawthorne	This area has been identified in the Hudson Bayou Basin Study as an inadequate culvert crossing.	The project involves replacing an existing 72-inch CMP with a double 72-inch reinforced concrete pipe. This area has been identified as a flood-prone area in the City Wide Master Drainage Plan – Area 48.	Completed

Project	General Description	Project Description	Status
Euclid Canal Improvements - Hudson Bayou	This project has been identified in the Hudson Bayou Basin Study, which recommended improvement to culverts within the canal to improve the conveyance capacity.	The improvements proposed under this project also include the activation of a 54-inch storm sewer pipe from Fruitville Road to Ringling Boulevard that was previously installed when Fruitville Road was constructed.	Completed
Loma Linda	Drainage improvement	This project involves constructing a pipe to provide an outfall for stormwater to eliminate a flooding problem. Private developers are to construct an outfall pipe from Loma Linda Court to US 41, with reimbursement from the County through the City.	Completed
Little Five Points – Hudson Bayou	The project has been redesigned and evaluated for partial stormwater improvements at the Little Five Points intersection.	Improvements include upsizing old drainage pipes, relocating curb inlets, and installing a stormwater outfall treatment system.	Completed
Euclid Canal Weir	Erosion control	This project proposes to replace failed concrete armoring downstream of the Euclid Canal Weir (north of Hatton Street and west of Shade Avenue). Approximately 80 feet of armoring (articulated block revetment) will be placed on the banks of the Euclid Canal.	Completed
Lockwood Ridge Road	This initial phase of the project will investigate the cause of depressions forming in the pavement of Lockwood Ridge Road (17th Street north to DeSoto Road).	Phase 1 includes cleaning and videoing the interior of the pipe for analysis and making decisions for Phase 2 to repair the problem and prevent future depressions.	Completed
27th St - MLK Way, Culvert Rehabilitation	Drainage improvement	Project involves rehabilitating 100 feet of 72-inch-diameter CMP below 27th Street/MLK Way at the Canal 3-7 crossing using trenchless technology methods (i.e., no trench excavation).	Completed
Brother Geenan Way Storm Culvert	Drainage improvement	This project is a citizens' request to design and construct 830 feet of stormwater culvert (4-foot-x-6-foot concrete box culvert or size and type of pipe determined through stormwater modeling and engineering) for City of Sarasota.	Active
US 41 Canal Rehabilitation	This project proposes to rehabilitate existing stormwater infrastructure.	This project includes an upland cut drainage canal west of US 41 between Sarasota Quay and Ritz Carlton properties. This includes determining the methodology for lining pipes to return the pipe's structural integrity and substantially extend the life of the stormwater system pipes or to replace the pipe to ensure continued drainage control and serviceability. The exact method of rehabilitation to reestablish the slopes and stabilize canal banks will be determined at the conclusion of a preliminary design study.	Active
17th and 18th Streets Drainage Improvements	This project will rehabilitate and/or replace existing/old stormwater infrastructure including pipes, drainage structures, and canal system in 17th and 18th Streets at Orange Avenue and the neighboring area.	This project includes determining the methodology for lining pipes to return the pipe's structural integrity and substantially extend the life of the stormwater system pipes or to replace the pipes to ensure continued drainage control and serviceability. The exact method of rehabilitation to reestablish the slopes and stabilize canal banks will be determined at the conclusion of a preliminary design study.	Active
15th-19th Streets	The project area involves an existing ditch conveyance between 15th throughout 19th Streets and Seminole Gulf Railroad within Sarasota City limits. The existing conveyance system is inadequate, resulting in frequent flooding along the eastern portions of these streets.	The proposed plan for this project will involve installing pipe with ditch inlet structures and swale for water quality treatment.	Completed
Newtown Canal 3-2 – Whitaker Bayou	Drainage improvement	This project will involve enclosing approximately 2,165 feet of open ditch along 20th and Osprey Streets with a double 43-inch-x-68-inch elliptical RCP. This project will also construct a grass-lined swale to pre-treat stormwater runoff before discharge and line an existing CMP along 21st Street to improve overall conveyances of the system.	Completed

Project	General Description	Project Description	Status
St. Armands Drainage – Coastal	This project addresses severe flooding of a state road and evacuation route that runs through St. Armands Key. By addressing this major roadway flooding, local structure and roadway flooding will be incidentally addressed as well.	This project proposes to install additional and larger pipes and inlets as well as a series of pump stations.	Completed
Pelican Drive Outfall – Hudson Bayou Basin	The project involves a closed drainage system to address street flooding in the short term.	The design will include conveyance system improvements, pipe replacements, and a pipe slip line along South Pelican and South Lime Avenue. A future phase will address FPLOS for structure flooding of four homes. This depends on adjacent development, County purchase of railroad right-of-way, and coordination with City of Sarasota.	Active
Arlington Canal Bypass – Hudson Bayou	Drainage improvement	This project, which has been identified in the Hudson Bayou Master Basin Plan Study, involves an existing storm sewer system from Waldemere Street to Floyd Street along the Arlington Canal that requires the design and construction of a new improved conveyance system.	Completed
School Desiltation/School Bypass	Drainage improvement	This project will replace the existing metal pipes with a reinforced concrete box culvert from School Avenue to the stormwater outfall facility at Sarasota High School. This project also involves an existing canal between Euclid and School Avenues that has an inadequate conveyance capacity and severe bank erosion. This project is being coordinated with the Sarasota County School Board improvements adjacent to the canal.	Completed
East Avenue - Hudson Bayou	Drainage improvement	This project involves replacing approximately 2,000 feet of existing storm sewer that has failed.	Completed
Euclid Avenue - Hudson Bayou	Drainage improvement	This project involves an existing storm sewer system with an inadequate conveyance capacity located at Euclid Avenue and Courtland Street. The existing double 36-inch CMP installed in the 1950s has deteriorated substantially in recent years. The system requires a redesign to replace the existing pipe and associated inlet structures to reduce existing runoff from sheet flow across the pavement areas and erosion within the existing canal.	Completed
Gocio Road Culvert - Stormwater	This project was added by IFAS upload.		Completed
Arlington/Euclid Canal Improvement - Hudson Bayou	This project has been identified in the Hudson Bayou Basin Study as one that will reduce structure and street flooding.	The project involves widening the channel, upsizing existing culverts, and constructing several control structures. The improvements also include activation of a 54-inch pipe under Fruitville Road that was previously installed when Fruitville Road was constructed.	Completed
School Avenue By-Pass	Drainage improvement	This project will replace the existing metal pipes with a reinforced concrete box culvert from School Avenue to the stormwater outfall facility at Sarasota High School. This project also involves an existing canal between Euclid and School Avenues that has an inadequate conveyance capacity and severe bank erosion. This project is being coordinated with the Sarasota County School Board improvements adjacent to the canal.	Completed
Leon & Noble Ave	Drainage improvement	This project involves an existing inadequate storm sewer system and inlet capacity in the Leon and Nobel Avenue areas in the City of Sarasota. This project will require a redesign to improve the conveyance efficiency of the system and reduce existing flooding problems. This project will reduce the current flooding problems in the areas adjacent to Leon and Nobel Avenues and will improve conveyance of the stormwater runoff.	Complete

ATTACHMENT 3 REMOVAL EFFICIENCY STUDIES REFERENCES

Study	Year	Reference
Evaluation of Current Stormwater Design Criteria within the State of Florida	2007	Harper, H.H. and Baker, D.M. (2007). Evaluation of Current Stormwater Design Criteria within the State of Florida. Florida Department of Environmental Protection. http://www.dep.state.fl.us/
The Cost Effectiveness of Stormwater Management Practices	2005	Weiss, Peter, John S Gulliver, and Andrew J. Erickson. (2005). The Cost Effectiveness of Stormwater Management Practices. Minnesota Department of Transportation.
Technical Memorandum: The Runoff Reduction Method	2008	Hirschman, David and Collins, Kelly. (2008). Technical Memo: The Runoff Reduction Method. Center for Watershed Protection. http://www.cwp.org/
Urban Pollutant Loads and General BMP Cost Analysis	2005	Keiser and Associates. (2004). Urban Pollutant Loads and General BMP Cost Analysis. www.kalamazooriver.net/pa319new/docs/handouts/
Effective Use of BMPs in Stormwater Management	2005	Field, R., Talfuri, A., & AnnMandge, B. (2004). The Use of Best Management Practice in Urban Watersheds. Lancaster, Pennsylvania: Destech.
Permeable Pavement Summary Fact Sheet	2005	Fairfax County, (2005). Permeable Pavement Summary Fact Sheet. Retrieved from website: http://www.lowimpactdevelopment.org/ffxcty/3-2_permeablepavement_draft.pdf
Stormwater Pollutant Removal Criteria	2004	State of New Jersey. (2004). New Jersey Stormwater Best Management Practices Manual: Stormwater Pollutant Removal Criteria. Retrieved fromhttp://www.njstormwater.org/bmp_manual/NJ_SWBMP_4%20print.pdf
Stormwater Management Program for Nutrient Control	2004	City of Washington, (2004). Stormwater Management Program for Nutrient Control. Retrieved from website: http://infohouse.p2ric.org/ref/41/40246.pdf
Riparian Forest Buffer Practice and Riparian Grass Buffer Practice	2007	Simpson and Weammert. (2008). Riparian Forest Buffer Practice and Riparian Grass Buffer Practice. University of Maryland. Retrieved from http://archive.chesapeakebay.net/pubs/bmp/Year_1_Reports/Riparian%20Forest%20and%20Grass%20Buffers.pdf
Final Report of the Statewide Task Force on Riparian Forest Buffers	2000	University of South Carolina. (2000). Final Report of the Statewide Task Force on Riparian Forest Buffers. Center for Environmental Policy and Institute of Public Affairs.
Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping	2008	Law, N.L., DiBlasi, K., Ghosh, U., Stack, B., Stewart, S., Belt, K., Pouyat, R., and Welty, C. (2008). Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin.
Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts	2002	Zarriello, P.J., Breault, R.F., and Weiskel, P.K. (2002). “Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts.” Water-Resources Investigations Report 02-4220.
Residential Street Dirt Accumulation Rates and Chemical Composition and Removal Efficiencies	2004	Breault, Robert Kirk P. Smith, and Jason R. Sorenson. (2005). Residential Street-Dirt Accumulation Rates and Chemical Composition, and Removal Efficiencies by Mechanical and Vacuum type Sweepers, New Bedford, Massachusetts. United States Department of Interior, United States Geological Survey.
New Developments in Street Sweeper Technology Article 121	2002	Center for Watershed Protection. (2002). “New Developments in Street Sweeper Technology.” Article 121, 8-11.
Stormwater Best Management Practices in an Ultra Urban Setting: Selection and Monitoring	2006	Federal Highway Administration (2006). Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. http://www.fhwa.dot.gov/environment/
East Baton Rouge Parish Stormwater BMPs Chapter 7	2007	East Baton Rouge Parish: Green roofs. (2007, August). http://brgov.com/dept/planning/pdf/bmp7.pdf
Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated	2011	(2011). Accounting for stormwater wasteload allocations and impervious acres treated. Retrieved from http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES

ATTACHMENT 4 GENERAL REFERENCES

Environmental Services and Natural Resources, Resource Protection, Sarasota County. 2009. *2007–2008 Mangrove Trimming Study*. Sarasota County, Florida.

Jones Edmunds & Associates, Inc. 2010. *Roberts Bay North Watershed Management Plan*. Prepared for Sarasota County and the Southwest Florida Water Management District.

Tampa Bay Estuary Program. 2008. *Technical Memorandum: Model-Based Estimates of Nitrogen Load Reductions Associated with Fertilizer Restriction Implementation.* Retrieved from: http://www.tampabay.wateratlas.usf.edu/upload/documents/Final_Reduction_Credits_TBEP_Regional_Fertilizer_Guideline_Recommendations.pdf

US Army Corps of Engineers (USACE). 2012. *Mechanical Control Methods.* Retrieved from: http://www.glmris.anl.gov/documents/docs/anscontrol/MechanicalControlMethods.pdf

Appendix H

Bibliographies

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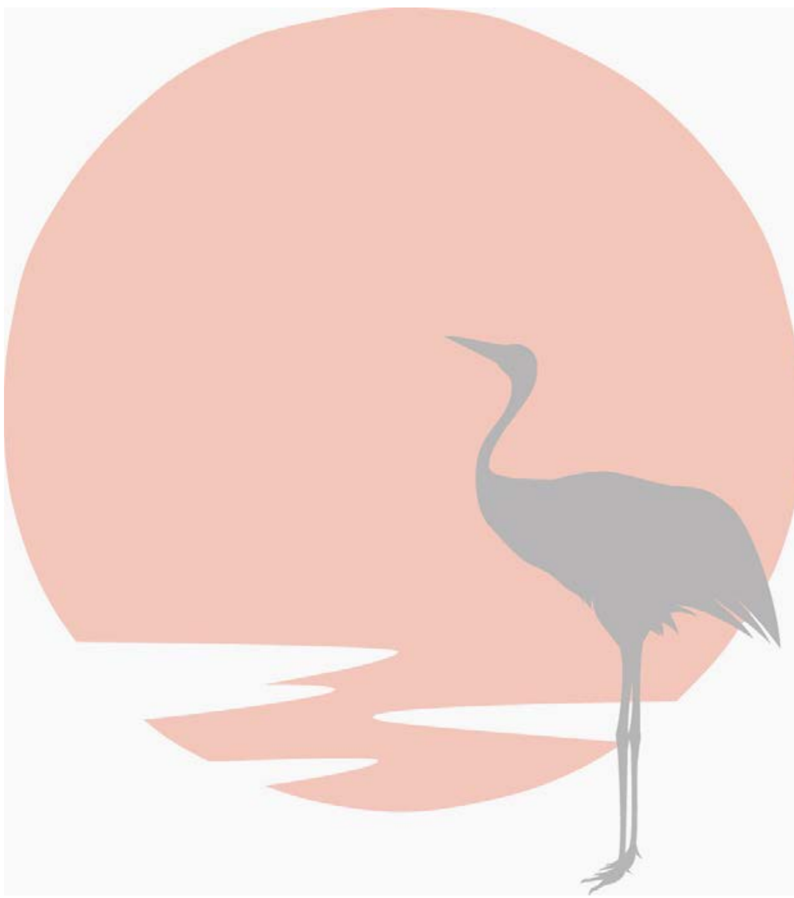

December 2012

Sarasota County
Southwest Florida Water Management District
Jones Edmunds
Janicki Environmental, Inc.

Alderson, M., 1/1/1992, Sarasota Bay: A Framework for Action, http://sarasotabay.org/documents/Shellfish-of-Sarasota-Bay.pdf

Alderson, M., SBEP, 2000, Sarasota Bay 2000: A Decade of Progress and Just…"Another Day in Paradise," http://12.174.210.206/athcgi/athweb.pl?a=f&ci=ML&pg=8&st=std&in=18&fr=1&lr=28&li=09278186&nh=28&kw=SARASOTA%20BAY&k1=SARASOTA%20BAY&k2=&k3=&o1=1&o2=1&l1=1&l2=1&l3=1&loc=All+Locations&fmt=All+Formats&vrss=&vrps=&jw=&tx=000007364

Alderson, M. and Kutz, R.C., SBEP, 3/1/2005, Sarasota Bay Watershed Management Plan for the Sarasota Bay Planning Unit, Florida, http://www.sarasota.wateratlas.usf.edu/upload/documents/398_SBEPRADRAFT24MAR05.pdf

Anderson, D. L., and Otis, R.J., 1/1/2000, R.B. Brown, J. H. Huddleston, and J. L. Anderson, Ed. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, WI. pp. 199 – 250, Managing Soils in an Urban Environment, Agronomy Monograph No. 39, Integrated Wastewater Management in Growing Urban Environments, https://www.soils.org/publications/books/abstracts/agronomymonogra/managingsoilsin/199

Antonini, G.A., D.A. Fann, and P. Roat, A Historical Geography of Southwest Florida Waterways, Volume One: Anna Maria Sound to Lemon Bay, http://nsgl.gso.uri.edu/flsgp/flsgpm99004/flsgpm99004_full.pdf

Ardaman & Associates., Inc., Sarasota County, 4/20/1999, Surface Water, Sediment, and Biological Sampling for "Big Slough, Hudson Bayou, and Phillippi Creek Basins, Sarasota County, FL, http://www.sarasota.wateratlas.usf.edu/upload/documents/BigHudPhilSedDry1998.pdf

Bahr, L.M. and Lanier, W.P., U.S. Department of Interior Fish and Wildlife Service. FWS/OBS-81/15. Washington, D.C., 1/1/1993, The Ecology of Intertidal Oyster Reefs of the South Atlantic Coast: a Community Profile, http://www.nwrc.usgs.gov/diglib.htm

Barr, G.L., U.S. Geological Survey, Sarasota County, SWFWMD, 1996, Hydrogeology of the Surficial and Intermediate Aquifer Systems in Sarasota and Adjacent Counties, Florida, Water-Resources Investigations Report 96-4063, http://fl.water.usgs.gov/PDF_files/wri96_4063_barr.pdf

Bateman, Michael, Florida Stormwater Association, 1/1/2012, Methodology For Calculating Nutrient Load Reductions Using The FSA Assessment Tool, http://www.florida-stormwater.org/files/FSA%20Educational%20Foundation/Research/MS4/MS4%20Narrative%204-4-12w.pdf

Benson, B.B., and D.D. Krause, Jr., 1/1/1984, The Concentration and Isotopic Fractionation of Oxygen Dissolved in Freshwater and Seawater in Equilibrium with the Atmosphere, Limnol. Oceanogr. 29: 620–632, http://new.aslo.org/lo/toc/vol_29/issue_3/0620.pdf

Berretta, Christian; Raje, Saurabh; University of Florida 5/31/2011, Quantifying Nutrient Loads Associated With Urban Particulate Matter (Pm), And Biogenic/Litter Recovery Through Current MS4 Source Control And Maintenance Practices, Maintenance Matters, http://www.florida-stormwater.org/files/FSA%20Educational%20Foundation/Research/MS4/MS4%20Assessment%20Project%20%E2%80%93%202011%20Final%20Report.pdf

Blackburn, Brett Ramey; Leber, Kenneth M.; Peatrowsky, Sara, 11/11/2007, 2006 Final Report of the Sarasota and Tampa Bay Artificial Reef Evaluation of the Influence of Reef Number and Artificial Habitat on Fish Colonization, https://dspace.mote.org/dspace/bitstream/2075/472/1/blackburn%231224.pdf

Bosworth, W.S. and Thibodeaux, L.J., 1/1/1990, Bioturbation: A facilitator of contaminant transport in bed sediment, http://onlinelibrary.wiley.com/doi/10.1002/ep.670090414/abstract

Boyle Engineering, Sarasota County, 9/1/2001, Hudson Bayou Stormwater Study.

Breault, Robert F.; Smith, Kirk P.; Sorenson, Jason R.; 1/1/2003, Residential Street-Dirt Accumulation Rates and Chemical Composition, and Removal Efficiencies by Mechanical- and Vacuum-Type Sweepers, http://pubs.usgs.gov/sir/2005/5184/pdf/SIR2005_5184_all.pdf

Brown, David P., U.S. Geological Survey, SWFWMD, 1982, Water Resources and Data-Network Assessment of the Manasota Basin, Manatee and Sarasota Counties, Water Resources Investigations 82-37, http://onlinepubs.er.usgs.gov/djvu/WRI/wrir_82_37.djvu

Buck, J.D., Journal of Coastal Research, 1990, Potentially pathogenic marine Vibrio species in seawater and marine animals in the Sarasota, Florida, area, http://www.jstor.org/pss/4297767

Bureau of Historic Sites and Properties Division of Archives, History and Records Management Florida Department of the State, City of Sarasota, 12/1/1977, Historical, Architectural and Archaeological Survey of Sarasota, FL, Miscellaneous Project Report Series Number 51.

Carollo Engineers, Sarasota County, 6/2005, Water Supply Master Plan Update, Technical Memorandum 1 – Water Demand Projections.

Carollo Engineers, Sarasota County, 8/2005, Water Supply Master Plan Update, Technical Memorandum 2 – Water System Assets.

Carollo Engineers, Sarasota County, 3/2006, Water Supply Master Plan Update, Technical Memorandum 3 – Water Supply Projects.

Carollo Engineers, Sarasota County, 3/2006, Water Supply Master Plan Update, Technical Memorandum 4 – 2050 Supply Scenarios.

Carollo Engineers, Sarasota County, 4/2006, Water Supply Master Plan Update, Technical Memorandum 5 – 10-Yr Water CIP.

Carollo Engineers, Sarasota County, 12/31/2006, Water Supply Master Plan Update.

Carr, Wilfred J.; Alverson, Douglas C., U.S. Geological Survey, U.S. Department of the Interior, 1959, Stratigraphy of Middle Tertiary Rocks in Part of West-Central Florida, Geological Society Bulletin 1092, http://onlinepubs.er.usgs.gov/djvu/B/bull_1092.djvu

Cathey, Anna; Alyssa, Cameron; Hall, Hollie; Conservation Clinic Watersheds Initiative, Large Woody Material: Science, Policy, and Best Management Practices for Florida Sandbed Streams.

CDM, 1987, Stormwater Master Plan for Sarasota County, http://www.sarasota.wateratlas.usf.edu/upload/documents/Stormwater%20Mast%20Plan%20Final%20Report%20Mr%201987.pdf

CDM, 1990, Sarasota Bay Water Quality Trend Evaluation, http://books.google.com/books/about/Sarasota_Bay_Water_Quality_Trend_Evaluat.html?id=mJMdtwAACAAJ

CDM, SBEP, 1/10/1992, Point/Non-Point Source Pollution Loading Assessment, Phase I, http://www.sarasota.wateratlas.usf.edu/upload/documents/SBEPPointNPPollLoadAssPhaseI1992.pdf

CDM, SBEP, 1/10/1992, Sarasota Bay National Estuary Program Pollutant Loading Assessment Phase I.

CDM, SBEP, 4/30/1992, Sarasota Bay National Estuary Program Pollutant Loading Assessment Phase II.

City of Longboat Key, City of Longboat Key, A Brief History of Longboat Key, http://www.longboatkey.org/history.htm

City of Sarasota, Administration and Planning and Redevelopment Dept., Newtown Community Redevelopment Area Plan, http://www.sarasotagov.com/Newtown/Newtown%20CRA%20Plan%20Volume%20I.pdf

City of Sarasota, City of Sarasota, City of Sarasota Floodplain Management Plan.

City of Sarasota, City of Sarasota Compliance Monitoring – Benthic Invertebrates – 2005.

City of Sarasota, City of Sarasota Compliance Monitoring – Sediment Quality – 2005.

City of Sarasota, City of Sarasota Compliance Monitoring – Benthic Invertebrates – 2007.

City of Sarasota, City of Sarasota Compliance Monitoring – Benthic Invertebrates – 2008, 12/31/2008.

City of Sarasota, City of Sarasota, 12/1/2008, Sarasota City Plan 2030 Ordinance No. 08-4792, http://www.sarasotagov.com/NDS/NDS_guide.htm

City of Sarasota, City of Sarasota Compliance Monitoring – 2010, 12/31/2010.

City of Washington North Carolina, 1/27/2004, Stormwater Management Program for Nutrient Control, http://infohouse.p2ric.org/ref/41/40246.pdf

Committee on Environmental Preservation and Conservation, The Florida Senate, 9/2009, The Florida Senate Interim Report 2010-114, Chapter 373, F.S., Water Resources, http://www.flsenate.gov/Publications/2010/Senate/reports/interim_reports/pdf/2010-114ep.pdf

Culter, J. K. and Leverone, J. R., SBEP, Mote Marine Laboratory, 3/12/1993, Bay Bottom Habitat Assessment (Draft Final Report), Mote Marine Laboratory Technical Report No. 303, https://dspace.mote.org/dspace/bitstream/2075/54/1/303.pdf

Davis, R.A., Wang, P., USF, Sediments and Processes at Big Sarasota Pass, Sarasota County, http://www.sarasota.wateratlas.usf.edu/upload/documents/Sediments_Processes_BigPass.pdf

Deming, Joan; Spain Schwarz, Rebecca; Carender, Patricia; Delahaye, Daniel; Sarasota County, 3/1990, An Historic Resources Survey of the Coastal Zone of Sarasota County, FL.

Dendrou, S.A., C.I. Moore, and R. Walton, Camp, Dreser, & McKee, 1983, Little Sarasota Bay Circulation Study, https://dspace.mote.org/dspace/bitstream/2075/14/1/57.pdf

DeWitt, D., Kraft, C., Mallams, J., SWFWMD, EPA, 3/2010, SWFWMD comments on EPA/FDEP analysis of geologic formations (e.g. Bone Valley) in the SWFWMD for determination of total phosphorus (TP) numeric nutrient criteria for flowing surface waters.

Diehl, T.H., Proceedings of Extended Abstracts, American Water Resources Association, Middleburg, VA (1994), pp. 97–100, 1/1/1994, Causes and Effects of Valley Plugs in West Tennessee, M.J. Sale and R.O. Wadlington, Editors, Symposium on Responses to Changing Multiple-Use Demands: New Directions for Water Resources Planning and Management, Nashville, Tenn., April 17–20, http://tn.water.usgs.gov/publications/abstracts/plug_7b.html

Dillon, K.S., J.P. Chanton, D.R. Corbett, and W.C. Burnett, Nitrogen Isotopic Compositions of Seagrasses and Algae and Implications for Tracing Nutrient Sources in Two Florida Estuaries, http://dl.cr.usgs.gov/net_prod_download/public/gom_net_pub_products/doc/Tech0402notnutrients.pdf

Divins, D.L. and Metzger D., NOAA, National Geophysical Data Center Coastal Relief Model, http://www.ngdc.noaa.gov/mgg/coastal/crm.html

Dixon, L.K., 7/10/1992, Bivalved Shellfish of Sarasota Bay: A Framework for Action, https://dspace.mote.org/dspace/bitstream/2075/50/1/264.pdf

Dixon, L.K., J.M. Sprinkle, N.J. Blake, G.E. Rodrick, and R.H. Pierce, Bivalve Shellfish Contamination Assessment, http://business.management6.com/BIVALVED-SHELLFISH-CONTAMINATION-ASSESSMENT-FINAL-Prepared-for-download-w31692.pdf

Dixon, L. K., Kirkpatrick, G., and Jay L.R., 9/24/1999, Biological Effects of Atmospheric Deposition on Algal Assemblages. Draft Final Report, https://dspace.mote.org/dspace/bitstream/2075/2810/1/MTR%20652.pdf

Dixon, L.K. and Kirkpatrick, G. 1/19/1995, Light Attenuation with Respect to Seagrasses in Sarasota Bay, Florida, http://digitool.fcla.edu/R/BN7XCU36GIAYSKRCB8G8L51537S187GB1B6MARLIAK36N39CUN-00694?func=dbin-jump-full&object_id=172898&local_base=GEN01&pds_handle=GUEST

Dixon, L.K., M.G. Heyl, and J.S. Perry, Camp Dresser & McKee, SBEP, 9/29/1999, Contaminant Survey of Sarasota Bay Priority Watershed – Cedar Hammock Creek, Bowlees Creek, Whitaker Bayou, Hudson Bayou, and Phillippi Creek, MML Technical Report #651.

Dixon, L.K. and M.G. Heyl, Mote, 9/2/1999, Trend Analysis of Water Quality Data for the Sarasota Bay National Estuary Program, http://www.sarasota.wateratlas.usf.edu/upload/documents/Trend%20Analysis%20of%20Water%20Quality%20Data%20for%20the%20Sarasota%20Bay%20National%20Estuary%20Program.pdf

Dixon, L.K., Perry, J.S., Mote, SBEP, 11/20/03, Analysis of Changes in Seagrass Coverage, 1996-1999 and 1999-2001, for Anna Maria Sound, Sarasota, Roberts, Little Sarasota, and Blackburn Bays, MML Technical Report No. 920, http://www.sarasota.wateratlas.usf.edu/upload/documents/Seagrass_Water_Quality.pdf

Duerr, A.D. and R. M. Wolansky, U.S. Geological Survey, Sarasota County, Hydrogeology and the Surficial and Intermediate Aquifers of Central Sarasota County, Florida, Water-Resources Investigations Report 86-4068, http://onlinepubs.er.usgs.gov/djvu/WRI/wrir_86_4068.djvu

East Baton Rouge Parish, Ch. 7 Green Roofs, http://brgov.com/dept/planning/pdf/bmp7.pdf

Edwards, R.E., 1/1/1994, Role of Little Sarasota Bay as a Nursery for Finfish and Shellfish.

Edwards, R.E.; Hueter, Robert E., 9/30/1992, Sarasota Bay Fishery Resource Assessment. Final Project Report, https://dspace.mote.org/dspace/bitstream/2075/1282/1/MTR%20256.pdf

Environmental Services and Natural Resources, Resource Protection, Sarasota County, 1/1/2006, 2005 Mangrove Trimming Study, Sarasota County, Florida.

Estevez, E.D., Blanchard, G., Mote Marine Lab, U.S. Environmental Protection Agency, 4/15/1988, A Bibliography on Sarasota Bay, Florida, Its Resources and Surrounding Areas, http://isurus.mote.org/techreps/117-a/117-a.pdf

Estevez, E.D., MML, 10/1/1994, Phillippi Creek Basin Master Plan – Hudson Bayou Basin Master Plan, Characterization of Ecological Conditions and Impacts of Stormwater Runoff.

Estevez, E. D., Mote, 6/3/1986, Survey of Mollusks in Southern Sarasota Bay, Florida: Emphasizing Edible Species, http://isurus.mote.org/techreps/102/102.pdf

Estevez E.D, and Palmer C.P, SBEP, Mote Marine Laboratory, 6/7/1990, A Segmentation System for the Sarasota Bay Project National Estuary Program, http://isurus.mote.org/techreps/161/161.pdf

Evans, M.W. and R.K. Evans, 1988, Sarasota County Estuarine Shoreline Inventory, https://dspace.mote.org:8443/dspace/bitstream/2075/38/4/MTR%20120.pdf

Estevez, E.D., Sarasota County, Mote Marine Laboratory, 4/3/2007, Tidal Creek Condition Index for Coastal Streams in Sarasota County, Florida, Mote Marine Laboratory Technical Report Number 1131, http://www.sarasota.wateratlas.usf.edu/upload/documents/304_200_FinalCreekReportfor2006.pdf

Estevez, E.D., SC SEU, 10/1/1994, Characterization of Ecological Conditions and Impacts of Stormwater Runoff on Hudson Bayou and Phillippi Creek, with Recommendations for Analytical Methods and Management Objectives, http://www.sarasota.wateratlas.usf.edu/upload/documents/Phillippi%20Creek%20Hudson%20Bayou%20Basin%20Master%20Plan%20Characterization%20of%20Stormwater%20Runoff.pdf

Estevez, E.D., 8/17/2005, Whitaker Bayou Reconnaissance Report, https://dspace.mote.org/dspace/bitstream/2075/155/4/MTR%2b1036.pdf

Fairfax County, 2/28/2005, Permeable Pavement Summary Fact Sheet, http://www.lowimpactdevelopment.org/ffxcty/3-2_permeablepavement_draft.pdf

Field, Richard; Talfuri, Anthony N; AnnMandge, Bethany; 9/1/2004, The use of Best Management Practice in Urban Watersheds, CH 5 Effective Use of BMPs in Stormwater Management, http://books.google.com/books?id=GDtdPIdOebgC&pg=PR3&lpg=PR3&dq=Effective+Use+of+BMPs+in+Stormwater+Management+Bethany+madge&source=bl&ots=1kZEhHo301&sig=BjWCSMlKwFATKMU_54NEVd0w9P0&hl=en&sa=X&ei=g7kjUIzxJ4yi8gS1qIGwDg&ved=0CEwQ6AEwAg

Fire, Spencer E., 2007, Effects of Karenia brevis Blooms on Wild Coastal Bottlenose Dolphins (Tursiops truncatus) in Sarasota Bay, Florida, http://12.174.210.206/athcgi/athweb.pl?a=f&ci=ML&pg=8&st=std&in=8&fr=1&lr=28&li=09278186&nh=28&kw=SARASOTA%20BAY&k1=SARASOTA%20BAY&k2=&k3=&o1=1&o2=1&l1=1&l2=1&l3=1&loc=All+Locations&fmt=All+Formats&vrss=&vrps=&jw=&tx=000010039

Florida Department of Environmental Protection (FDEP), tmdl-grants-cost-per-pound-removed_updated630

Florida Department of Environmental Protection (FDEP), 1/1/2003, Group 3 Water Quality Status Reports, http://www.dep.state.fl.us/water/basin411/sbpm/index.htm

Florida Department of Environmental Protection (FDEP), Sarasota County, 7/24/2009, Sarasota County MS4 NPDES Permit Year 1 Annual Report Comments.

Florida Department of Environmental Protection (FDEP), Sarasota County, 9/18/2009, MS4 NPDES Stormwater Audit Report.

Florida Department of Environmental Protection (FDEP), 8/1/2010, Model Ordinance for Florida-Friendly Fertilizer Use On Urban Landscapes, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/dep-fert-modelord.pdf

Florida Department of Environmental Protection (FDEP), 9/15/2010, List of Impaired Waters of Cycle 2 Group 3 Basins, http://www.dep.state.fl.us/water/watersheds/assessment/adopted_gp3-c2.htm

Florida Department of Environmental Protection (FDEP), Sarasota County, 10/11/2010, Domestic Wastewater Facility Permit: fl0177008, North Master Reuse System.

Florida Department of Environmental Protection (FDEP), 2011, Numeric Nutrient Criteria Briefing for the Environmental Regulatory Commission.

Florida Department of Environmental Protection (FDEP), 2011, Verified List of Impaired Waterbodies, sbpm-verified-c2.

Florida Department of Environmental Protection (FDEP), 5/17/2011, City of Sarasota AWWTF, State of Florida Domestic Wastewater Facility Permit.

Florida Department of Environmental Protection (FDEP), Sarasota County, 5/19/2011, Domestic Wastewater Facility Permit: fl0040771, Permit NO fl0040771.

Florida Department of Environmental Protection (FDEP), 2012, Derivation of Dissolved Oxygen Criteria to Protect Aquatic Life in Florida's Fresh and Marine Waters, http://www.dep.state.fl.us/water/wqssp/docs/do/tsd-do-criteria-aquatic-life.pdf

Florida Department of Environmental Protection (FDEP), 4/16/2012, Reuse of Reclaimed Water and Land Application, http://www.dep.state.fl.us/legal/rules/wastewater/62-610.pdf

Florida Department of Environmental Protection (FDEP), 2012, Stream Condition Index data for Sarasota Bay waters, Sarasota_Basin_SCI_Data_060812.xls.

Florida Department of Environmental Protection (FDEP), Stream/river assessment Field Sheet.

Florida Department of Environmental Protection (FDEP) and Water Management Districts, 3/1/2010, Environmental Resource Permit: Stormwater Quality Applicant's Handbook, Design Requirements For Stormwater Treatment Systems, http://www.dep.state.fl.us/water/wetlands/docs/erp/AH_General.pdf

Florida Department of Environmental Regulation, 1986, Proposed Designation of Sarasota Bay and Lemon Bay as Outstanding Florida Waters, http://www.sarasota.wateratlas.usf.edu/upload/documents/Proposed%20Designation%20of%20Sarasota%20Bay%20and%20Lemon%20Bay%20as%20Outstanding%20Florida%20Waters.pdf

Florida Department of Environmental Regulation, Mote, U.S. Environmental Protection Agency, 5/24/1988, Sarasota Bay, Florida Identification of Resource Management Problems and Issues and National Estuary Program Analysis, MML Technical Report Number 117, https://dspace.mote.org/dspace/bitstream/2075/112/4/MTR%20117.pdf

Florida Fish and Wildlife Conservation Commission, Florida Fish and Wildlife Conservation Commission, Sarasota County, Boating and Angling Guide to Sarasota County, http://www.sarasota.wateratlas.usf.edu/upload/documents/Boating_Guide_Sarasota_Part1_of2.pdf

Florida Seagrant, SBEP, Photoscience, Inc., 1/1/2003, GIS coverage of historical oyster bar locations in Sarasota Bay.

Florida Stormwater Association, MS4 Assessment Project – 2011 Final Report – Load Reduction Tool, http://www.florida-stormwater.org/content.asp?pl=18&contentid=19

Florida Stormwater Association, Street Sweeping, Stormwater Sediment and Catch Basin Disposal, http://www.florida-stormwater.org/Files/FSA%20Educational%20Foundation/Research/Street%20Sweeping/pospaper_sediment.pdf

Folit, Ruth, 1992, Beds, Boats, and Buoys: A Study in Protecting Seagrass Beds from Motorboat Propeller Damage, http://www.sarasota.wateratlas.usf.edu/upload/documents/Beds,%20Boats,%20and%20Buoys%20A%20Study%20in%20Protecting%20Seagrass%20Beds%20From%20Motorboat%20Propeller%20Damage.pdf

Foushee, T., Ayres, City of Sarasota, 4/10/2010, Bradenton Road LID Project.

Frazier, Tim G.; Wood, Nathan; Yarnal, Brent, Applied Geography 30 (2010) 506–517, 12/2010, Stakeholder perspectives on land-use strategies for adapting to climate-change-enhanced coastal hazards: Sarasota, Florida, Stakeholder perspectives on land-use strategies for adapting to climate-change-enhanced coastal hazards: Sarasota, Florida

Geselbracht, L., R. Torres, G. Cumming, D. Dorfman, M. Beck, The Nature Conservancy, Department of Wildlife Ecology and Conservation, 9/2005, Marine/Estuarine Site Assessment for Florida, A Framework for Site Prioritization.

Gettys, L.A., Haller, W.T., and Bellaud, M., Aquatic Ecosystem Restoration Foundation, 10/1/2009, Biology and Control of Aquatic Plants, A Best Management Practices, http://www.aquatics.org/aerf_handbook.pdf

Gorzelany, Jay F., 9/30/2001, Effects of increased police enforcement on boater compliance in speed-restricted areas, https://dspace.mote.org/dspace/bitstream/2075/8/4/MTR%20782.pdf

GPI Southeast, 1/7/2010, Baffle Box Effectiveness Monitoring Project, DEP Contract NO. S0236, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/fdeps0236-baffle-box-final-report.pdf

Grizzle, R.E., 8/15/1984, Pollution Indicator Species of Macrobenthos in a Coastal Lagoon, Marine Ecology Progress Series. 18: 191–200, http://www.int-res.com/articles/meps/18/m018p191.pdf

Gunter, G., University of Texas, 10/1955, Mortality of Oysters and Abundance of Certain Associates as Related to Salinity, http://www.jstor.org/pss/1931298

Hall, Emily R.; Perry, Jon S.; Dixon, L. Kellie, 5/16/2006, Reconnaissance of Listed Water Bodies on Roberts Bay, Little Sarasota Bay, Blackburn Bay, Donna Roberts Bay, and Lemon Bay and Recommendations for Future Sampling, https://dspace.mote.org/dspace/bitstream/2075/539/1/MTR%201104_report.pdf

Hall, Emily R.; Perry, Jon S.; Dixon, L. Kellie, 5/16/2006, Reconnaissance of Listed Water Bodies on Roberts Bay, Little Sarasota Bay, Blackburn Bay, Donna Roberts Bay, and Lemon Bay and Recommendations for Future Sampling, Appendices, https://dspace.mote.org/dspace/bitstream/2075/539/3/MTR%201104_appendices.pdf

Hammett, K.M., Delcharco, M.J., U.S. Geological Survey, U.S. Department of the Interior, 2005, Estimating the Magnitude and Frequency of Floods for Streams in West-Central Florida, Scientific Investigations Report 2005-5080, http://pubs.usgs.gov/sir/2005/5080/Resources/PDF_Files/SIR_2005-5080.pdf

Harper, Harvey; Baker, David M, Environmental Research & Design, Inc., 6/2007, Evaluation of Current Stormwater Design Criteria within the State of Florida, FDEP Contract NO. S0108, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/SW_TreatmentReportFinal_71907.pdf

Hazen and Sawyer, CHNEP, 3/5/1998, Estimated Economic Value of Resources. Report to the Charlotte Harbor National Estuary Program, http://www.chnep.org/info/EconEval1998.pdf

HDR Engineering, Inc, U.S. Army Corps of Engineers, n.d., Ecosystem Restoration Report for Sarasota Bay, Sarasota County, Fl Draft, http://www.saj.usace.army.mil/Divisions/Planning/Branches/Environmental/DOCS/OnLine/Sarasota/Bay1135/02-DraftEcosystemRestorationReport.pdf

Heilprin, Angelo; 1887, Explorations on the West Coast of Florida and in the Okeechobee Wilderness.

Hirschman, David; Collins, Kelly; Schueler, Tom; Center for Watershed Protection, Inc., 4/18/2008, Technical Memorandum: The Runoff Reduction Method, http://www.region9wv.com/Bay/Calculators/RRTechMemo.pdf

Holland, A.F., D.M. Sanger, C.P. Gawle, S.B. Lerberg, M.S. Santiago, G.H.M. Riekerk, L.E. Zimmerman, and G.I. Scott, Journal of Experimental Marine Biology and Ecology. 298:151–178, 1/1/2004, Linkages between tidal creek ecosystems and the landscape and demographic attributes of their watersheds, http://www.sciencedirect.com/science/article/pii/S0022098103003575

Hutchings, P. and Saenger, P., University of Queensland Press. Brisbane, Australia, 1/1/1987, Ecology of Mangroves, http://books.google.com/books/about/Ecology_of_mangroves.html?id=KNwKAQAAIAAJ

Hyde, Adam G., Hurt, Wade G., Wettstein, Carol A., Soil Conservation Service, USDA, SCS, 1991, Soil Survey of Sarasota County, FL, http://soildatamart.nrcs.usda.gov/manuscripts/FL115/0/sarasota.pdf

Hydrologic Evaluation Section Resource Conservation and Development Department, 8/12/2002, Saltwater Intrusion and the Minimum Aquifer Level in the Southern Water Use Caution Area, http://www.swfwmd.state.fl.us/projects/mfl/reports/saltwater_intrusion.pdf

Janicki Environmental, Sarasota County Water Resources, 2006, Establishment of Estuarine Water Clarity Targets for Sarasota County Estuarine Waters, Draft, http://www.sarasota.wateratlas.usf.edu/upload/documents/Sarasota%20Water%20Clarity%20Report%20DRAFT%2010-24-06.pdf

Janicki Environmental, Sarasota County, 9/2007, Recommendations for the Development of a Water Quality Response Model and an Approach to Assessing Water Quality in the Estuarine Waters of Sarasota County, http://www.sarasota.wateratlas.usf.edu/upload/documents/RecomDevelWQRespModel_Sept2007.pdf

Janicki Environmental, Sarasota Bay Estuary Program, 8/2010, Numeric Nutrient Criteria For Sarasota Bay, http://www.sarasotabay.org/documents/SBEPNutrientCriteriaFinalReport.pdf

Janicki Environmental, SBEP, 1/1/2011, Sarasota Bay Numeric Nutrient Criteria: Task 1 – TN and TP Concentration and Loading Based Criteria, http://www.sarasota.wateratlas.usf.edu/upload/documents/738_SBEP_NNC_TN_TP_Final_Letter_Memo_17Mar2011.pdf

Janicki Environmental, SBEP, 1/1/2011, Sarasota Bay Numeric Nutrient Criteria: Task 3 – dissolved oxygen, http://www.sarasota.wateratlas.usf.edu/upload/documents/SBEP_NNC_DO_Final_Letter_Memo_17Mar2011.pdf

Janicki Environmental, SBEP, 1/1/2011, Sarasota Bay Numeric Nutrient Criteria: Tidal Creeks – Letter Memorandum, http://www.sarasota.wateratlas.usf.edu/upload/documents/SBEP_NNC_Tidal_Creeks_Letter_Memo_17Mar2011.pdf

Janicki Environmental, Inc., Tampa Bay Estuary Program, Sarasota Bay Estuary Program, and Charlotte Harbor National Estuary Program, 1/1/2010, Empirical Approaches to Establishing Numeric Nutrient Criteria for Southwest Florida Estuaries, http://www.tbeptech.org/NitrogenMgmtConsort/NNC/SW_Florida_NEP_NNC_methods_options-July_14_2010.pdf

Jones Edmunds & Associates, Inc., 7/24/2007, Stormwater manual for site, development, subdivision, and capital improvement projects.

Jones Edmunds & Associates, Inc., Sarasota County, SWFWMD, 1/1/2008, Sarasota County Pollutant Loading Model Development Design Report.

Jones Edmunds & Associates, Inc., Sarasota County, SWFWMD, 1/1/2009, Sarasota County Pollutant Loading Model Development Simple-Monthly Calibration Report.

Jones Edmunds & Associates, Inc., PBS&J, 1/1/2009, Sarasota County Pollutant Loading Model Development (W552) Simple-Monthly Calibration Report.

Jones Edmunds & Associates, Inc., 11/1/2009, Sarasota County Low-Impact Development Manual http://www.scgov.net/EnvironmentalServices/Water/SurfaceWater/documents/PreliminaryLIDManual.pdf

Jones Edmunds & Associates, Inc., Sarasota County, SWFWMD, 1/1/2010, Roberts Bay North Watershed Management Plan, http://www.sarasota.wateratlas.usf.edu/upload/documents/Roberts_Bay_North_WMP_Aug2010_full.pdf

Jones, Gregg W.; Scott, Kathy F.; Barcelo, Mark D., SWFWMD, 12/2006, SWFWMD Regional Water Supply Plan, http://www.swfwmd.state.fl.us/documents/plans/RWSP/previous/rwsp.pdf

Jones, M.S., Sarasota County, 4/25/2006, Sarasota County Comprehensive Oyster Monitoring Program Annual Report 2006, http://www.sarasota.wateratlas.usf.edu/upload/documents/2006CountyOysterMonitoringReport_Small.pdf

Joyner, D., FDEP, 2012, Florida's Adopted Numeric Nutrient Criteria and Proposed Revisions to Dissolved Oxygen Criteria, http://www.flawma.com/Conference_Files/2012%20FL%20Presentations/1-JoynerNutrientsandDO2012AWMAConf.pdf

Kaufman, Galen; Oliver, Jacques L.; Thomas, Dana A.; Wool, Tim; Yuan, Lester L.; Butcher, Jon; Gerritsen, Jeroen; Paul, Michael J.; Lei Zheng, EPA, 2010, Technical Support Document for U.S. EPA's Final Rule for Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Inland Surface Fresh Waters.

Kimley Horn and Associates, Inc., Sarasota County, 9/14/2010, Agreement for Professional Services, Hudson Bayou Water Quality Improvement Project.

Kimley Horn and Associates, Inc., Watermark Engineering Group, Inc., 2/9/2011, Hudson Bayou Watershed, Status of Pollutant Load Reduction Estimates and Cost Effective Evaluation.

Kish, George R.; Harrison, Arnell S.; Alderson, Mark, U.S. Geological Survey, Sarasota Bay Estuary Program, 2008, Retrospective Review of Watershed Characteristics and a Framework for Future Research in the Sarasota Bay Watershed, Florida, Open-File Report 2007-1349, http://pubs.usgs.gov/of/2007/1349/pdf/ofr2007-1349.pdf

Knowles, S.C., 1983, Holocene Geologic History of Sarasota Bay, FL., http://books.google.com/books/about/Holocene_Geologic_History_of_Sarasota_Ba.html?id=sQ0iOAAACAAJ

Knowles, S.C., 1/1/1983, Hurricane influence on Holocene sediment accumulation in Sarasota Bay, Florida, Am. Assoc. Pet. Geol. Bul l., 67(3): 481-496, http://archives.datapages.com/data/bulletns/1982-83/images/pg/00670003/0450/04960.pdf

Lackey, James B.; Hynes, Jacqueline A., University of Florida, Florida Engineering and Industrial Experiment Station,, 2/1955, The Florida Gulf Coast Red Tide, Bulletin Series No. 70, http://www.sarasota.wateratlas.usf.edu/upload/documents/433_Florida%20Gulf%20Coast%20Red%20Tide.pdf

Leverone, J. R. and M.J. Marshall, SBEP, 1992, Seagrass Bed Faunal Utilization Study

Leverone, J.R., Mote, 3/15/2005, Preconstruction Assessment and Evaluation of Proposed Oyster Restoration Sites in Little Sarasota Bay, MML Technical Report No. 1003, https://dspace.mote.org/dspace/bitstream/2075/334/4/MTR%2b1003.pdf

Leverone, Jay R., Mote, 9/14/2006, Sarasota Bay Estuary Program Oyster Habitat Monitoring Results: Year 1, MML Technical Report #1129, https://dspace.mote.org/dspace/bitstream/2075/491/1/JLev-oysters.pdf

Leverone, J.R., Oyster Habitat Assessment in Little Sarasota Bay, http://www.sarasota.wateratlas.usf.edu/lake/default.asp?wbodyid=14268&wbodyatlas=lake

Leverone, Jay R., 12/15/1994, Stocking and Reestablishment Feasibility Demonstration: Recruitment of Bay Scallops in Pansy Bayou, Sarasota Bay, Florida through Spawner Transplants, https://dspace.mote.org/dspace/bitstream/2075/62/1/401.pdf

Lipp, E.K., Dissertation Abstracts International Part B: Science and Engineering, 2/2000, The Occurrence, Distribution and Transport of Human Pathogens in Coastal Waters of Southwest Florida, http://linkinghub.elsevier.com/retrieve/pii/S0025326X00001521

Lipp, E.K., S. A. Farrahb and J. B. Rose, Marine Pollution Bulletin, 4/2001, Assessment and Impact of Microbial Fecal Pollution and Human Enteric Pathogens in a Coastal Community, http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V6N-42RDMGJ-7&_user=10&_coverDate=04/30/2001&_alid=1579185810&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5819&_docanchor=&view=c&_ct=146&_acct=C000050221&_version=1&_u

Locker, S.D., Davis, R.A., Brooks, B.R., Hine, A.C., and Twichell, D.C., US Geological Survey, 1/1/1999, West-central Florida Coastal Transect #7: Longboat Key, http://pubs.usgs.gov/of/1999/of99-511/

Lowery, S., SBEP, Mote, 2/2/1993, Framework for Action Chapter 2: Physical and Chemical Properties – Bay Water and Sediment Quality, Mote Marine Laboratory Technical Report Number 266, https://dspace.mote.org/dspace/bitstream/2075/49/1/266.pdf

Lowery, Susan, SBEP, 2/2/1993, Physical and Chemical Properties of Bay Water and Sediment Quality, MML Technical Report #266.

Lowery, S.S., L.K. Dixon, Sherblom P., Heyl, M.G., SBEP, Mote Marine Laboratory, 1/27/1993, Water and Sediment Quality: Trends and Status for Sarasota Bay, Mote Marine Laboratory Technical Report No. 254, https://dspace.mote.org/dspace/bitstream/2075/47/4/MTR%20254.pdf

Luer, George M., The Florida Anthropologist, 45, pp. 266-279, 1992, The Boylston Mound: A Safety Harbor Period Shell Midden, with Notes on the Paleoenvironment of Southern Sarasota Bay.

MacDonald, D.D.; FDEP, 11/94, Approach to the Assessment of Sediment Quality in Florida Coastal Waters, Volume 1 – Development and Evaluation of Sediment Quality Assessment Guidelines, http://www.dep.state.fl.us/Waste/quick_topics/publications/documents/sediment/volume1.pdf

MacDonald, T.C., E. Weather, P.W. Stevens, and R.H. McMichael, Jr., Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute, 1/1/2010, Nekton of Sarasota Bay and a Comparison of Nekton Community structure in Adjacent Southwest Florida Estuaries, http://www.sarasotabay.org/documents/FirstYearFIMResultsforSarasotaBay.pdf

Mahadevan, K. and Dixon, L.K., Mote, 2/17/1992, Sediment Contaminants in Selected Sarasota Bay Tributaries, MML Technical Report #242, https://dspace.mote.org/dspace/bitstream/2075/46/1/242.pdf

Mallin, M.A., Parsons, D.C., Johnson, V.L., McIver, M.R., and CoVan, H.A., Journal of Experimental Marine Biology and Ecology. 298:211–231, 1/1/2004, Nutrient limitation and Algal Blooms in Urbanizing Tidal Creeks, Journal of Experimental Marine Biology and Ecology. 298:211–231, http://uncw.edu/cms/aelab/Reports%20and%20Publications/Mallin%20et%20al.%20JEMBE%202004.pdf

Manatee County, Manatee County Department of Air/Watershed Management, 1/1/2012, Ambient Surface Water Data.

Mangrove Systems Inc., Sarasota County Natural Resources Dept., 9/1/1988, Marine Habitat Trend Analysis Sarasota County, http://www.sarasota.wateratlas.usf.edu/upload/documents/562_Marine%20Habitat%20Trend%20Analysis%20Sarasota%20County%20Final%20Report.pdf

Marshall, Michael J.; Leverone, Jay R., 5/25/1994, The Distribution and Effects of Hypoxia on Marine Organisms in Sarasota Bay. Final Report, https://dspace.mote.org/dspace/bitstream/2075/1626/1/MTR%20381.pdf

Maryland Department of the Environment, Accounting For Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance For National Pollutant Discharge, http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20Draft%20Guidance%206_14.pdf

Mayers, T.M., New College, Univ. of South Florida, 5/1/1991, Sarasota Bay Mangroves 1991: Past Alterations and Future Possibilities, http://www.sarasota.wateratlas.usf.edu/upload/documents/475_Sarasota%20Bay%20Mangroves%201991%20Past%20Alterations%20and%20Future%20Possibilities.pdf

McDonough, M., The Journal of Decorative and Propaganda Arts, Vol. 23, Florida Theme Issue (1998), pp. 10-31, 1/1/1998, Selling Sarasota: Architecture and Propaganda in a 1920s Boom Town, http://www.jstor.org/stable/1504161

McKnight, M.D., Homblette, D.J. and T.W. Liby, 9/1995, Integration Of Flood Control, Wetland Habitat, Reuse, Recreational Features and Stormwater Treatment, http://www.fwrj.com/articles/9509.pdf

McKnight, M.D. and M.A. Hanson, Engineering Floodplain Management, http://www.owr.ehnr.state.nc.us/ref/41/40227.pdf

McRae, G. and Madley, K., Florida Fish and Wildlife Conservation Comm. And USEPA Environmental Research Lab, 5/9/2001, Florida's Inshore Marine Monitoring and Assessment Program (IMAP), Annual Report Year Two, http://www.epa.gov/nheerl/arm/documents/annual0001_4638.pdf

McRae, G. and Madley, K., Florida Fish and Wildlife Conservation Comm. And USEPA Environmental Research Lab, 5/9/2001, Florida's Inshore Marine Monitoring and Assessment Program (IMAP), Annual Report Year Three, http://www.epa.gov/nheerl/arm/documents/annual0001_4638.pdf

McRae, G. and Madley, K., Florida Fish and Wildlife Conservation Comm. And USEPA Environmental Research Lab, 9/30/2005, Florida's Inshore Marine Monitoring and Assessment Program (IMAP), Annual Report Year Six, http://research.myfwc.com/engine/download_redirection_process.asp?file=annual2005_final_3738.pdf&objid=25854&dltype=article

Metz, P.A., Brendle, D.L., U.S. Geological Survey, SWFWMD, 1996, Potential for Water-Quality Degradation of Interconnected Aquifers in West-Central Florida, U.S. Geological Survey Report 46-4030, http://www.sarasota.wateratlas.usf.edu/upload/documents/Potential%20for%20Water%20Quality%20Degrad%20Aquifers.pdf

Miller, James J; Gale Organization, Inc., 11/1974, An Archaeological Survey of the Palmer Oaks Tract in Sarasota County, Bureau of Historic Sites and Properties Division of Archives, History and Records Management Florida Department of the State Miscellaneous Project Report Series Number 20.

Mote, Florida Fish and Wildlife Conservation Commission, Prepared for Sarasota County Government by Mote Marine Laboratory in consultation with Sarasota County Staff and the Florida Fish and Wildlife Conservation Commission, SC, 9/24/03, Sarasota County Manatee Protection Plan, Mote Marine Laboratory Technical Report No. 894, http://www.scgov.net/environmentalservices/resourceprotection/documents/AdoptedMPP.pdf

Mote Marine Laboratory, Sarasota County Planning Dept., 12/1/1980, The Phillippi Creek Basin: a spatial analysis of its existing and future land use, physical characteristics, and population growth, https://dspace.mote.org/dspace/bitstream/2075/7/1/27.pdf

Neely L. Law, Katie DiBlasi, Upal Ghosh, 9/1/2008, Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping, http://www.worldsweeper.com/Street/Studies/CWPStudy/CBStreetSweeping.pdf

Neidig, Carole L.; Phelps, Pamela A.; Dufault, Paul C.; Dukeman, Angela K., 7/30/1993, Fish Stock Enhancement Research Project. Final Report, https://dspace.mote.org/dspace/bitstream/2075/1394/1/MTR%20325.pdf

New Developments in Street Sweeper Technology, Watershed Protection Techniques, http://www.stormwatercenter.net/Practice/121-Street%20Sweepers.pdf

New Jersey Stormwater Best Management Practices Manual, 2/1/2004, Stormwater Pollutant Removal Criteria, http://www.njstormwater.org/bmp_manual/NJ_SWBMP_4%20print.pdf

Nowacek, Douglas P.; Buckstaff, Kara C.; Johnson, Mark P.; Wells, Randall S., 9/20/2001, Transmission Loss of Vessel Noise in Manatee Environments: Final Report, https://dspace.mote.org/dspace/bitstream/2075/252/4/MTR%2b721A.pdf

Odum, W.E., McIvor, C.C., and Smith, T.J., United States Fish and Wildlife Service, Office of Biological Services. Washington, DC., 1/1/1982, The Ecology of the Mangroves of South Florida: A Community Profile, FWS/OBS-81/24, http://sofia.usgs.gov/publications/reports/fws-obs-81-24/index.html

PBS&J, City of Sarasota, 9/1/1987, City Wide Master Drainage Plan City of Sarasota.

PBS&J and Janicki, Sarasota County, 2/28/2006, Establishment of Estuarine Water Clarity Targets for Sarasota County.

PBS&J, PBS&J, 8/2003, County-wide Survey of Sediment Quality at Weir Structures.

PBS&J, Sarasota County, 9/1/1994, Hudson Bayou Basin Master Plan.

PBS&J, Sarasota County, 10/1/2004, Whitaker Bayou Flood Attenuation Alternatives Analysis.

PBS&J, Sarasota County, 11/2010, EMC Monitoring in Support of Pollutant Load Modeling.

PBS&J, SBEP, 3/25/2005, Sarasota Bay Reasonable Assurance Plan, Sarasota Bay Watershed Management Plan, http://www.sarasota.wateratlas.usf.edu/upload/documents/398_SBEPRADRAFT24MAR05.pdf

PBS&J, SBEP, 1/1/2007, Sarasota Bay TMDL Support, http://www.sarasota.wateratlas.usf.edu/upload/documents/PBSJ%20Clarity%20Draft%20August%202007.pdf

PBS&J, SBEP, 4/2008, Sarasota Bay Estuary Program Outfall Prioritization Project.

Peene, Steven J., UF, 8/1995, Circulation and Transport Within a System of Shallow, Interconnected Barrier Island Lagoons. http://www.sarasota.wateratlas.usf.edu/upload/documents/674_Circulation%20and%20Transport%20Within%20a%20System%20of%20Shallow%20Interconnected%20Barrier%20Island%20Lagoons.pdf

Perry, J.S., Sarasota County, Sarasota County Geographic Information Systems and Watershed Management, http://www.stormwater.ucf.edu/conferences/9thstormwaterCD/documents/SarasotaCo.pdf

Photo Science, Inc., SBEP, GIS Coverage of Historical Oyster Bar Locations in Sarasota Bay.

Pierce, R. H. and Brown, R.C., Bulletin of Environmental Contamination and Toxicology, 1/1/1984, Coprostanol distribution from sewage discharge into Sarasota Bay, Florida, http://www.springerlink.com/content/r70010327t238557/

Preide-Sedgwick, Inc., FDEP, 1/21/1983, Sarasota Bay Water Quality Study, http://www.sarasota.wateratlas.usf.edu/upload/documents/Sarasota%20Bay%20Water%20Quality%20Study%20-%201983.pdf

Preserve America, Preserve America Community: Sarasota, Florida, http://www.preserveamerica.gov/07-17-08PAcommunity-sarasotaFL.html

Ray, D., FDEP, 1/1/1999, Ecological and morphological significance of old growth deadhead logs in The Blackwater River, http://www.dep.state.fl.us/water/bioassess/docs/biorepts/otherepts/blackh2o.pdf

Reddy, K.R. and J.R. White, 1/1/1997, Denitrification Enzyme Assay (DEA) as an Indicator of Nitrate Pollution.

Reynolds, J. E.; Kessenich, Teresa; Scolardi, Kerri, 12/12/2005, Photo-identification and Aerial Surveys of Manatees in Sarasota County Waters: Sarasota County Boating Improvement Program 2004-2005 Final Report, https://dspace.mote.org/dspace/bitstream/2075/146/4/MTR%201057f.pdf

Roat, P., 1990, The Sarasota Bay Project: State of the Bay Report, http://12.174.210.206/athcgi/athweb.pl?a=f&ci=ML&pg=8&st=std&in=21&fr=1&lr=28&li=09278186&nh=28&kw=SARASOTA%20BAY&k1=SARASOTA%20BAY&k2=&k3=&o1=1&o2=1&l1=1&l2=1&l3=1&loc=All+Locations&fmt=All+Formats&vrss=&vrps=&jw=&tx=000004861

Ryan, J.; Meaux, K.; Perry, J.; Sarasota County, 10/28/2010, Oil Spill Sampling by Sarasota County.

Sarasota Bay Estuary Program (SBEP), A Chronicle of Florida Gulf Coast, Nature, History, Culture, Recreation, http://www.sarasotabay.org/publications.htm

Sarasota Bay Estuary Program (SBEP), 1995, Sarasota Bay: The Voyage to Paradise Reclaimed, The Comprehensive Conservation and Management Plan for Sarasota Bay, http://www.sarasotabay.org/pdf/ccmp_95.pdf

Sarasota Bay Estuary Program (SBEP), City of Sarasota, 9/25/2001, Hudson Bayou Press Release.

Sarasota Bay Estuary Program (SBEP), 2006, State of the Bay 2006, http://www.sarasotabay.org/pdf/StateOfTheBay_06.pdf

Sarasota Bay Estuary Program (SBEP) Staff, Paul Roat, and Caroline McKeon, SBEP, 9/24/2010, State of the Bay 2010, Celebrating Paradise – Staying the Course, http://www.sarasotabay.org/pdfs/SOB%202010%20for%20website.pdf

Sarasota Bay Estuary Program (SBEP) Technical Advisory Committee, 1/1/2011, Sarasota Bay Tidal Creek Workshops Sampling & Measurement Program(s) for Sarasota Bay Tidal Creek, http://chnep.org/MC/2011agenda/TAC10-13-11_11bLeveroneSBEPTidalCrs.pdf

Sarasota Bay National Estuary Program, 1992, Tidal Inlet Dynamics, https://dspace.mote.org/dspace/bitstream/2075/48/1/266(a).pdf

Sarasota Bay and Peace and Myakka Rivers Basin Team, FDEP, 1/1/2003, Water Quality Status Report, Sarasota Bay and Peace and Myakka Rivers, http://tlhdwf2.dep.state.fl.us/basin411/sbpm/status/Sarasota-Bay-WEBX.pdf

Sarasota Bay and Peace and Myakka Rivers Basin Team, FDEP, 1/1/2006, Water Quality Assessment Report, Sarasota Bay and Peace and Myakka Rivers, http://tlhdwf2.dep.state.fl.us/basin411/sbpm/assessment/G3AS-SBPMR-LowResMerge.pdf

Sarasota County Environmental Services, 4/1/2009, 2007–2008 Mangrove Trimming Study Sarasota County, Florida, http://www.sarasota.wateratlas.usf.edu/upload/documents/2007-08MangroveTrimmingStudy.pdf

Sarasota County Health Department Healthy Beaches Program, SC, Our Gulf Environment, Red Tide Sampling, http://www.ourgulfenvironment.net/Red_tide_results.aspx

Sarasota County, Historic Sarasota County, http://scg.co.sarasota.fl.us/historical_resources/history/timeline.asp

Sarasota County History Center, Sarasota County, Sarasota County Dreamers of Our Past, http://scg.co.sarasota.fl.us/historical_resources/Dreamers/index.asp

Sarasota County, Hudson Bayou Water Quality Improvement Areas, http://www.sarasotagov.com/InsideCityGovernment/Content/CAC/Communications/Releases/County_Hudson_Bayou_meeting_11911.htm

Sarasota County, Individual NPDES Permits for Municipal Separate Storm Sewer Systems Application, DEP Form 62-624.600(2).

Sarasota County, Introduction to Sarasota County History, http://www.scgov.net/TPM/ArticulatePresentations/History%20Center%20Presentation/player.html

Sarasota County, Sarasota County Stormwater Environmental Utility Ordinance No. 89-117, https://www.scgov.net/SEU/Stormwater%20Ordinances%20and%20Resolutions/Ordinance%2089-117.pdf

Sarasota County, Sarasota Estuary Program, University of South Florida, Sarasota County Water Atlas, http://www.sarasota.wateratlas.usf.edu/bay/?wbodyatlas=bay&wbodyid=14147

Sarasota County, 12/31/1997, Sarasota County NPDES Sampling.

Sarasota County, 9/15/1998, Surface Water and Sediment Sample Collection and Analysis.

Sarasota County, 12/1/1999, Strategic Maintenance Plan.

Sarasota County, 5/7/2001, Land Development Regulations, For Subdivision and Site and Development Plans.

Sarasota County, Sarasota County, 11/13/2001, Ordinance No. 2001-081, Water – Efficient Landscaping Regulations.

Sarasota County, 4/1/2002, State of Florida Municipal Separate Storm Sewer System Permit, Permit Number: Fls000004, Major Facility.

Sarasota County, 10/11/2005, Habitat Profile Update.

Sarasota County, 11/17/2006, Sarasota County Comprehensive Plan, http://www.scgov.net/PlanningandDevelopment/CompPlan/TOC.asp

Sarasota County, 9/4/2007, Sarasota County Fertilizer Ordinance, Ordinance NO. 2007-062.

Sarasota County, FDEP, 1/1/2008, Sarasota County/Sarasota Bay Watch 2008 Scallop Search Data.

Sarasota County, 1/1/2009, Sarasota County Floodplain Management Plan 2009 Update.

Sarasota County, 2/11/2009, Sarasota Bay Estuary Program, North lido Beach Habitat Restoration Project.

Sarasota County, 4/1/2009, Coastal and Marine Habitat Restoration Project Grants Lido Key Beach Parks, http://www.littoralsociety.org/index.php/chapters1/southeast-chapter/habitat-restoration-projects?showall=&start=3

Sarasota County Local Rule Review Committee (LRRC) for Florida Fish and Wildlife Conservation Commission, Sarasota County, Florida Fish and Wildlife Conservation Commission, 7/1/2009, Recommendations Regarding Manatee Protection Zones in Sarasota County, Florida, http://scgov.net/EnvironmentalServices/ResourceProtection/documents/ReportA-D.pdf

Sarasota County, 10/13/2009, Hudson Bayou: Water Quality Improvement Area Detailed Site Map, http://www.sarasotagov.com/Landing/Hudson%20Bayou%20Mtg.pdf

Sarasota County, 11/23/2009, Order Adopting and ratifying water, wastewater, Resolution No. 2009-201.

Sarasota County, Sarasota County Department of Natural Resources, 1/1/2011, Tidal Creek Index Data for 2008-2010.

Sarasota County, Sarasota County Department of Natural Resources, 1/1/2012, Ambient Surface Water Quality Data.

Sarasota County Stormwater Environmental Utility, Sarasota County, 2000, Stormwater Environmental Utility Strategic Plan.

Sarasota County, Sarasota County, The Utilities Support Document, http://www.sarasotagov.com/NDS/SarasotaCityPlan(2030)/6-UtilitiesChapter/6%20-%20Utilities%20Chapter%20(Support%20Document).pdf

Sarasota Dolphin Research Program, Research, Conservation, and Education Since 1970, http://sarasotadolphin.org/

Sarasota High School, Sarasota High School, 6/1/1979, Hydrologic and Biological Monitoring of Lower Sarasota Bay 1975-1978, Report, http://www.sarasota.wateratlas.usf.edu/upload/documents/SHS_1979_Marine_Science.pdf

Sarasota History Alive!, Sarasota History Alive Website, http://www.sarasotahistoryalive.com/index.php?src=&submenu=home

Sarasota Soil Conservation District, Sarasota County, Board of Commissioners, & Manatee River Soil Conservation District, USDA-Soil Conservation Service, 1961, Work Plan for Sarasota West Coast Watershed, http://www.sarasota.wateratlas.usf.edu/upload/documents/49_Work%20Plan%20for%20Sarasota%20West%20Coast%20Watershed.pdf

Scheda Ecological Associates, Inc., SBEP,4/1/2010, Conceptual Design Report for Whitaker Bayou 32nd Street Greenway Park and Watershed Restoration.

Scheda Ecological Associates, Inc., SBEP, 11/30/2003, Five-year Habitat Restoration Plan 2004– 2009, http://www.sarasota.wateratlas.usf.edu/upload/documents/SBEP5YrPlan&AppA.pdf

Scheda Ecological Associates, Inc., SBEP, 7/2010, Five-year Habitat Restoration Plan 2010-2014.

Scott, Thomas M., Florida Geological Survey, 1990, The Lithostratigraphy of the Hawthorn Group of peninsular Florida in Phosphate Deposits of the World, Open File Report 36, http://publicfiles.dep.state.fl.us/FGS/FGS_Publications/OFR/OFR36LithoHawthornGrpPenFLScott.pdf

Serviss, G.M. and Sauers, S., SBEP, 1/1/2003, Sarasota Bay Juvenile Fisheries Habitat Assessment, http://www.sarasota.wateratlas.usf.edu/upload/documents/SarasotaBayJuvenileFishHabitatAssess.pdf

Shaw L. Yu, Monika D. Stopinski, Virginia Transportation Research Council, 1/1/2001, Testing Of Ultra-Urban Stormwater Best Management Practices, http://virginiadot.org/vtrc/main/online_reports/pdf/01-r7.pdf

Sheng, Y.P., Peene, S., E. Yasuda, J. D., and Schofield, S., SBEP, A Field and Modeling Study of Circulation and Transport in Sarasota Bay, http://books.google.com/books?id=jdQBdz0_WYoC&pg=PA208&lpg=PA208&dq=A+Field+and+Modeling+Study+of+Circulation+and+Transport+in+Sarasota+Bay&source=bl&ots=sHmnmRyG5p&sig=phQnkaNTNyCDWqKVTuHLfZrQROw&hl=en&sa=X&ei=JxnSUPPXNoma9gTTq4D4Ag&ved=0CDIQ6AEwAA

Sheng, Y.P., Yassuda, E.A., and Yang, C. 1995, Modeling The Impact of Nutrient Load Reduction on Water Quality and Seagrass in Roberts Bay and Little Sarasota Bay, http://www.sarasota.wateratlas.usf.edu/upload/documents/Modeling%20the%20Impact%20of%20Nutrient%20Load%20Reduction%20on%20Water%20Quality%20and%20Seagrass%20in%20Roberts%20Bay%20and....pdf

Sherblom, P.M., D. Kelly, D.H. Pierce, Marine Pollution Bulletin, 1995, Baseline survey of pesticide and PAH concentrations from Sarasota Bay, Florida, USA, Marine Pollution Bulletin [MAR. POLLUT. BULL.]. Vol. 30, no. 8, pp. 568-573, Baseline survey of pesticide and PAH concentrations from Sarasota Bay, Florida, USA

Sherwood, E.T., Pinellas County Environmental Fund. Tampa Bay Estuary Program, 1/1/2008, Tampa Bay Tidal Tributary Habitat Initiative Project: Final Report and Management Recommendations, Tampa Bay Estuary Program Technical Report 02-08; 83, http://www.tbeptech.org/TBEP_TECH_PUBS/2008/TBEP_02_08_Tidal_Tributary_Habitat_Initiative_Integrated_Summary_Report.pdf

Shields, F.D., Morin, N. and Cooper, C.M., 1/1/2004, Large Woody Debris Structures for Sand-Bed Channels, J. Hydraul. Eng. 130, 208–217, http://naldc.nal.usda.gov/download/10587/PDF

Shumway, S.E., Maryland Sea Grant College, 1/1/1996, Natural Environmental Factors, The Eastern Oyster Crassostrea virginica. Maryland Sea Grant College, University of Maryland. College Park, MD. pp. 467-513, http://www.mdsg.umd.edu/store/books/oyster/index.php

Smally, Wellford, and Nalven, Inc., Smally, Wellford, and Nalven, 9/1961, Sarasota County Coastal Basins Flood Control Study, http://www.sarasota.wateratlas.usf.edu/upload/documents/Sarasota%20County%20Coastal%20Basins%20Flood%20Control%20Study%20(1961).pdf

Smally, Wellford, and Nalven, Inc., Smally, Wellford, & Nalven, 12/1962, Proposed Sarasota Area Flood Control District, http://www.sarasota.wateratlas.usf.edu/upload/documents/Engineering%20Report%20Proposed%20Sarasota%20Area%20Flood%20Control%20District.pdf

Smally, Wellford and Nalven, Sarasota County, 4/25/1963, Report on the Water Supplies of Sarasota County, http://www.sarasota.wateratlas.usf.edu/upload/documents/RptWaterSupplySarasotaCounty.pdf

Smally Wellford & Nalven Consulting Engineers, 5/1970, Shoreline analysis of the City of Sarasota, https://dspace.mote.org/dspace/bitstream/2075/341/1/shorline%20analysis%20city%20sarasota-web.pdf

Southern Society of Civil Engineers, Proceedings of the Southern Society of Civil Engineers Annual Reports for 1885 and 1886.

Southwest Florida Regional Planning Council, Southwest Florida Regional Planning Council, 1/1/1978, Technical Appendix of the Productivity Study for the Phillippi Creek Study Area, http://books.google.com/books/about/Technical_Appendix_of_the_Productivity_S.html?id=33nDtgAACAAJ

Southwest Florida Regional Planning Council, Southwest Florida Regional Planning Council, 1980, Section 208 Water Quality Management Program – Executive Summary of the Final Water Quality Report for the Phillippi Creek Study Area, http://books.google.com/books/about/Water_Quality_Management_Program_Section.html?id=EKdeGwAACAAJ

Southwest Florida Water Management District (SWFWMD), n.d., Southern Coastal Watershed Excursion, http://www.swfwmd.state.fl.us/education/interactive/southerncoastal/index.html

Southwest Florida Water Management District (SWFWMD), SWFWMD Geographic Information System library. Brooksville, FL, Seagrass coverage for 1950, 1988, 1994, 2001, 2004, 2006, 2008, and 2010, https://www.swfwmd.state.fl.us/data/gis/layer_library/

Southwest Florida Water Management District (SWFWMD), SWFWMD, 11/2000, Southern Coastal Watershed Comprehensive Watershed Management Plan, http://www.swfwmd.state.fl.us/documents/plans/cwm/cwm-southerncoastal.pdf

Southwest Florida Water Management District (SWFWMD), SWFWMD Geographic Information System library. Brooksville, FL, 1/1/2002, Environmental Resource Permitting Information Manual, Part B: Basis of Review for 40-D Rules, https://www.swfwmd.state.fl.us/permits/rules/

Southwest Florida Water Management District (SWFWMD) SWIM Section, 12/2002, Sarasota Bay Surface Water Improvement and Management (SWIM) Plan, http://www.swfwmd.state.fl.us/documents/plans/sarasota_bay_2002.pdf

Southwest Florida Water Management District (SWFWMD), 3/2006, Southern Water Use Caution Area Recovery Strategy, http://www.swfwmd.state.fl.us/documents/plans/swuca_recovery_strategy.pdf

Southwest Florida Water Management District (SWFWMD), 2010, Regional Water Supply Plan, Southern Planning Region.

Stanley, J.G. and M.A. Sellers, Fish and Wildlife Service, U.S. Department of the Interior, 7/1986, Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico), American oyster, http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-064.pdf

Staley, N.; Wynn, T., Benham, B., and Yagow, G., Center for TMDL and Watershed Studies, 12/2006, Modeling Channel Erosion at the Watershed Scale: Model Review and Case Study, BSE Document Number 2006-0009, http://www.tmdl.bse.vt.edu/uploads/File/pub_db_files/VTBSE_Channel_Modeling_Guidance_Document.pdf

The State Of Florida, Department Of State, The State Of Florida, Department Of Environmental Protection, Surface Water Quality Standards, Rule Chapter: 62-302, https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-302

The State Of Florida, Department Of State, The State Of Florida, Department Of Health; Division: Division Of Environmental Health, Standards For Onsite Sewage Treatment And Disposal Systems, Rule Chapter: 64E-6, https://www.flrules.org/gateway/ruleNo.asp?id=64E-6.010

Supreme Court of Florida, 11/4/2003, Street Sweeping Report, http://www.florida-stormwater.org/Files/FSA%20Educational%20Foundation/Research/Street%20Sweeping/Gainesville%20decision.pdf

Tampa Bay Estuary Program, 11/1/2008, Model-Based Estimates of Nitrogen Load Reductions Associated with Fertilizer Restriction Implementation. http://www.tampabay.wateratlas.usf.edu/upload/documents/Final_Reduction_Credits_TBEP_Regional_Fertilizer_Guideline_Recommendations.pdf

Tampa Bay Regional Planning Council, 1993, Implications and Management of a Sea Level Rise in the Sarasota Bay Region, http://books.google.com/books/about/Implications_and_Management_of_a_Sea_Lev.html?id=4kCzHAAACAAJ

Taylor, Ron; FFWC, 12/17/2008, The Developmental Stages (Ontogeny) and Associated Habitats of Common Snook, http://www.snookfoundation.org/news/research/108-the-developmental-stages-ontogeny-and-associated-habitats-of-common-snook.html

Tiffany, William J., 1974, Checklist of Benthic Invertebrate Communities in Sarasota Bay with Special Reference to Water Quality Indicator Species.

Tiffany, William J., 8/1980, Environmental Status of Sarasota Bay: Selected studies., Part 1, https://dspace.mote.org/dspace/bitstream/2075/148/4/MTR%2030_part%201.pdf

Tiffany, William J., 8/1980, Environmental Status of Sarasota Bay: Selected studies., Part 2.

Tolley, S.G., and Volety, A.K., 1/1/2005, The Role of Oysters in Habitat Use of Oyster Reefs by Resident Fishes and Decapod Crustaceans, Journal of Shellfish Research 24:1007-1012, http://www.bioone.org/doi/abs/10.2983/0730-8000(2005)24%5B1007%3ATROOIH%5D2.0.CO%3B2

Town of Longboat Key, Town of Longboat Key, 12/2/2003, Town of Longboat Key 2007 Comprehensive Plan, Ordinance 2007-37, http://www.longboatkey.org/Departments/PZB/CP.pdf

Townsend, Timothy G.; Yong-Chul Jang, Paul, Florida Department of Environmental Protection, University of Florida, 12/31/2002, Research was performed to examine the chemical characteristics of street sweepings, stormwater pond sediments, and catch basin sediments, http://www.florida-stormwater.org/Files/FSA%20Educational%20Foundation/Research/Street%20Sweeping/stsweepchar.pdf

Tomasko, D.A; Corbett, C.A.; Greening, H.S.; Raulerson, G.E., 2005, Spatial and Temporal Variation in Seagrass Coverage in Southwest Florida, Assessing the Relative Effects of Anthropogenic Nutrient Load Reductions and Rainfall in Four Contiguous Estuaries, https://www.com.univ-mrs.fr/~boudouresque/Master_Oceanographie_Biologie_Ecologie_Marine/Cours_BENT_Lejeusne_pub_Tomasko.pdf

Tomasko, D.A., Dawes, C. J., and M.O. Hall, SBEP, USF, Mote, 6/1996, The effects of Anthropogenic Nutrient Enrichment on Turtle Grass (Thalassia testudinum) in Sarasota Bay, Florida, http://www.jstor.org/pss/1352462

Tomasko, D.A. and M.O. Hall, SWFWMD, Florida Marine Research Institute, 9/1999, Productivity and Biomass of the Seagrass Thalassia testudinum Along a Gradient of Freshwater Influence in Charlotte Harbor, Florida, http://www.jstor.org/pss/1353047

Tomasko, D. A., SBEP, 8/1/1997, Technical Synthesis of Sarasota Bay, http://www.p2pays.org/ref/41/40279.pdf

Torres, A.E.; L.A. Sacks; D.K. Yobbi; L.A. Knochenmus; B.G. Katz, Southwest Florida Water Management District; U.S. Department of the Interior; U.S. Geological Survey, 2001, Hydrogeologic Framework and Geochemistry of the Intermediate Aquifer System in Parts of Charlotte, De Soto, and Sarasota Counties, Florida, Water-Resources Investigations Report 01-4015, http://fl.water.usgs.gov/Abstracts/wri01_4015_torres.html

University of Maryland, Permeable Pavement Fact Sheet.

University of South Carolina, 7/1/2000, Final Report of the Statewide Task Force on Riparian Forest Buffers, http://www.scdhec.gov/environment/water/docs/npsrip.pdf

Urban Pollutant Loads and General BMP Cost Analysis, 1/1/2005, http://www.kalamazooriver.net/pa319new/docs/handouts/pond_costs_loads.pdf

US Army Corp of Engineers, Jacksonville, Fl, Corp of Engineers, 11/1962, Report on Flood of 20-21 September 1962 Southwest Florida, http://www.sarasota.wateratlas.usf.edu/upload/documents/Rpt%20Flodd%2020-2i%20Sept%2062%20SW%20FL.pdf

US Army Corps of Engineers, Sarasota County, 5/1/1993, Whitaker Bayou Flood Study, Hydrologic & Hydraulic Modeling Data.

U.S. Army Corps, U.S. Army Corps, 5/1/2003, Whitaker Bayou Feasibility Study, Section 205.

US Army Corps of Engineers, 4/1/2012, Mechanical Control Methods, http://www.glmris.anl.gov/documents/docs/anscontrol/MechanicalControlMethods.pdf

US Environmental Protection Agency (EPA), Office of Water, Office of Science and Technology, EPA, 8/2003, Developing Water Quality Criteria for Suspended and Bedded Sediments (SABS), Potential Approaches.

US Environmental Protection Agency (EPA), 3/2005, Sarasota Bay Tributary Survey, Project Number: 05-0371, http://www.sarasota.wateratlas.usf.edu/upload/documents/EPA2005SarasotaBayTributarySurvey.pdf

US Environmental Protection Agency (EPA) Region 4, 4/1/2006, Total Maximum Daily Load (TMDL) for Nutrients, Dissolved Oxygen, and Coliforms in Sarasota Bay/Charlotte Harbor Basin Groups, http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.tmdl_report?p_tmdl_id=22988&p_tribe=&p_report_type=T

US Environmental Protection Agency (EPA), SBEP, 6/2007, National Estuary Program Coastal Condition Report, Chapter 5: Gulf of Mexico National Estuary Program Coastal Condition, Sarasota Bay Estuary Program, http://www.epa.gov/owow/oceans/nepccr/index.html

US Environmental Protection Agency (EPA), 3/1/2008, Handbook for Developing Watershed Plans to Restore and Protect Our Waters, http://water.epa.gov/polwaste/nps/handbook_index.cfm

US Environmental Protection Agency (EPA), Washington, D.C., 1/1/2010, Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters, http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/FL%20Estuaries%20TSD?OpenDocument

US Environmental Protection Agency (EPA), 10/3/2010, Comments of the Southwest Florida Water Management District, Water Quality Standards for the State of Florida Lakes and Flowing Water.

US Geological Survey (USGS), U.S. Geological Survey Photographic Library, http://libraryphoto.cr.usgs.gov/cgi-bin/search.cgi?search_mode=noPunct&free_form=sarasota&free_form=&free_form=&free_form

Verity, W. Evans, W. and Tipple, V. K., U.S. Dept. of Commerce, NOAA, 12/10/1987, Tampa and Sarasota Bays: Issues, Resources, Status, and Management: Proceedings of a Seminar held Dec 10, 1987, Washington, D.C., NOAA Estuary-of-the-Month Seminar Series No. 11, https://dspace.mote.org/dspace/bitstream/2075/305/1/Tampa%26Sarasota%20Bays%28NOAA%2311%29-web.pdf

Weamert, Sarah; Simpson, Tom; University of Maryland, 1/1/2008, Riparian Forest Buffer Practice and Riparian Grass Buffer Practice, http://archive.chesapeakebay.net/pubs/bmp/Year_1_Reports/Riparian%20Forest%20and%20Grass%20Buffers.pdf

Wegner, S., Institute of Ecology, University of Georgia, 1/1/1999, A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation, http://www.rivercenter.uga.edu/service/tools/buffers/buffer_lit_review.pdf

Weiss, Peter T.; Gulliver, John S.; Erickson, Andrew J., 6/1/2005, The Cost and Effectiveness of Stormwater Management Practices, http://www.lrrb.org/pdf/200523.pdf

Wells, H.W., 1/1/1961, The Fauna of Oyster Beds, with Special Reference to the Salinity Factor, Ecological Monographs 31(3): 239-266, http://www.esajournals.org/doi/abs/10.2307/1948554

Wells, R.S.; Nowacek, D. P., et al., 3/1/2006, Responses of Bottlenose Dolphins to Construction and Demolition of Underwater Structures: Final Report, https://dspace.mote.org/dspace/bitstream/2075/249/4/MTR%2b1081.pdf

Wessel, M.R., Janicki, A. and R. Nijbroek, Sarasota County, 9/21/2007, Establishing Water Clarity Benchmarks for Sarasota County Estuarine Waters, http://www.sarasota.wateratlas.usf.edu/upload/documents/EstabWQTargetsSaraCoEstuarineWaters_09-21-07.pdf

Wildermuth, Robert, Huber, Joseph L., Leighty, Ralph g., USDA, SCS, US Department of Agriculture, University of Florida, 11/1959, Soil Survey of Sarasota County, FL.

Wilsonmiller Stantec, Wilsonmiller Stantec, 1/1/2012, Indian Beach/Sapphire Shores LID Retrofit Pilot, SBEP, http://sarasotabay.org/documents/Indian-Beach-LID-Project-Jan-2012.pdf

Wilsonmiller Stantec, Wilsonmiller Stantec, 1/1/2012, Whitaker Bayou Greenway Park and Stormwater Lid Retrofit Pilot Prepared.

Wolansky, R.M., U.S. Geological Survey, SWFWMD, 1983, Hydrogeology of the Sarasota-Port Charlotte Area, Florida, Water Resources Investigations Report 82-4089, http://onlinepubs.er.usgs.gov/djvu/WRI/wrir_82_4089.djvu

Zarriello, P.J., Breault, R.F., and Weiskel, P.K., USGS, 1/1/2002, Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts, http://pubs.usgs.gov/wri/wri024220/pdfs/wrir024220.pdf