Technical Memorandum

To: **Mac Hatcher, PM Collier County**

From: **Moris Cabezas, PBS&J**
Dave Tomasko, PBS&J
Amy Krebs, PBS&J

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Re: **Watershed Model Update and Plan Development**
Contract 08-5122, PO 4500106318
Element 2, Task 4 Coastal Habitats

1.0 Objective

This Technical Memorandum addresses Element 2, Task 4: Coastal Habitats. The objective of this task is to quantify, to the extent possible, changes over time in the areal extents of oyster bars, seagrass beds, mangrove forests and salt marshes for the estuaries of Wiggins Pass, Naples Bay, Rookery Bay, and the Ten Thousand Islands.

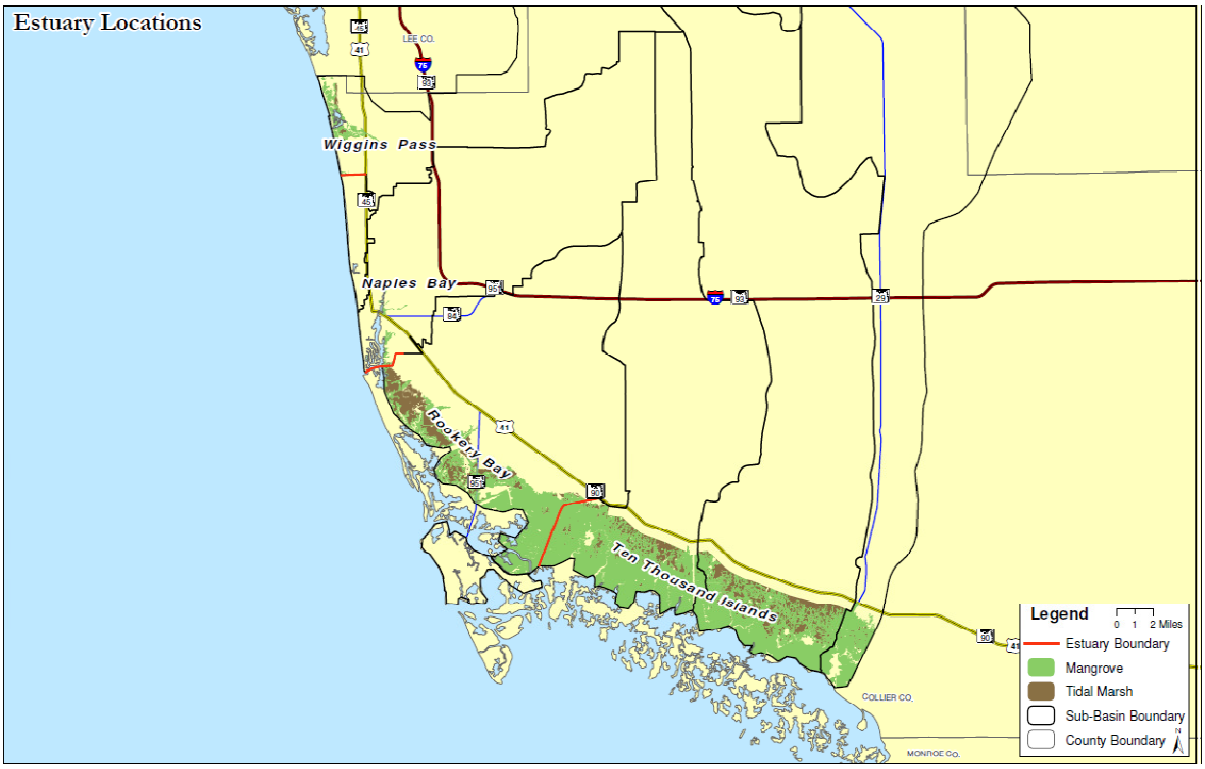
2.0 Introduction

Estuaries provide many ecosystem functions, including shoreline stabilization, nutrient recycling, and providing habitat for a diverse assemblage of plants and animals. Within Collier County, coastal ecosystems have been previously impacted by alterations in the timing and amounts of freshwater inflow (e.g., Browder et al. 1988, Shirley et al. 1997, Shirley et al. 2005, Popowski 2006, etc.) and physical destruction (Shirley et al. 1997). Less frequently mentioned is environmental degradation due to nutrient enrichment, a topic discussed by Shirley et al. (1997).

Many of the large-scale hydrologic alterations in Collier County began in the early 1950's. Dredge-and-fill became the established method to meet the post-World War II demand for housing. Canals served to create waterfront property, increase access for boating, and provided fill material needed for the creation of buildable lots (Antonini et al 2002). Coastal development has also led to an increase in impermeable surfaces and a subsequent increase in freshwater inputs from the watershed. The timing and volume of freshwater discharges to the estuaries have been significantly altered from natural conditions, with the primary problem being the delivery of too much fresh water during the wet season and too little during the dry season (e.g., Browder et al. 1988, Shirley et al. 1997). As a result, the historical areal extents of oyster bars and seagrass beds have been reduced by salinity alterations, shading, and smothering. The tidal mangrove habitat has also been affected by coastal development and hydrologic alterations to the salinity regime (Doyle et al 2003, Popowski 2006).

This technical memo focuses on four estuaries: Wiggins Pass, Naples Bay, Rookery Bay, and the Ten Thousand Islands. The locations of these estuaries are shown in **Figure 1.1.**

Figure 1-1. Estuary Locations



3.0 Methodology

To quantify changes, if any, in the spatial extent of oyster bars, seagrass beds, mangrove forests, and salt marshes, a variety of GIS databases were queried, and results compared and contrasted. GIS databases searched included those from the South Florida Water Management District (i.e., Duever 2004 and other sources) and the Florida Freshwater Fish and Wildlife Conservation Commission. The amount and type of data available differed between the four estuaries examined (Wiggins Pass, Naples Bay, Rookery Bay, and the Ten Thousand Islands).

For Wiggins Pass, GIS data on oysters was found for 1999, seagrass data was found for 2006, tidal marsh data was available for pre-development and 2007 time periods, and mangrove data was available for both pre-development and 2007 time periods.

In Naples Bay, GIS data was obtained for both oysters and seagrass for the years 1953 and 2005. Data on both tidal marshes and mangrove forests were available for both pre-development and 2007 time periods.

For Rookery Bay, GIS data were found for both tidal marshes and mangrove forests for both pre-development and 2007 time periods. No GIS data were found for the spatial extent of oysters

and seagrasses, although reports were found that discussed locations where oyster reefs and seagrass beds had been encountered; such sources were insufficient for a GIS-based analysis of spatial trends in coverage.

In the Ten Thousand Islands, GIS data were found for both tidal marshes and mangrove forests for both pre-development and 2007 time periods. As in Rookery Bay, no GIS data were found that would allow for a detailed assessment of the changes (if any) in the spatial extent of oysters and seagrasses, although reports were found that discussed locations where oyster reefs and seagrass beds had been encountered.

In the report "Seagrass Status and Trends in the Northern Gulf of Mexico", the authors found that the coastal waters of Collier County are the only region on both east and west coasts of Florida without seagrass acreage estimates (Handley et al. 2007). In general, the lack of GIS data for seagrasses and oysters in much of Collier County may be due to the reduced water clarity in many coastal waters, making delineation of features from aerial photography a difficult task to accomplish.

For all estuaries, the development of a trend analysis is dependent upon obtaining an accurate assessment of the spatial extent of various landscape features at the earliest time possible. For Collier County, the land use maps developed by Duever (2004) allow for a comparison of more recent landscapes with a "pre-development" condition. However, the physical boundaries of that pre-development mapping effort does not include the islands that lay south and west of the mainland of Collier County, particularly in the region of the Ten Thousand Islands. This data limitation restricts GIS comparisons to those regions along the mainland portion of Collier County. While this is a somewhat disappointing condition of the available data, most of the changes in natural system features over time have occurred along the mainland shoreline, not on the offshore islands of the Ten Thousand Islands estuary, with the exception of the large-scale development of Marco Island.

4.0 Results and Discussion

This section presents the results of the GIS-based land cover analysis conducted as part of this project. The section is structured such that the four estuaries of Wiggins Pass, Naples Bay, Rookery Bay and the Ten Thousand Islands are discussed separately, as follows:

4.1. Wiggins Pass

Wiggins Pass was first officially dredged in 1952, and dredging has continued within the inlet and along the inland waterway south of Bonita Beach and north of Naples Park. Development within the coastal area surrounding Wiggins pass began in the early 1950's resulting in the creation of residential canals which have altered natural sheet flow in the area. As shown on **Figure 4.1.1,** the area adjacent to Wiggins pass has changed from a mangrove dominated system to a system including both tidal marsh and mangroves. In addition, there is an overall decrease in the mangrove community associated with direct physical alterations of the shoreline due to coastal development.

As summarized in **Table 4.1.1**, mangrove acreage in the Wiggins Pass estuary boundaries had decreased from 1,660 in pre-development times (Duever 2004) to 999 acres in 2007, a decline of approximately 40 percent. Tidal marsh habitat was not mapped for pre-development conditions (Duever 2004) in the Wiggins Pass estuary boundaries, but it accounted for 183 acres in 2007 (**Table 4.1.1**. Due to natural cycles of succession between mangroves and salt marshes (Lewis and Streever, 2000), analysis may be best focused on examining the combined acreage of these two communities, rather than each one separately. With this approach, it was determined that the Wiggins Pass estuary has experienced a combined decrease of mangroves and tidal marsh from 1,660 acres in pre-development years to 1,182 in 2007, a decline of 29 percent.

No GIS data sources of oyster resources were located other than a 1999 coverage obtained from the Fish and Wildlife Research Institute (FWRI). **Figure 4.1.1** depicts several small patches of oysters in the northern portion of Wiggins Bay in 1999. **Figure 4.1.1** also shows the location of seagrasses from a data layer compiled in 2006 by the FWRI. These limited oyster and seagrass data could function as a potential baseline for identifying future changes in estuarine conditions.

Figure 4.1.1 - Wiggins Pass Estuarine Communities
(GIS data from SFWMD and the FWRI)

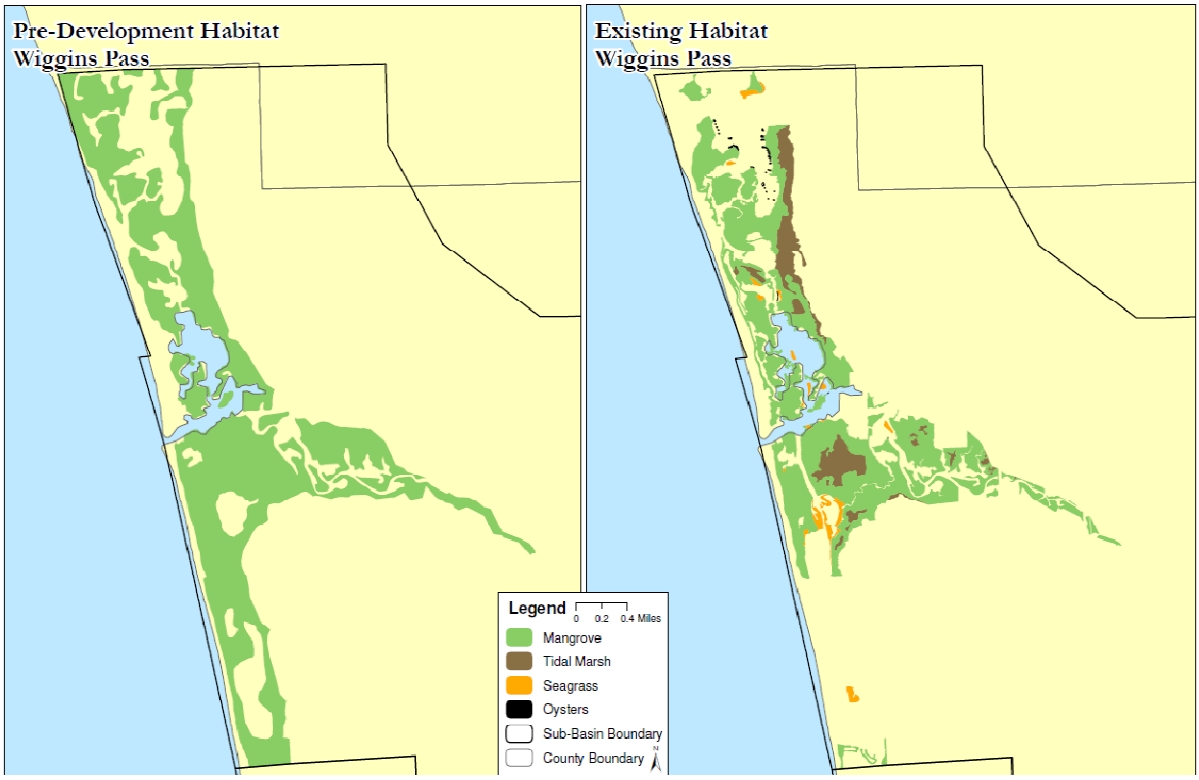


Table 4.1.1
Wiggins Pass Estuarine Communities

Wiggins Pass	Pre-Development	Current	Acres Lost	Percent Loss
Oyster (1999)	No Data	5		
Seagrass (2006)	No Data	39		
Tidal Marsh (Pre-Dev vs. 2007)	0	183	477	29
Mangrove (Pre-Dev vs. 2007)	1,660	999		

4.2. Naples Bay

Historic maps and records indicate that Naples Bay was a shallow estuarine system containing mangrove islands surrounded by oysters and seagrass beds (Antonini et al. 2002, Schmid et al. 2006). Historically, extensive oyster bars were found along the shorelines and at the mouth of Naples Bay's many tidal creeks. Seagrass beds were also noted in the historical record (Schmid et al 2006).

Dredging activities conducted to create the system of residential development along man-made canals, significantly altered the tidal flushing patterns and the overall functionality of the bay as a shallow estuarine system (Schmid et al 2006). According to Schmid et al. (2006), the shoreline length of Naples bay increased by nearly 50 percent between 1927 and 1965, followed by an additional increase of 11 percent between 1965 and 1978. The increase in shoreline length is directly related to the construction of residential canal systems. In addition, Schmid et al. (2006) documented a 91 percent loss in seagrass habitat and 82 percent loss in oyster habitat since the 1950s.

The loss of oyster coverage is shown in **Figure 4.2.1** where the past widespread distribution of oysters in 1953 is now restricted to scattered locations along the eastern shoreline south of Haldeman Creek. **Figure 4.2.1** also shows the significant decrease in natural shoreline vegetation, particularly the mangrove fringe. Schmidt et al. (2006) reported that 70 percent of the fringing mangrove shoreline of Naples Bay has been converted to residential developments. This is consistent with the analysis of GIS data shown in **Table 4.2.1**, where a 76 percent decline in combined mangrove and tidal marsh acreage was estimated between the pre-development and 2007 time periods (1,549 and 367 acres, respectively) within the Naples Bay estuary boundaries.

Figure 4.2.1 - Naples Bay Habitat Changes
(GIS data from SFWMD and the FWRI)

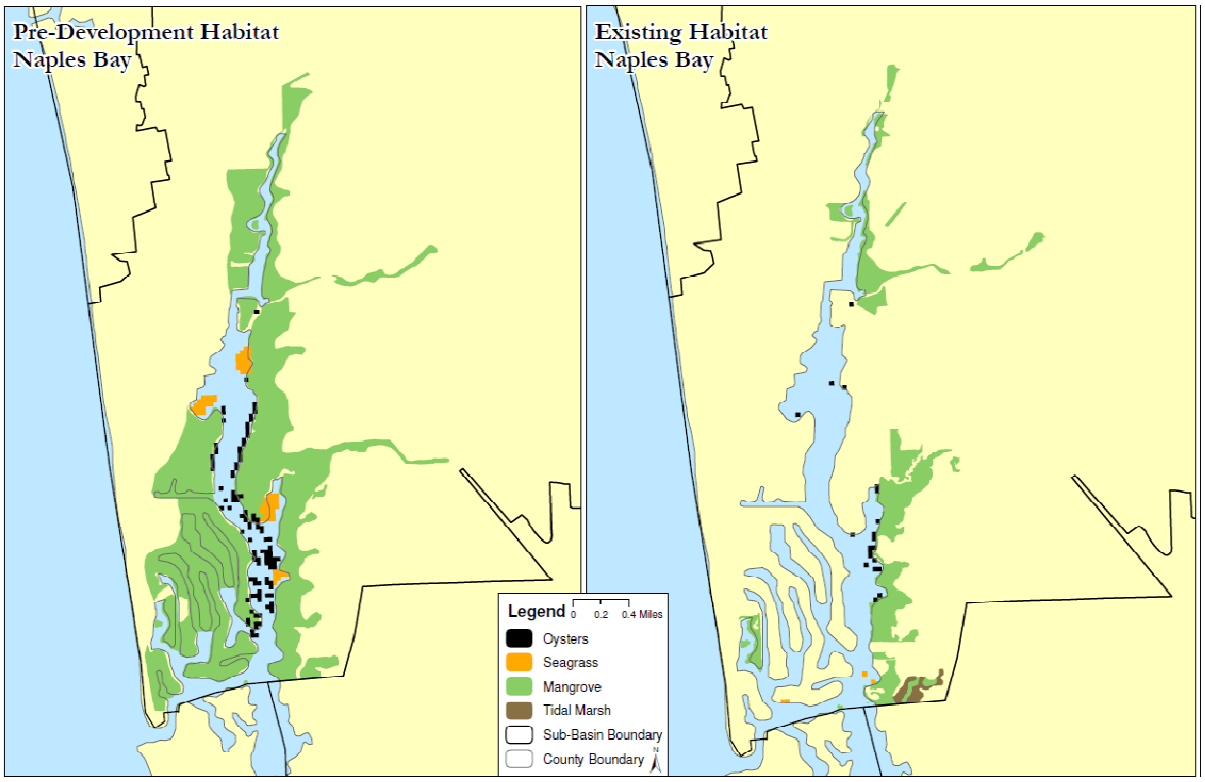


Table 4.2.1 - Naples Bay Habitat Changes

Naples Bay	Pre-Development	Current	Acres Lost	Percent Loss
Seagrass (1953 vs. 2005)	51	2	48	95
Oyster (1953 vs. 2005)	68	12	55	82
Tidal Marsh (Pre-Dev vs. 2007)	0	20	1,182	76
Mangrove (Pre-Dev vs. 2007)	1,549	347		

4.3. Rookery Bay

The Rookery Bay watershed has been significantly altered by channelization, and its present estuarine salinity regimes are more strongly influenced by canal management than by tides or rainfall (Shirley et al 2004). This altered freshwater inflow has been identified as the most important threat to the natural biodiversity of this protected area (Shirley et al., 2004).

Based on assessments of the rates of vertical accretion in the mangrove forests within Rookery Bay, it was determined the mangrove forest elevation has kept pace with sea level rise over approximately the past 70 years (Cahoon and Lynch 1997). This finding supports the

importance of mangroves as a means of stabilizing shorelines and preventing erosion in coastal regions. **Figure 4.3.1** illustrates the transition of the mangrove community into tidal marsh in some locations, a finding at odds with the pattern described by Popowski (2006). This transition could be the result of natural cycles of succession, or such a "transition" could be a mapping artifact associated with delineating the boundaries of tidal marshes in the pre-development vegetation data layers (i.e., Duever 2004).

Overall, it was estimated that Rookery Bay has experienced a decrease in the combined mangrove and salt marsh habitat of within its estuary boundaries, from 17,866 acres in pre-development times to 15,697 in 2007, a decline of 12 percent (**Table 4.3.1**).

Figure 4.3.1 - Rookery Bay Mangroves and Salt Marshes (GIS data from SFWMD)

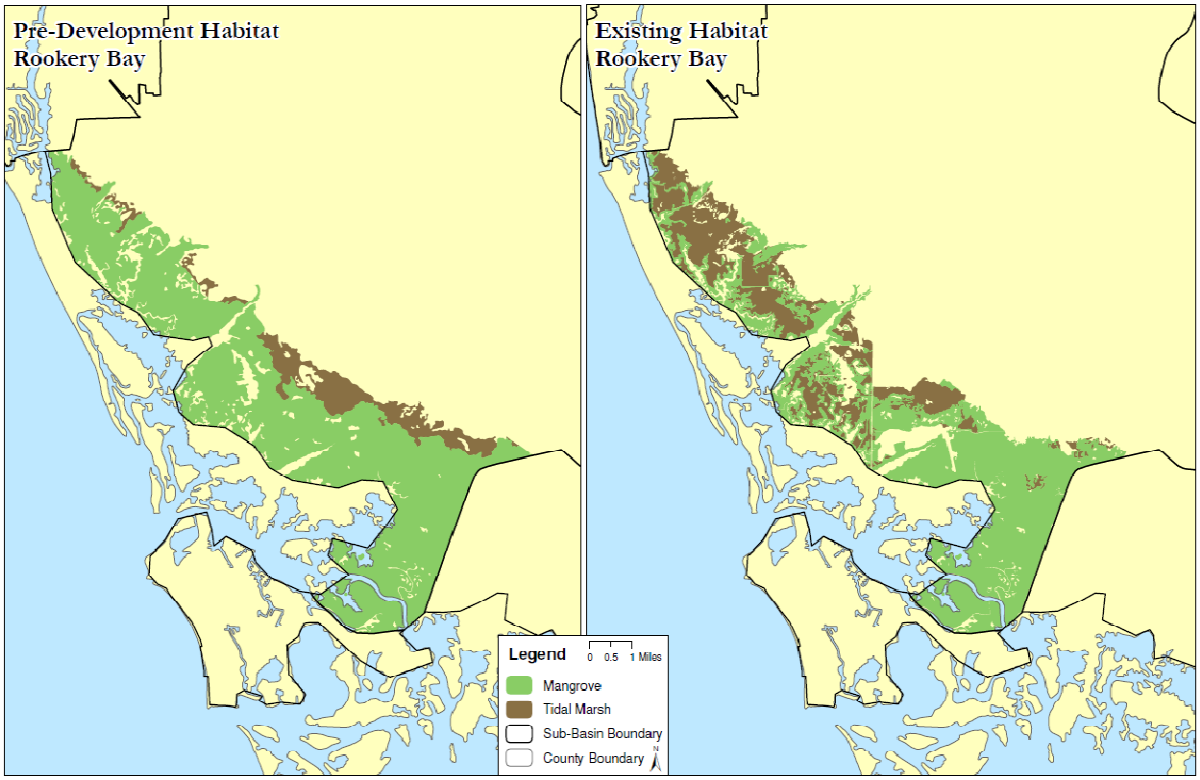


Table 4.3.1 - Rookery Bay Mangroves and Salt Marshes

Rookery Bay	Pre-Development	Current	Acres Lost	Percent Loss
Tidal Marsh (Pre-Dev vs. 2007)	2,131	5,122	2,170	12
Mangrove (Pre-Dev vs. 2007)	15,735	10,575		

4.4. Ten Thousand Islands

Within the Ten Thousand Islands estuary, the natural pattern of spatial and temporal variation in salinities has been significantly and adversely affected by upstream water management practices (Browder et al. 1988, Shirley et al. 1997, Shirley et al. 2005, Popowski 2006). Two major examples of large-scale hydrologic alteration are the Tamiami Trail Canal, which intercepts inflows from the north and passes them through a fixed number of bridges and box culverts underneath Tamiami Trail (Popowski, 2006) and the Golden Gate Estates canal system, which discharges perhaps 30 percent excess freshwater inflow into Faka Union Bay during the wet season (Browder et al. 1988).

The Ten Thousand Islands estuary is described as a complex community consisting of mangrove islands, oyster beds and shallow lagoons (Wanless et al 1994). As depicted in **Figure 4.4.1**, the Ten Thousand Islands mangrove system appears to have been slightly reduced but has also undergone an apparent transition into tidal marsh habitat when comparing the pre-development vegetation map (Duever 2004) to 2007 data. This finding is in contrast to the pattern of an increase in mangrove coverage, at the expense of tidal marsh, cited by Popowski (2006). A transition from mangrove to salt marsh, or vice versa, could be due to natural cycles of succession, or it could be an artifact associated with the difficulty of accurately locating GIS based features in the pre-development vegetation data layer (Duever 2004) used for this analysis.

As with the other estuaries examined, the status and trends (if any) of the combined acreage of salt marsh and mangroves was examined. These data (**Table 4.4.1**) indicate a decrease in combined salt marsh and mangrove extent from 40,405 acres in pre-development times to 38,490 in 2007, a decline of 5 percent (**Table 4.4.1**). Within the more extensive watershed boundaries of these estuaries, which extend north of Tamiami Trail, a more substantial loss in mangrove and salt marsh extent was found – a combined reduction of 13 percent from pre-development conditions (Technical Memorandum for Element 1 Task 3.1).

Figure 4.4.1 – Ten Thousand Islands Mangroves and Tidal Marshes (GIS data from SFWMD)

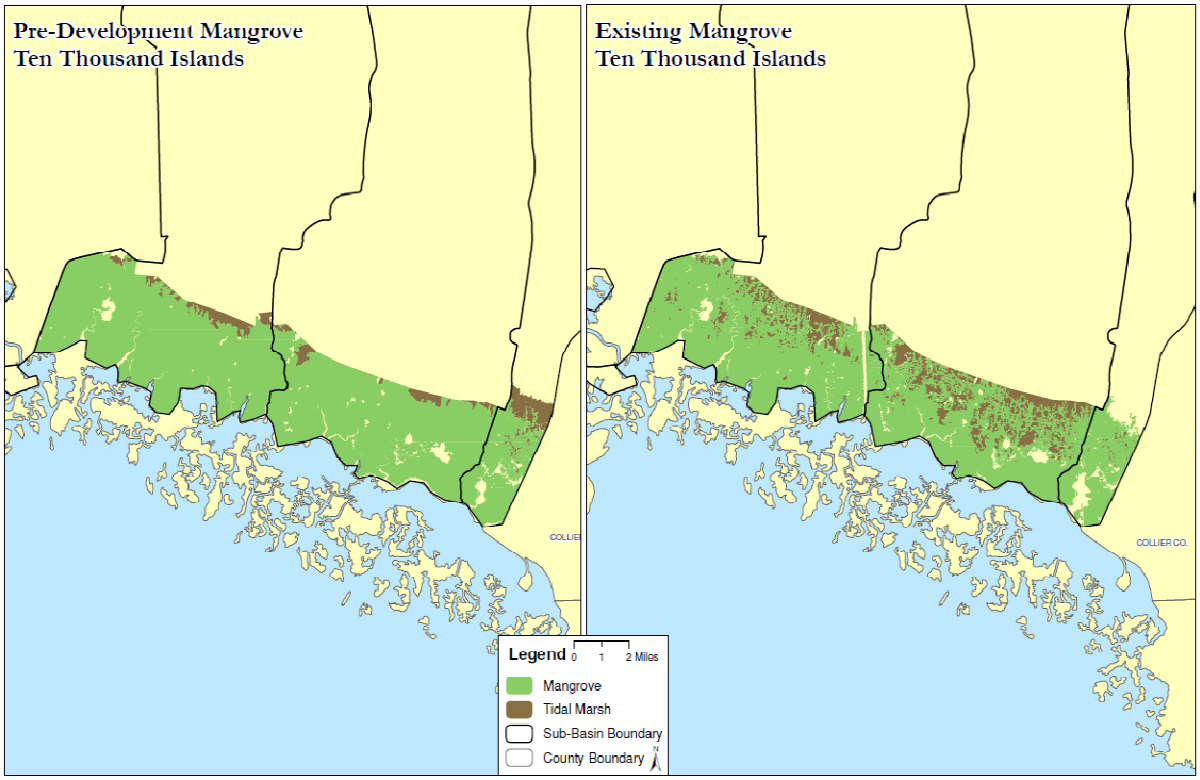


Table 4.4.1 - Ten Thousand Islands Mangroves and Salt Marshes

Ten Thousand Islands	Pre-Development	Current	Acres Lost	Percent Loss
Tidal Marsh (Pre-Dev vs. 2007)	2,711	7,737	1,916	5
Mangrove (Pre-Dev vs. 2007)	37,694	30,753		

5.0 Conclusions

A general gradient of disturbance is evident, when comparing the relative loss of coastal habitats in Collier County's estuaries. In the Wiggins Pass estuary, the combined acreage of salt marsh and mangroves has declined by 29 percent over pre-development conditions. To the south, salt marsh and mangrove acreage has declined by approximately 76 percent over time in Naples Bay. In contrast, the less-impacted estuaries of Rookery Bay and the Ten Thousand Islands have experienced salt marsh and mangrove declines of 12 and 5 percent, respectively.

For Wiggins Pass and Naples Bay, the amount of loss of salt marsh and mangrove reflects the greater degree of development pressures. The lesser degree of development within the coastal reaches of the Rookery Bay estuary reflects the protection this area has received through various land acquisition activities (e.g., the 110,000 acre Rookery Bay National Estuarine Research Reserve). Direct loss of salt marsh and mangrove habitat is much less in the Ten Thousand Islands; however the remaining estuarine habitats have been adversely affected by alterations in the timing and quantity of freshwater inflows (e.g., Browder et al. 1988, Shirley et al. 1997, Shirley et al. 2005, Popowski 2006).

Documenting changes over time in the extent of oyster reefs and seagrass beds is more difficult. The coastal waters of Collier County are mostly unique for the absence of any seagrass bed delineations and/or quantification in the State of Florida (Handley et al. 2007). The data that were found were restricted to Wiggins Pass and Naples Bay, and historical data was only found for Naples Bay. In Naples Bay, the areal extent of oyster reefs has declined by perhaps 82 percent from the 1950s, with seagrass coverage down by 95 percent. In Wiggins Pass, oysters and seagrass meadows are not wide-spread features of these estuaries, yet it is not known if their declines over time have been as substantial as that found in Naples Bay. Through the use of side-scan sonar, Locker (2005) found that there were substantial meadows of seagrass, mostly *Halophila decipiens*, within Fakahatchee Bay, but little evidence of anything other than small isolated patches of seagrass within Faka Union Bay. It was also found (Locker 2005) that for Faka Union Bay "…an anthropogenic mud layer blankets much of the bay due to flushing of organic-rich fines from the Faka Union Canal due to high-velocity freshwater inflows."

In addition to the reduced functioning of estuarine ecosystems due to alterations in the timing and quantity of freshwater inflow, Collier County's more urbanized estuaries (e.g., Wiggins Pass and Naples Bay) have also been impacted by large-scale losses due to direct physical alterations of the shoreline. For Wiggins Pass and Naples Bay, recreating a more natural hydrologic inflow pattern might not be sufficient for restoring past estuarine functions, since the physical features of oyster reefs and seagrass meadows have been lost over time. In contrast, the majority of tidal marsh and mangrove acreage is still intact in Rookery Bay and the Ten Thousand Islands. What remains to be accomplished in Rookery Bay and Ten Thousand Islands appears to be restoration of a more natural pattern of freshwater inflow for these less-developed estuaries, a feasible option that will be fully developed as part of this project.

6.0 Bibliography

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