CLAM BAY NRPA MANAGEMENT PLAN

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Version 6.5

PREPARED BY:



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CLAM BAY NRPA MANAGEMENT PLAN EXECUTIVE SUMMARY

The Clam Bay Natural Resource Protection Area (NRPA) is a 560.05-acre estuarine system consisting of sandy beaches, Clam Pass, shallow bays, tidal creeks or tributaries, seagrass beds, and mangrove forests on the west coast of Collier County in Southwest Florida. The NRPA includes three primary bays, Outer Clam Bay (southernmost), Inner Clam Bay (central), and Upper Clam Bay (northernmost), connected by a series of tidal creeks and connected to the Gulf of Mexico by Clam Pass.

The preparation and implementation of the Clam Bay NRPA Management Plan has been undertaken by the Pelican Bay Services Division at the direction of the Collier County Board of County Commissioners. The Management Plan will provide guidance for future management activities within the NRPA, building on the successes of the 1998 Restoration and Management Plan, by outlining the goal and objectives designed to protect, maintain, and monitor the natural resources within the NRPA and foster responsible stewardship going forward. The Management Plan provides an overview of the natural resources and processes within the NRPA along with a summary of the surrounding development and a brief historical perspective of past events and activities which have affected it.

Coordination with community members and stakeholders has been balanced with anticipated administrative and financial resources to develop the following goal and supporting objectives for this Management Plan. All activities in support of these objectives will be prioritized and governed by the PBSD and available funding.

Goal: *To establish the basis for management activities that will be undertaken to protect the health of the Clam Bay NRPA estuary.*

Objectives to support this goal include:

1. *Maintain and protect the native floral and faunal communities within the Clam Bay NRPA*
2. *Ensure the estuary has adequate tidal and freshwater flows to maintain ecological health within the Clam Bay NRPA*
3. *Monitor and maintain water quality within the Clam Bay NRPA*
4. *Monitor archaeological sites within the Clam Bay NRPA*
5. *Ensure recreational activities are environmentally compatible within the Clam Bay NRPA*

In support of these objectives, periodic monitoring of the flora and fauna will be conducted. Encroachments into the NRPA by exotic and nuisance vegetation will be documented and reported for removal or control. Monitoring of water quality and freshwater inputs into the NRPA will be continued. Archaeological resources within the NRPA will be periodically monitored, and any degradation will be reported to the State Historic Preservation Offices. Educational opportunities will be explored and acted upon to promote environmentally compatible recreational uses within the NRPA. Irresponsible or environmentally damaging activities will be documented and, where appropriate, reported to the proper authorities.

Regular monitoring of Clam Pass will be conducted to track the stability of the inlet. The Management Plan outlines the hydraulic and bathymetric parameters that will be investigated to enable the PBSD to

make recommendations to the BCC on when and where dredging might be undertaken to maintain the tidal exchange necessary for the long-term health of the estuary. The Management Plan also includes typical dredging designs for the three main sections of Clam Pass and shows the cross sectional areas that could be dredged. The pros and cons of dredging will be weighed in regards to both hydrologic and ecological consequences.

All monitoring, investigative, and management activities from the preceding year will be compiled into an annual report and summarized in an annual presentation to the PBSD Board. Comparisons to historic data will be done where appropriate to track trends and make determinations as to whether additional interventions are needed to maintain the estuary's health. Biological monitoring, water quality monitoring, pass bathymetry and status investigations, and any other activities conducted or data collected during the preceding year will be documented in the annual report. The PBSD will then determine if changes to management strategies and activities are needed.

The Management Plan will be an integral part of permit applications that may be required for management activities in support of the Goal and Objectives. The Management Plan will provide background information to permitting agencies regarding conditions that may be present, why management actions are being undertaken, and how impacts to natural resources will be minimized. The document also allows for changes to the Management Plan should new information or management techniques come to light that would benefit the Clam Bay NRPA.

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Acronym Key

BCC	**Collier County Board of County Commissioners**
DHR	**Division of Historical Resources**
DNR	**Department of Natural Resources**
ESA	**Endangered Species Act**
FDEP	**Florida Department of Environmental Protection**
FDER	**Florida Department of Environmental Regulations**
FLEPPC	**Florida Exotic Pest Plan Council**
FLUCFCS	**Florida Land Use, Cover, and Forms Classification System**
FSU	**Florida State University**
FWC	**Florida Fish and Wildlife Conservation Commission**
FWS	**Fish and Wildlife Service**
LIDAR	**Light Detecting and Ranging**
MAG	**Mangrove Action Group**
MGD	**Millions of Gallons / Day**
MHW	**Mean High Water**
MLW	**Mean Low Water**
MSTBU	**Municipal Services Taxing Benefit Unit**
NMFS	**National Marine Fisheries Service**
NOAA	**National Oceanic and Atmospheric Administration**
NRCS	**National Resource Conservation Services**
NRPA	**Natural Resource Protection Area**
PBID	**Pelican Bay Improvement District**
PBSD	**Pelican Bay Services Division**
PUD	**Planned Unit Development**
SSAC	**Site Specific Alternative Criteria**
ST	**Sensitive Treatment**
STORET	**Storage and Retrieval Data Warehouse**
TMDL	**Total Maximum Daily Load**
USACE	**U.S. Army Corps of Engineers**
USDA	**United States Department of Agriculture**
USFWS	**U.S. Fish and Wildlife Service**
WBID	**Water Body Identification**
WCI	**Westinghouse Communities Inc.**

1.0 Introduction

Purpose of the Clam Bay Natural Resource Protection Area Management Plan

The purpose of this management plan is to provide guidance and direction for the protection, preservation, and maintenance of the Clam Bay Natural Resource Protection Area (NRPA). This plan will form the basis by which future management decisions can be made by identifying the appropriate techniques necessary to achieve long-term sustainability for the natural resources and their uses within the Clam Bay NRPA.

This plan, in addition to providing a brief historical perspective of activities undertaken within this system, will identify the management goal and objectives; allow for development of methods to achieve the goal and objectives; and summarize implementation, assessment, and evaluation strategies that strive to balance resource protection with recreational use. While the 1998 Clam Bay Restoration and Management Plan (1998 Management Plan) primarily focused on mangrove health and recovery, this plan will address all floral and faunal components of the NRPA. The plan will draw from the 1998 Management Plan, input from multiple interested stakeholders, and historical biological, hydrological, and physical reports to outline the goal and objectives for future management of the ecosystems throughout Clam Bay.

The 2014 Clam Bay NRPA Management Plan (Management Plan) and any subsequent revisions recommended by the Pelican Bay Services Division (PBSD) shall be submitted to the Collier County Board of County Commissioners (BCC) for approval. Once approved by the BCC, this Management Plan, or future amendments to the plan by the PBSD Board, will supersede all others and will serve as the primary guidance tool for future permitting and other management activities necessary to protect, preserve, maintain, and monitor resources within the system.

Development of the Clam Bay NRPA Management Plan

Turrell, Hall & Associates, Inc. served as the principal consultant for the Management Plan. This consultant firm has a long history of work in the Clam Bay NRPA and was primarily responsible for the implementation of the 1998 Management Plan that resulted in the successful restoration of Clam Bay's mangrove forest. The coastal engineering firm of Humiston & Moore, Inc. provided input and monitoring data for the 2014 Management Plan relative to Clam Pass and the dredging design criteria.

The PBSD Clam Bay Committee consists of members of the PBSD Board, which is an advisory board to Collier County's Board of County Commissioners. The Clam Bay Committee met regularly in 2013 and 2014 and provided input and direction to the consultants. Additional regular input was provided by representatives of several stakeholder organizations, including the Mangrove Action Group, as well as several interested Pelican Bay residents. All Committee and Board meetings were properly noticed, open to the public, and allowed audience participation. Input was also solicited via notices to more than 30 area businesses, government officials and employees, condominium associations, and individuals who regularly use Clam Bay. These representatives were invited to participate in two

meetings held in the spring of 2013. Some have attended and provided comments at the regular meetings of the PBSD Clam Bay Committee where drafts of the Management Plan have been discussed. Stakeholders were also notified in April 2014 that a draft of the Management Plan was available on the PBSD's website, and they were invited to send their comments to the PBSD's office and/or attend a workshop about the Clam Bay NRPA Management Plan on May 14, 2014. A list of these area people/organizations is included with this Management Plan (pages 48 and 49).

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Role of the Pelican Bay Services Division

In order for the management and maintenance of the Clam Bay NRPA to be successful, coordination between a myriad of local, state, and federal agencies and interested citizens groups is required. The PBSD has undertaken that role for most of the past fifteen years.

The Pelican Bay Municipal Services Taxing and Benefit Unit (MSTBU) is a dependent special district that was formed pursuant to Chapter 125 of the Florida Statutes and was formally enabled by the BCC pursuant to Ordinance numbers 90-111 and 91-22. These ordinances were replaced in 2002 by Ordinance 2002-27 which further clarified the role of the MSTBU and the PBSD Board. This MSTBU was created to, among other things, provide for the maintenance of conservation and preserve areas within Pelican Bay.

This responsibility was undertaken diligently from 1998 to 2008 and resulted in the implementation of the previous 1998 Management Plan and the recovery of the mangrove die-off areas. Per action by the BCC, the responsibility for many of the monitoring and maintenance activities associated with Clam Bay was given to Collier County's Coastal Zone Management Department from 2008 to 2012. In 2013, the BCC returned responsibility for the monitoring and maintenance of the system to the PBSD via Ordinances 2013-19 and 2013-61. It is under the PBSD's direction that this current management plan has been written.

While the MSTBU is a dependent special taxing and benefit district, the PBSD is an arm of Collier County government and makes recommendations to the BCC. The PBSD implements its defined responsibilities within the Pelican Bay community, sets its own budget and agenda, and regularly submits them to the BCC for approval. The BCC has commonly approved the Clam Bay management activities, dedicated funds towards those activities, and authorized the development of this Management Plan. The PBSD's effective working relationship with the BCC is expected to continue as the PBSD serves as the official manager of the 2014 Management Plan, which is consistent with Ordinances 90-111, 2002-27, 2013-19 and 2013-61 of Collier County.

The PBSD will direct the Management Plan and has the responsibility for its implementation and operation over time. As such, the PBSD will plan and implement defined management activities with BCC approval whose purpose will be to protect, preserve, maintain, and monitor the natural communities and ecological integrity of the Clam Bay NRPA.

The PBSD has several attributes which make it a logical guiding force in the management and maintenance of Clam Bay. The PBSD:

- is located within the Clam Bay drainage basin;
- has an advisory board made up of residential and business members within Pelican Bay;
- garners fiscal support for community projects, including Clam Bay NRPA activities, collected from local special assessments (non ad valorem taxes) of the residents and business members within Pelican Bay;

- is accessible to the public due to its local governing board and advertised public monthly meetings; and
- has demonstrated a long-term commitment to the Clam Bay NRPA and a successful track record regarding its preservation, restoration and maintenance over the past fifteen years.

These attributes give the PBSD the knowledge and expertise in matters of local concern and, in particular, the problems, opportunities, and interests of local residents as they relate to the Clam Bay ecosystem. Its relationship with the BCC gives it an additional level of access to technical expertise and oversight that will be necessary to assure that the Management Plan, as contemplated in this document, is fully implemented in the field.

As part of its responsibilities, the PBSD will assemble and distribute various technical reports and assessments as required under the Management Plan, as well as coordinate with other public and private groups interested in Clam Bay. The PBSD is organized for and designed to maintain both its knowledge of the Clam Bay resources and to generate public support of the same. The PBSD will insure that the general public, residents in Pelican Bay, the PBSD consultants, and representatives from government agencies with jurisdiction over Clam Bay each have on-going involvement and input into the Management Plan as appropriate.

2.0 Overview of the Clam Bay NRPA

Description of the System

The Clam Bay NRPA is a 560.05-acre estuarine system (per Turrell, Hall and Associates, Inc. 2014 FLUCCS mapping) consisting of sandy beaches, Clam Pass, shallow bays, tidal creeks or tributaries, seagrass beds, and mangrove forests on the west coast of Collier County in Southwest Florida. The Clam Bay system is part of the Cocohatchee-Gordon River Transition referred to by the Collier County Department of Natural Resources as Coastal Zone II. It is one of the few remaining estuarine systems in the Cocohatchee-Gordon River Drainage System and the only coastal NRPA in Collier County.

Historically the Clam Bay System was connected to Wiggins Pass to the north via a system of mangrove swamps and shallow creeks with intermediate open water areas that were excavated and are now known as Vanderbilt Lagoon (Collier County, 1994, Tropical BioIndustries, 1978). It is recognized that the connection was marginal at best and while passable at times, it was not uniformly and consistently navigable (Clam Bay Restoration and Management Plan, 1998). Connection to Vanderbilt Lagoon ended in 1952 with the construction of Vanderbilt Beach Road.

Similarly, aerial photos of the Seagate Drive area taken prior to its construction show that Outer Clam Bay was connected to the mangrove swamps to the south via shallow meandering creeks and intermediate open waters leading to Doctors Pass. These creeks were only navigable by canoes and small skiffs (Turrell, 2009). These swamps to the south were eventually excavated to become Venetian and Moorings Bays. The connection to Outer Clam Bay ended in 1958 when Seagate Drive was constructed.

Today, the Clam Bay NRPA includes three primary bays, Outer Clam Bay (southernmost), Inner Clam Bay (central), and Upper Clam Bay (northernmost), connected by a series of tidal creeks and connected to the Gulf of Mexico by Clam Pass. The main creek system between the Pass and Bays is a multi-use waterway which at times sees swimmers, fishermen, boaters, canoers, kayakers, and paddleboarders all sharing the open waters of the waterways and the Pass. A canoe/kayak trail has also been permitted and markers installed throughout the system. The community of Pelican Bay abuts the northern and eastern edges of the system, while Seagate and Naples Cay communities abut the southern portion of the system. This system is an important natural and recreational resource for local residents and visitors.

The Clam Bay system was designated a Natural Resources Protection Area (NRPA) by Collier County in 1995. The purpose of the NRPA designation is to protect endangered or potentially endangered species and to identify large connected intact and relatively unfragmented habitats, which may be important for listed species (Collier County, 1994). A timeline of important events that occurred within the Clam Bay NRPA along with a compilation of permits issued in and around Clam Bay are presented in Appendix 1.

Clam Pass is a small, marginally stable inlet that has migrated north and south along the shore over the years. Prior to dredging, average water depths of Clam Pass were -2.5’ to -1.0’, and its width ranged

from 30-50' (Collier County, 1994). The Pass remains the primary source of tidal exchange for the Clam Bay system, but it is restricted by sediment deposits just inside the Pass and in the long meandering tidal creeks surrounded by mangrove forests.

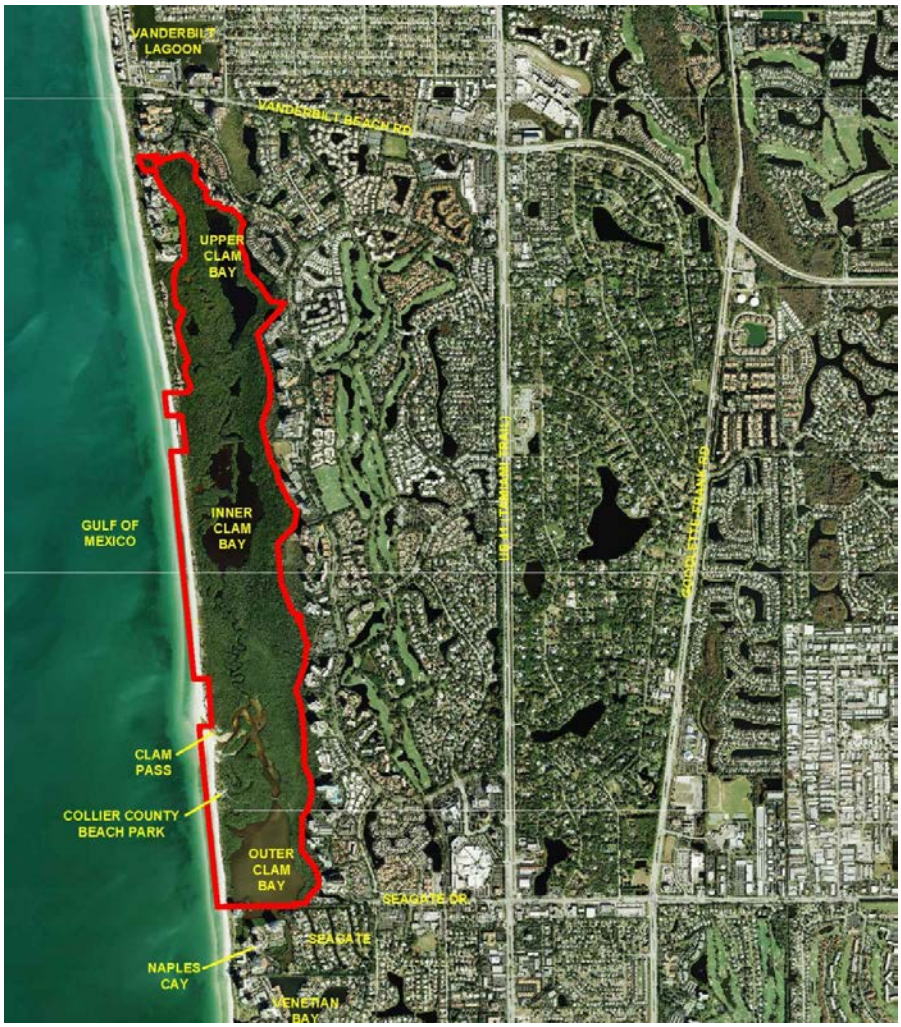


Figure 1: Approximate extent of Clam Bay NRPA boundary.

Clam Bay NRPA Vital Statistics

Total acres: Approx. 560.05 acres
Beaches: Approx. 8,235 feet
Beach Park: Approx. 35 acres
Mangrove: Approx. 360 acres
Seagrass: Coverage varies – see annual report for current acreage
Open Water: Approx. 116 acres
Latitude and Longitude of Pass: N 26° 13' 11", W 81° 49' 01"
Section, Township, Range: Sec. 32 & 33, Twp 48S, Rng 25E, & Sec. 4, 5, 8, & 9, Twp 49S, Rng 25E
Water Body Identification (WBID) 3278Q1

Adjacent Communities

The Clam Bay NRPA is bound on the north by the Bay Colony portion of the Pelican Bay development; to the south by Seagate Drive, and the Seagate and Naples Cay developments; to the east by the Pelican Bay development; and to the west by the Gulf of Mexico and the Strand neighborhood of Bay Colony that is within the Pelican Bay development.

Pelican Bay is predominately a residential community consisting of private single-family homes, villas, and both high and low-rise condominium units. The community also includes a 27-hole golf course, common areas with meeting rooms, tennis courts, beach park facilities, emergency services facilities, and commercial areas with shopping and hotels. The 2,104-acre Planned Unit Development (PUD) and Development of Regional Impact (DRI) was approved in 1977 as a partnership between Collier Enterprises and Westinghouse Communities (WCI). It was one of the first developments in Florida required to save fragile coastal wetlands and associated ecosystems (Urban Land Institute, 1981). The development of Pelican Bay had a limited impact on the wetlands themselves with approximately 94 acres, including about 78 acres in the northwestern corner of the property, being developed. This left the majority of the mangrove forest intact and preserved around the bays. As mitigation for these wetland impacts, the 560.05 acre preserve area, including the 35 acre beach park, was donated to Collier County and eventually became the NRPA which is in place today.

Development of Pelican Bay required a stormwater management system designed to spread runoff along the eastern edge of the Clam Bay estuary. A four to six foot high and 2 ½ mile long berm separates the developed portion of Pelican Bay from the estuary lying to the west of the development, but numerous culverts through the berm discharge water to a swale system along the eastern perimeter of Clam Bay. The eastern edge of Pelican Bay is about 12-14 feet above sea level at US 41, sloping in an east-west direction to about 2 feet above sea level near the berm. Six drainage basins operate on a gravity system to slowly move surface water into the receiving area of Clam Bay.

Naples Cay is a high rise development consisting of 8 multi-story condominium buildings. The community also includes pools, tennis courts, approximately 33 acres of park and preserve areas, and two canoe and kayak launching piers. Construction on the first building in Naples Cay started in the late 1970's, and the last building was completed in 2002. Stormwater management is accomplished through several internal detention areas before water flows into Outer Clam Bay.

The Seagate community is composed of about 80 single-family residences. The community was first laid out in the 1950's and still has a few undeveloped lots. Because development of this community occurred prior to stormwater regulations enacted in the 1970's, no community-wide stormwater system existed and septic systems were used for waste disposal. More recent improvements to the road and utility systems have allowed for some dry retention and elimination of septic systems. Many of the homes within Seagate were built with boat docks along the community's man-made canals. Some homeowners keep motorized vessels at these docks. The 1995 Manatee Protection Plan acknowledges motor boat utilization by the Seagate community while also stressing that access and use of Clam Bay by motorized vessels was limited due to the shallow nature of the bay and ephemeral conditions of the

Pass. Vessels utilizing the Clam Bay NRPA waters are generally shallow drafted, and their access is limited by the day-to-day conditions of the Pass and connecting waterway.

Clam Pass Park is a 35-acre County park providing beach access on the south side of Clam Pass. The Park is wholly contained within the NRPA boundary. Access to the Park is via a boardwalk through the mangroves from the parking lot at the very southern end of Pelican Bay. Operation and care of the Park is done under the supervision of the Collier County Parks and Recreation Department. Through an agreement between the County and the Waldorf Astoria Hotel, much of the day-to-day operation of the park is managed by the hotel.

Historical Overview

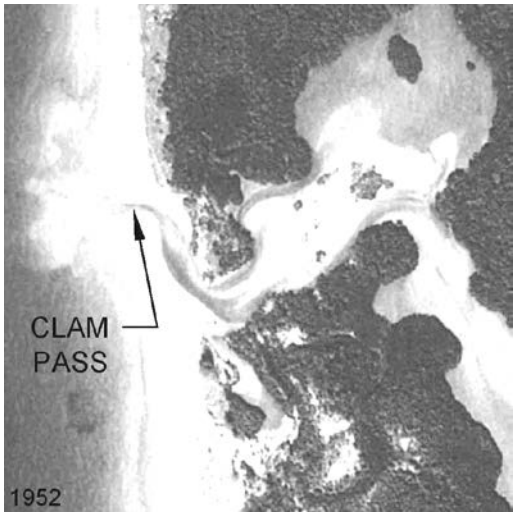
Prior to development, the entire coastline of South Florida would have resembled the Clam Bay ecosystem with meandering mangrove-lined shallow waterways buffering sandy barrier islands and natural terrestrial communities. Unique within the heavily developed coastal communities of Collier County, the Clam Bay estuarine system is a valuable resource for wildlife (particularly juvenile marine species and birds) as well as residents and visitors to the area who enjoy the low-impact recreational opportunities of the system.

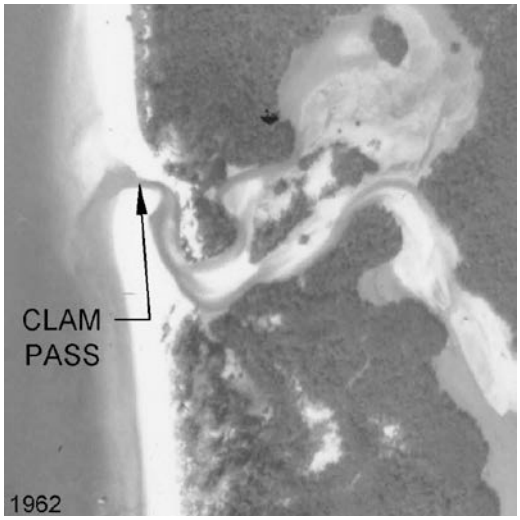
Within the Clam Bay NRPA, three Indian shell mounds have been identified and indicate that this area was used for settlement by past civilizations. The information obtained from the Florida Master Site File identifies these sites as Clam Bay Shell Ridge, Inner Clam Bay Shell Mound, and Brackish Hammock.

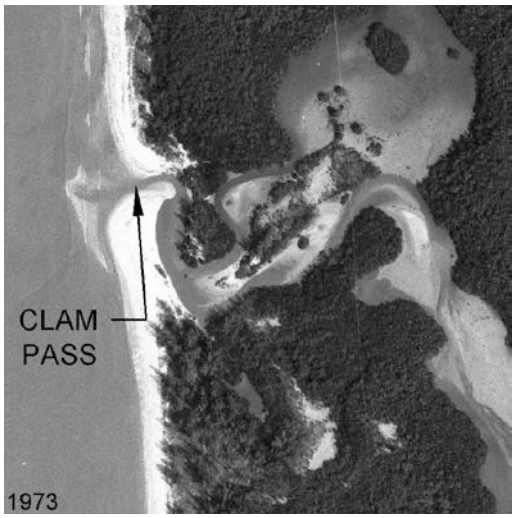
Historically, Clam Pass was a small part of a coastal barrier island system of relatively shallow waterways and interconnecting wetland communities extending from Lee County to Doctor's Pass. Anecdotal evidence suggests that canoes and shallow drafted skiffs were used within many of these interconnected areas.

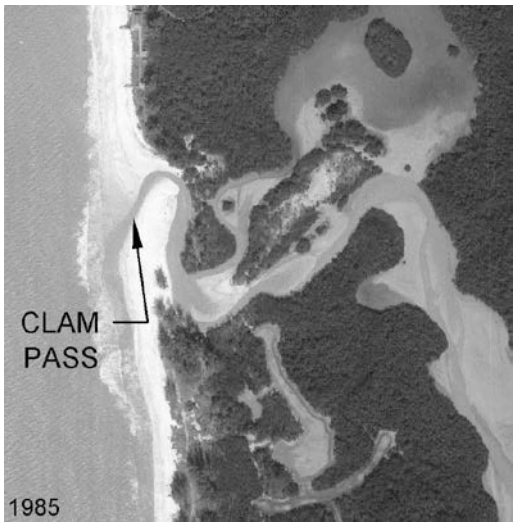
During the 1950's this system was isolated from adjacent mangrove lined creeks and bays by the construction of Seagate Drive to the south and the construction of Vanderbilt Beach Road to the north (see attached Exhibit, 1952 Aerial). The practical effect was to leave Clam Pass as Clam Bay's only connection to the Gulf.

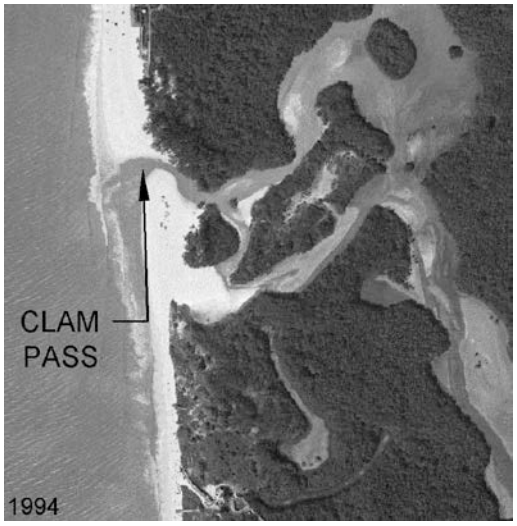
The Clam Pass opening has moved over its lifetime up and down the shoreline, influenced by major storm events and by man's alteration of the tidal prism and drainage basin that feeds the Pass. The shifting location of the Pass and its often tenuous connection to the Gulf is evident in the following series of aerial photos of the Pass over the past 60 years. Because of these conditions, the Pass is susceptible to outside events and can periodically close, which has happened six times in the last 25 years, most recently in 2013.


CLAM
PASS
1952


CLAM
PASS
1962


CLAM
PASS
1973


CLAM
PASS
1985


CLAM
PASS
1994

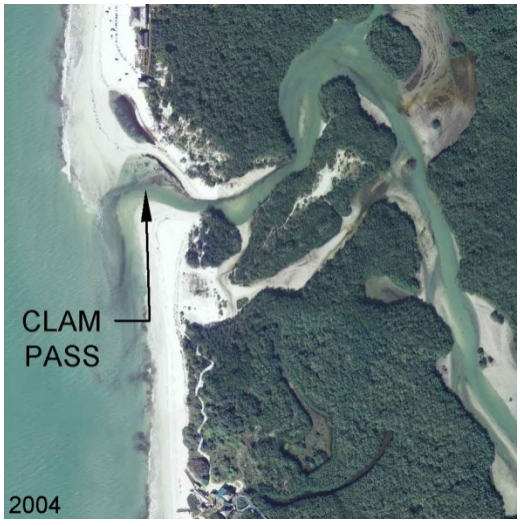

CLAM
PASS
2004



Figure 2: Historic aerials of the location of Clam Pass

The health of the mangrove forest is directly related to the connection at Clam Pass. The exchange of seawater between Clam Pass and the Gulf is critical to the ability of the estuary to export organic matter, as well as to help regulate excess salt and freshwater. It also supplies oxygen-rich water from the Gulf and keeps metabolic wastes from accumulating in the sediment, as discussed in more detail later in this Management Plan.

A man-made water management berm now divides natural and developed portions where historically mangrove forest would have transitioned gradually into the mesic coastal hammocks and upland pine scrubs that made up the now-developed portions of the Pelican Bay community.

With the development of the Collier County coastline, the Clam Bay NRPA has been protected as a managed natural system that preserves the essential features and ecological function of a mangrove estuary. The historical and natural events that have affected the Clam Bay system in recent times, along with governmental actions, scientific studies and management responses, are shown in timelines in Appendix 1. These depict the evolution of management activities in Clam Bay and provide the context for the management goal and objectives presented in this Management Plan.

Mangrove Die-off and Restoration

The first mention of stressed or dying mangroves within the Clam Bay NRPA came from the 1978 Tropical BioIndustries and Gee and Jensen report titled *Carbon Flows in Portions of the Clam Pass Estuarine System, Collier County, Florida*. Reports of stressed or dying mangroves continued through the 1980's and 90's. In 1995, a large area of dead and dying mangroves was documented encompassing approximately 42 acres adjacent to Upper Clam Bay (Turrell, 1995). By 1999, this area had expanded to approximately 50 acres (Turrell, 2000).

The Clam Bay Restoration and Management Plan (1998 Management Plan) was finalized in 1998 to address the mangrove die-off. The major objective of the plan was to restore the dead mangrove area through improvements to tidal flushing capabilities of the system, including enhancements to tidal flow into and out of the mangrove forest areas. This was accomplished through the dredging of Clam Pass and portions of the interior channels within the system, removing impounded water from the die-off areas and the construction of a network of hand-dug flushing channels throughout the original die-off area and a few other areas exhibiting stress.

In the fifteen years following the implementation of the 1998 Management Plan the mangrove forest has undergone a substantial recovery with over 90% of the original die-off area re-vegetated with new mangrove growth.

Appendix 2 contains additional information regarding the mangrove die-off and restoration.

3.0 Physical and Natural Resource Description and Assessment

The goal and objectives of this Management Plan aim to manage and preserve each of the resources that make up the Clam Bay NRPA as a whole. The objectives of the Management Plan focus on natural communities, tidal and freshwater flows, water quality, archeological resources and recreational uses, all discussed further in this section. There are many additional factors that come together to create the habitats and support the resources that make up the Clam Bay NRPA. These additional factors are discussed further in Appendix 4.

Soils

Based on the National Resource Conservation Service (NRCS) "Soil Survey of Collier County Area, Florida" (NRCS, 1998) there are 2 different soil types (soil map units) present within the NRPA boundary: frequently flooded Durbin and Wulfert muck; and Canaveral Beaches Complex. These mapping units named for soil series represent the dominant undisturbed soils in the landscape that existed predevelopment. The unit descriptions do not recognize or appropriately interpret the drastically disturbed nature of urban landscapes created after the soil survey was completed. For information regarding soils specific to the Clam Bay NRPA, see Appendix 4.



Figure 3: Soils map of the Clam Bay NRPA

Natural Communities

In this Section, a natural community refers to the mix of plant and animal species that form the natural basis of the Clam Bay NRPA. A combination of factors, including geology, climate, topography, soils, wind, waves, storms and anthropogenic influences, determines the specific types of plants found in any given area (see Appendix 4 for more information). These plants are a major factor in what type of animal species that may be present, including threatened and endangered species that may utilize the Clam Bay NRPA (see Appendix 4 for more information). The Florida Department of Transportation's Land Use, Cover and Forms Classification System (FLUCFCS 1999) has been used to identify the

plant communities found within the Clam Bay NRPA. See the attached Exhibits in Appendix 6 for an overall FLUCFCS map of the Clam Bay system and the existing monitoring plots within these habitats.

List of FLUCFCS Communities within the Clam Bay NRPA
Based on 2014 mapping by Turrell, Hall & Associates, Inc.

FLUCFCS Code	Community Description	Upland or Wetland	Acreage within the NRPA	% of Clam Bay NRPA
181	Swimming Beach	Upland	33.35	5.95
186	Community Recreation Facilities	Upland	2.06	0.37
322	Coastal Scrub	Upland	22.31	3.98
428	Cabbage Palm Hammock	Upland	2.50	0.45
510 and 540	Interior Creeks and Bays (with and without direct connection to Gulf or Ocean)	Wetland	129.73	23.16
612	Mangrove Swamp	Wetland	359.56	64.20
642	Saltwater Marsh	Wetland	2.35	0.42
651	Tidal Flat	Wetland	8.05	1.44
814	Roads and Highways	Upland	0.14	.03
911	Seagrasses**	Wetland	2.85**	0.84**

**included in the Bays (510 and 540) category

Several other components of the Clam Bay NRPA ecosystem are also addressed in Appendix 4. These components include offshore hardbottom, oyster, and other benthic faunal communities that are not specifically addressed in the FLUCFCS classification system. Additional historical information on the mangrove and seagrass communities is included as Appendix 2 and Appendix 3 to the Management Plan.

FLUCFCS Code 181- Swimming Beach



Figure 4: Beach habitat within the NRPA Boundary

There is approximately 8,235 linear feet of beach within the Clam Bay NRPA in three distinct segments. Contiguous beach habitat extends from the NRPA habitat both north and south along the coast. Shorebirds feed on marine invertebrates, such as coquina clams and mole crabs, at the water's edge, and beaches are crucially important habitat for nesting sea turtles.

This particular habitat has been monitored periodically in terms of width as part of the Collier County Beach renourishment program, though no conclusive statements can be made about the floral or faunal details of the ecotone over the years. Large-scale generalizations based on the annual aerial photographs can be made that the overall size, composition, and health of the habitat have remained relatively stable, and with the exception of the areas immediately adjacent to the Pass, are mostly unaffected by the status of the Pass.

Management concerns for the swimming beach are loss of beach area due to natural erosive processes and recreational over-use of the resource.

FLUCFCS Code 322 – Coastal Scrub



Figure 5: Coastal Scrub habitat within the NRPA Boundary

Landward of the frontal (beach) zone area is the back dune zone (also often called the coastal shrub or scrub zone). This portion of the dune is more stable, has greater organic matter, and supports less salt tolerant grasses and shrubs as well as some trees. Coastal scrub is represented by a conglomeration of coastal species generally found in a narrow band between an estuary and the beach.

Many of the woody species found in coastal scrub are low growing due to low nutrient and droughty conditions of sandy soils. High winds and salt spray often prune the terminal buds of the trees and shrubs growing on the dunes and result in salt-pruned, windswept canopies.

Species common in the coastal scrub zone of the Clam Bay system include: seagrape (*Coccoloba uvifera*), cabbage palm (*Sabal palmetto*), buttonwood (*Conocarpus erectus*) and Spanish bayonet (*Yucca aloifolia*). This is an important habitat as it helps anchor the back dune sands and provides

habitat for several listed plant and animal species including the gopher tortoise (*Gopherus polyphemus*).

The primary management issues of concern in the coastal scrub are gopher tortoise habitat management and exotic vegetation control.

FLUCFCS Code 428 – Cabbage Palm Hammock



Figure 6: Cabbage Palm Hammock habitat within the NRPA Boundary

This forested zone is composed of dune vegetation and is located inland of the coastal scrub - farthest from the Gulf of Mexico. The Cabbage Palm Hammock habitat consists primarily of cabbage palms (*Sabal palmetto*) and is found in sandy soils. In the Clam Bay NRPA it is generally found in pockets located between the mangrove forest and the coastal scrub zone or beach areas.

The primary management issues for this habitat are exotic control and preventing destructive visitor access.

FLUCFCS Code 510 and 540 – Interconnecting Creeks and Bays (with and without connection to the Gulf)



Figure 7: Open Water habitat within the NRPA Boundary

The Clam Bay NRPA contains the three larger bays associated with Clam Pass (Outer, Inner, and Upper) as well as the interconnecting shallow creeks and small open water areas. These bays and interconnections serve as the life blood of the estuary.

These open water habitats serve as the basis for many other communities. Seagrass beds, oyster bars, clam beds, and other benthic communities can all be supported to varying degrees with the open waters of the bays and interconnecting creeks.

Tidal creeks are passageways for fish and marine invertebrates between waters of the Gulf and the protected embayments of Clam Bay. Manatees, dolphins, and turtles may also use the Pass. Scouring action of the fast flowing tide generally prevents colonization of seagrasses and other benthic flora.

Management concerns related to the bays and associated creeks include maintaining sufficient flow through them to accomplish flushing needs of the system, stabilization of the Pass without harming other components of the NRPA, and educating recreational users of the NRPA of the need to protect the shallow water habitats and the communities located therein.

FLUCFCS Code 612 – Mangrove Swamp (Forest)



Figure 8: Mangrove habitat within the NRPA Boundary

Mangroves are salt-tolerant trees that grow in tidal areas of the tropics and are legally protected for their ecological value and function, such as:

- Providing habitat for marine, terrestrial, and avian wildlife.
- Protecting coastal areas from storm surges and coastal erosion.
- Improving water quality by acting as a natural filter for land-based freshwater run-off.
- Forming the basis of a highly productive estuarine food chain which includes many commercially valuable species.
- Enhancing the atmosphere by absorbing carbon dioxide and reducing greenhouse gases.

Approximately 65% of the Clam Bay NRPA is composed of the three most common mangrove species in Florida, namely red mangroves (*Rhizophora mangle*), black mangroves (*Avicennia germinans*), and white mangroves (*Laguncularia racemosa*). All three species have special biological adaptations to cope with salt and unstable, mucky, low oxygen soils that result from the tidal, hence continually waterlogged, environment. The dominance of mangroves in tidal areas is a function of these adaptations and their ability to out-compete other wetland plants. Tidal flushing allows nutrients to be distributed within the forest and provides for the transportation of dead leaves, twigs, etc. As this material decays, it becomes food for marine life. It is this mangrove detritus which is consumed by the many organisms at the base of the food chain which, in turn, creates the next level of the food chain necessary to support the fish populations that characterize the mangrove community.

The Clam Bay mangrove community is composed of both riverine (along the creeks) and basin forest components.

Riverine (Creeks) *Mangroves*
On the waterward edges of small islands and the tidal creeks, passes and estuarine waterways that make up the Clam Bay system, a fringe of red mangroves can be found growing up to 25 feet in height. This zone can be just one or two trees in depth or extend landward for some distance, depending on topography. The habitat provided by the prop roots of these red mangroves is of great importance to many fish and other aquatic organisms.

Forests
The majority of the Clam Bay mangrove habitat is low-lying basin forest where the dominant mangrove species varies between red, white, and black through the forest habitat. Portions of this forest community were affected by the mangrove die-off. The hand dug flushing channels were constructed throughout this community to increase the tidal flushing capacity through the forest and drain impounded freshwater out of the forest into the bays and tributaries.

Special attention has been given to the mangrove community in the past because of the die-off which occurred between 1991 and 1997 (though stress in the community was documented as far back as the late 1970's). The die-off affected black and red mangroves initially but eventually ended up encompassing some white mangroves as well. More details on the recent history of the mangrove management are provided in Appendix 2.

Management concerns within the mangrove habitat include ensuring adequate tidal flushing, preventing freshwater impoundment, and protection from exotic vegetation or pest infestations.

FLUCFCS Code 642 – Saltwater Marsh



Figure 9: Salt Marsh habitat within the NRPA Boundary

At the interface between forested mangrove areas and the water management berm in Pelican Bay are depressional areas that have become colonized by aquatic freshwater plants, such as cattails (*Typha latifolia*), Carolina willow (*Salix caroliniana*), bulrush (*Scirpus californicus*), needlerush (*Juncus romerianus*), and leather fern (*Acrostichum danaeifolium*). Wildlife, such as otters (*Lutra canadiensis*), alligators (*Alligator mississippiensis*), various turtles, and wading birds can be commonly observed. These areas require regular maintenance to prevent the spread of nuisance and exotic plant species and ensure optimal functioning and interface between the natural mangrove forest and the water management system. Historically, some of the marsh areas along the berm may have been freshwater marsh, however brackish water has affected these areas as a result of the change in hydrology.

Management concerns for this habitat are to prevent exotic vegetation infestation as well as ensuring appropriate water and salinity levels.

FLUCFCS Code 651 – Tidal Flats



Figure 10: Tidal Flat habitat within the NRPA Boundary

The sand and mudflats of Clam Bay are rich feeding grounds for many species of fish and wading birds. These organically rich sediments support a variety of mollusks, worms, and invertebrates that scavenge detritus or, in the case of many bivalve mollusks, extend siphons at high tide and filter vast quantities of water. Birds, such as a variety of herons, ibis, egrets, and spoonbills pick through the sediment for the invertebrate food sources.

The dredging of the Pass associated with the 1998 Restoration and Management Plan resulted in an increase of exposed tidal flats within the southern portion of the system. Increased tidal range resulting from the dredging allowed more area to be periodically exposed during the tidal cycle. Some of the area that had supported seagrasses prior to the dredging work were converted into the tidal flats by the increased range and reduced phase lag.

Management concerns related to the tidal flats include the templates established for the dredging, the resultant currents that could be expected as a result of dredging, and the frequency of disturbance.

FLUCFCS Code 911 – Seagrass Beds



Figure 11: Seagrass habitat within the NRPA Boundary

Several areas within the Clam Bay system host seagrass beds, specifically Outer Clam Bay and waterways just inside Clam Pass (see Appendix 2). Three species are commonly found in these Clam Bay waters: turtle grass (*Thalassia testudinum*), with flat strap shaped leaves; shoal grass (*Halodule beaudettei* (fka *wrightii*)), with narrow, flat blades; and paddle grass (*Halophila decepiens*), with paddle shaped leaves. Shoal grass is by far the most common though a small area of turtle grass has persisted since the 1998 dredging. Paddle grass is much more ephemeral in nature, and diligence is required to be able to locate it during the time frames when it is present.

Seagrass coverage in Clam Bay has varied over time but is predominately found in Outer Clam Bay and the waterway between this bay and Clam Pass. A 1994 Collier County Environmental Services Division report estimated seagrass coverage at approximately 10 acres. Seagrass coverage had diminished to 7 acres in 1995 (Turrell, 1995). Pre-dredge surveys conducted in 1999 estimated coverage had further diminished to about 5.13 acres (Turrell, 2000). The seagrass loss during the

period of 1994-1999 was correlated with pass instability (closures) and subsequent dredging activities. Annual monitoring of seagrass beds along the monitoring transects has estimated coverage from a low of approximately 1.2 acres in 2003 to the current estimate of 2.85 acres from the 2013 survey. It should be noted that the coverage estimates are taken from along the survey transects only and do not account for other scattered grasses that may be located elsewhere in the system.

Management concerns related to seagrasses include direct impacts due to recreational use and potential dredging templates, turbidity and water quality concerns related to flushing (too much or too little) and stormwater inputs, and algal infestations due to nutrient increases.

A history of the seagrass monitoring efforts in Clam Bay is included in Appendix 3.

Other Benthic Habitats

Oyster Bars



Figure 12: Oyster locations within the NRPA boundary

Oysters (*Croassostrea americana*) are filter-feeding bivalves, which were once common within the tidal creeks of Clam Bay (Humm and Rehm 1972). Deteriorating conditions, in part related to Pass closures and subsequent dredging and clearing activities, are thought to have resulted in the disappearance of oyster bars in the system, though some reoccurrence has been observed to the south of the Pass in the last few years during seagrass transect monitoring. Oysters have been documented around the perimeter of Outer Clam Bay in past years' monitoring efforts.

A 2011 benthic habitat assessment conducted by the Conservancy of Southwest Florida found living oyster clusters in the upper reaches of Upper Clam Bay (a single cluster), in the tributary between Outer and Inner Clam Bays (a single cluster), and throughout the shoreline of Outer Clam Bay.

Management concerns related to oyster growth are similar to the seagrass concerns, namely protection from dredging, water quality deterioration, and recreational users.

Other bivalve mollusks

In addition to oysters, the 2011 benthic habitat assessment conducted by the Conservancy of Southwest Florida also found two other bivalves within the Clam Bay system. The pointed venus clam (*Anomalocardia auberiana*) and the stout razor clam (*Tagelus plebeius*) were both observed. Turrell, Hall & Associates, Inc. benthic surveys found several beds of southern hard clams (*Mercenaria campechiensis*) also present in the system.

These mollusks are generally found within the shoal and tidal flat areas of the system and could be susceptible to impact during dredging or other disturbance operations. Management concerns would be protection from recreational users, water quality deterioration, flushing and dredging.



Figure 13: Exhibit from Conservancy of Southwest Florida Report

Tubiculous Polychaetes

Tubiculous polychaetes (tube worms) are typically the most abundant biological assemblage in Clam Bay and are primarily associated with muddy and sandy substrates. Polychaetes, including worm tubes and mud tubes, shell-encrusted polychaete tubes (*Polychaeta*) and trumpet worm (*Pectinaria gouldi*) tubes, are a vital component of the estuarine food web, providing key linkages between primary producers and higher trophic levels. Polychaetes create habitat and food for many organisms, such as mollusks, fish and even sea turtles. These worms are usually filter or deposit feeders that keep the substrate aerated and free of waste accumulation. Polychaetes tend to dominate Inner and Outer Clam Bays, with lower occurrences in Upper Clam Bay, the Lower Tributary, and, to a lesser extent, the Upper Tributary. Management concerns include protection from dredging, water quality deterioration, and recreational users.

Hardbottom Communities

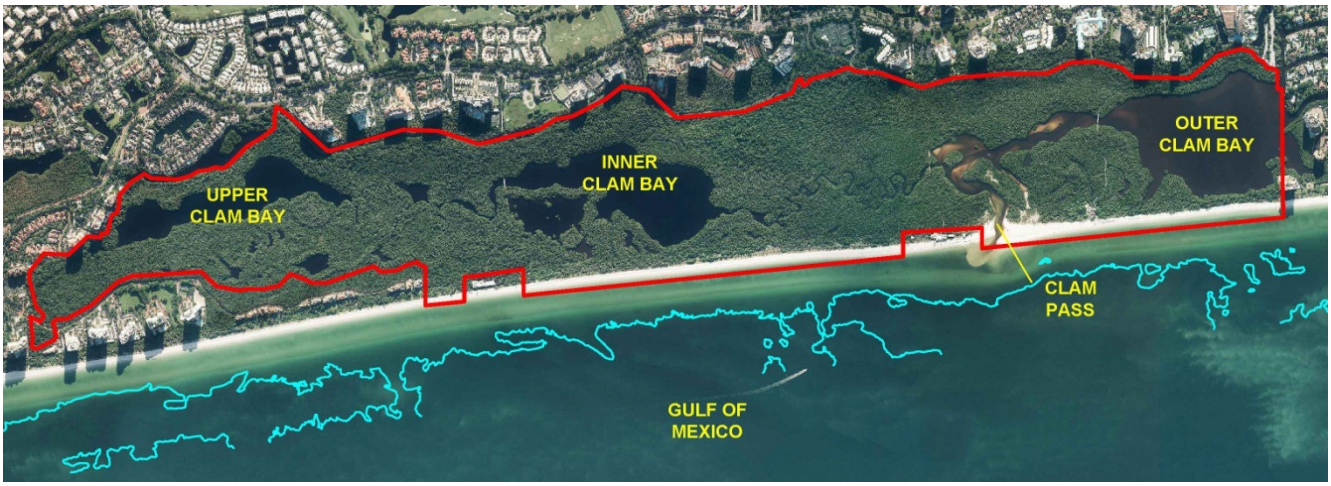


Figure 14: Hardbottom Community off-shore of the NRPA boundary

Another important marine habitat marginally associated with the estuarine system is the hard bottom reef community found just seaward of Clam Pass. In about 10-15 feet of water a variety of sponges, stony corals, gorgonians, fish and associated invertebrates can be found within a system of rocks and ledges. Outcroppings of similar habitat type occur along the length of Collier County and are a little known resource of regional significance.

Collier County has mapped this resource through side scan sonar surveys in 2005 and 2009 as part of its beach renourishment project. Based on these surveys and investigations conducted by Turrell, Hall and Associates, Inc. (Turrell, 1995), the landward edge of this habitat has varied from 200 to 300 feet offshore from the Pass.

Management concerns related to this habitat include recreation use and potential turbidity impacts resulting from dredging, beach renourishment, or other management activities within the Clam Bay NRPA.

Invasive, Non-native and Problem Species

In an ecological context, an invasive species is one that is aggressive in growth and expansion of range and tends to dominate other appropriate native species. Its establishment and dominance can cause widespread harm to an ecological system by altering the species composition, susceptibility to fire and hydrology of an area. Non-indigenous species (i.e., non-native or exotic species) are those that have been introduced purposefully or accidentally to an area outside their normal range. Category I species are those that have been documented to drastically alter natural communities by displacing native species. Category II plants have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species.

FLEPPC Category I plants observed within the Clam Bay NRPA boundary:

- Brazilian Pepper (*Schinus terebinthifolius*)
- Melaleuca (*Melaleuca quinquenervia*)
- Australian Pine (*Casuarina equisetifolia*)
- Beach Naupaka (*Scaevola taccada*)
- Earleaf Acacia (*Acacia auriculiformis*)
- Shoebutton Ardisia (*Ardisia elliptica*)
- Air Potato (*Dioscorea bulbifera*)
- Lantana (*Lantana camara*)
- Old World Climbing Fern (*Lygodium microphyllum*)

FLEPPC Category II plants observed within the Clam Bay NRPA boundary:

- Coconut Palm (*Cocos nucifera*)
- Wedelia (*Sphagneticola trilobata*)
- Oyster Plant (*Tradescantia spathacea*)
- Mahoe (*Taliparitі tiliaceum*)

These species will be removed or reported to the responsible entity for removal.

Listed Species

State and federal wildlife agencies will review any applicable management activities within the Clam Bay NRPA to determine if impacts to listed species will occur. While there are many listed species (State and Federal) that utilize the Clam Bay NRPA, the six listed below have garnered the most scrutiny as being vulnerable to impacts associated with Pass maintenance activities. These, as well as other listed species that do or potentially could utilize the NRPA, are listed in Appendix 4.

Smalltooth Sawfish (*Pristis pectinata*)
A juvenile smalltooth sawfish was observed by Turrell, Hall & Associates, Inc. biologists in 2008 in the connector creek between Inner and Outer Clam Bays. Other observations of smalltooth sawfish have been documented within the Clam Bay NRPA (http://www.flmnh.ufl.edu/fish/sharks/sawfish/sawfishdatabase.html). Smalltooth sawfish are found in the tropical and subtropical Atlantic Ocean. In the western Atlantic they have historically ranged from New York to Brazil, including the Gulf of Mexico and Caribbean Sea. Habitat destruction and overfishing have succeeded in eradicating the smalltooth sawfish from the majority of its former range. Consequently, it survives in small pockets throughout its current range. The last remaining population in U.S. waters is off south Florida, a small remnant of a population that once ranged from New York to Texas.

Mangrove Rivulus (*Rivulus marmoratus*)
This small fish has not been identified within the Clam Bay system in previous surveys or field work but is typically found in mangrove swamps and could be present in the upper reaches of the Clam Bay NRPA. The mangrove rivulus is primarily a saltwater or brackish water species, with limited occurrence in freshwater. Within the Everglades and along Florida's west coast, this fish occurs in stagnant, seasonal ponds, and sloughs as well as in mosquito ditches within mangrove habitats. The

mangrove rivulus is able to survive in moist detritus without water for up to 60 days during periods of drought, anaerobic, or high sulfide conditions.

Loggerhead Sea Turtle *(Caretta caretta*)
Loggerhead sea turtles have been documented nesting on beaches within the Clam Bay NRPA. Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific and Indian Oceans. They are the most abundant species of sea turtle found in the U.S. coastal waters. In the Atlantic, the loggerhead turtles range extends from Newfoundland to as far south as Argentina.

The loggerhead turtle was first listed under the Endangered Species Act as threatened throughout its range on July 28, 1978. In September 2011, National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) listed 9 Distinct Population Segments of loggerhead sea turtles under the Endangered Species Act (ESA). The population in the Northeast Atlantic Ocean Segment is listed as endangered. The agencies are currently proposing Critical Habitat designations on several areas which contain a combination of nearshore reproductive habitat, winter area, breeding areas, and migratory corridors. The Clam Bay NRPA is contained within the LOGG-N-27 segment of this proposed critical habitat area.

Gopher Tortoise (*Gopherus polyphemus*)
Gopher tortoises and their burrows are found along the coastal strand portions of the Clam Bay NRPA. The range of the tortoise includes southern portions of Alabama, South Carolina, Louisiana, Mississippi, and Georgia as well as most of Florida.

Piping Plover (*Charadrius melodus*)
Piping plovers have been rarely sighted foraging or resting along the shoreline within the Clam Bay NRPA boundaries. No nesting activities have been documented within the NRPA.

West Indian Manatee (*Trichechus manatus*)
Manatees have been sighted on numerous occasions within the Clam Bay NRPA boundaries. Manatees can be found in shallow, slow moving rivers, estuaries, saltwater bays, canals, and coastal areas particularly where seagrass beds or freshwater vegetation flourish. Manatees are a migratory species. Within the U.S., they are concentrated in Florida in the winter. In summer months, they can be found as far west as Texas and as far north as Massachusetts, but summer sightings in Alabama, Georgia and South Carolina are more common.

Other Species

Lists of plant and animal species that have been observed within the Clam Bay NRPA and the adjacent Pelican Bay development areas can be found in Appendix 4 of this Management Plan. These lists are not all-inclusive but represent a wide array of the species found within and adjacent to the Clam Bay NRPA habitats.

Hydrology

Hydrological regime, sometimes referred to as the surface water or surficial hydrology, in simple terms describes the long term spatial variation in the water depths and period of inundation within a wetland system. This is because the surficial hydrology has both horizontal and vertical components and provides key ecological functions to the mangrove forest (Lewis, pers. comm., 2008).

With respect to the horizontal component, incoming water (both tidal and surface water run-off) into an estuary brings with it nutrients, dissolved oxygen, and marginally lower salt concentrations. Conversely, the outgoing water leaving a mangrove wetland (through tidal exchange) removes some of the metabolic waste products (e.g. carbon dioxide and toxic sulfides) and excess salt. The vertical component refers to incoming water that percolates down into the sediment and root zone, and the sediment drainage, on a falling tide which removes metabolic wastes and excess salt. Vertical movements also include fresh or salt water upwellings, which have been documented in the northern terminus of the Clam Bay NRPA (Worley, 2006).

The movement of salt and fresh water into and out of the estuary is critical to managing ecological functions such as salt dissipation and organic matter cycling. It follows that anything that affects the system and alters the ability of the system to perform these functions, will, in most instances, cause stress to the system and, at some point in time, result in the death of the system or portions of it.

Hydrologic studies indicate that the tidal flushing capacity of Clam Bay prior to the restoration dredging was limited and almost insignificant in Upper Clam Bay. The preliminary hydrographic assessment of the Clam Bay system prepared by Tackney & Associates, Inc. (August 1996) demonstrated rather dramatically that there was a significant reduction in tidal range between the middle boardwalk and Inner Clam Bay. Tackney described the flow in that area as “measurably reduced” and “very inefficient”. The connecting tidal creek between the Pass and Inner Clam Bay is the key conduit for tidal input and outflow to the northern reaches of the Clam Bay system. Its constriction and the ancillary constriction of tributaries connecting to it impact the quantity and quality of the flushing that can occur in Inner and Upper Clam Bay.

Another key aspect of the surficial hydrology is the vertical location of the water level elevation relative to the sediment elevation. Specifically, the mean low water (tide) elevation has to be sufficiently lower than the sediment elevation in order for sediments to drain during low tide. A persistent high surface water elevation stops sediment drainage and results in anoxic sediment and the accumulation of toxic waste products. The absence of meaningful exchange was certainly a contributor to the significant degradation of the mangrove system within Clam Bay. (Tackney 1996; Lewis pers. comm., 2008).

In this context Tackney observed that, even in the absence of rainfall, the average water surface elevations for the inner and upper bays were higher than the average surface elevation for the Gulf. Analysis of the tidal data indicated that average water surface elevations in the Inner and Upper Clam Bays were both elevated above the average Gulf water surface elevation by approximately 0.2 feet. This indicated that the tidal range in Inner and Upper Clam Bays was muted and that the system was

receiving significant additional water through runoff and restricted capacity to drain additional inflow. In fact, in portions of the Tackney study no tidal fluctuation was noted in the Upper Clam Bay and only marginal tidal effects were observed in Inner Clam Bay.

The reduced tidal ranges were also accompanied by relatively large phase lags. The phase lag is the average time delay measured in hours and minutes between the occurrence of slack (high or low) water in the Gulf of Mexico and the measurement stations. It is affected by both the distance between measurement stations and the amount and quality of hydraulic resistance of the connecting channel. The longer the distance and the higher the resistance, the more pronounced one would expect the phase lag to be. In the upper bays, high and low waters generally occurred over three hours later than the Gulf tides.

These conditions indicate that the tidal creeks connecting the interior bays are hydraulically very inefficient. As a result, the upper bays are prone towards extended periods of flooding as a result of freshwater runoff and the inability of the system to drain efficiently. During Tackney's field studies of May 1996, rainfall of approximately 4 inches in three days was adequate to flood the Upper Clam Bay above high tide levels and sustain this flooded condition for over two days. Accordingly, he concluded that the creeks and bays that serve to connect the Inner and Upper Bays were significantly less efficient in the ebb tide stage than they were in the flood stage. Studies undertaken by both Lewis Environmental Services, Inc. and Turrell & Associates, Inc. would support this conclusion. (Turrell 1995).

Finally, an additional attribute of the system that is directly related to tidal prism and the quantity of inflow and outflow is the question of inlet stability. Inlet stability refers to a tidal inlet's capacity to adequately scour out deposited sediments and prevent inlet closure. For a given wave environment, inlet stability is governed primarily by the volume of water (tidal prism) carried by the inlet. To remain stable, an inlet must have the characteristic that a temporary constriction in cross-sectional area produces an increase in current velocities adequate to scour out the constriction. To function without mechanical intervention, the system must generate a sufficient volume of water on the ebb tide to scour out the inlet naturally, otherwise the inlet will, over time, continue to close. This is particularly true during periods of high wave activity and low tidal ranges. (Turrell 1995; Tackney 1996). The six closures of Clam Pass that have occurred in the past twenty-five years indicate that stability of Clam Pass is marginal. (Turrell 1995; Tackney 1996, Humiston 2010).

Hydrologic studies have indicated that during a tidal cycle, 75-80% of water that flows through the Seagate culverts originates in Clam Bay, while 20-25% of water that flows through the Seagate culverts comes from Venetian Bay (PBSJ 2009). Enlarging the Seagate culverts is not recommended because it would further reduce the tidal prism of the Bay and decrease the stability of Clam Pass (FDER 1981; Tackney 1996).

Since implementation of the 1998 Management Plan, the hydrologic conditions of the Clam Bay System have improved considerably, resulting in the restoration of the mangrove forest.

Freshwater Component

Under predevelopment conditions, much of the area's rainfall was held on the surface of the land in sloughs and other low areas. This water would either slowly filter through the soil to recharge the shallow aquifer or move through the mangrove community to the bay. Less than ten inches of the approximately 53 inch average rainfall is estimated to have been lost from the uplands east of Clam Bay as surface runoff. The storage capabilities of the land thus moderated surface flows, preventing extremely high flow rates during the rainy season and serving to maintain surface flow and groundwater flow during the dry season (FDER 1981).

The development of Pelican Bay had limited fill impact to the Clam Bay system, but it did modify the pattern of freshwater entering the Clam Bay system (Wilson, Miller et. al., 1996). The stormwater management system as designed, permitted, and implemented at Pelican Bay employs a series of detention ponds, swales, and culverts to regulate the discharge of run-off into Clam Bay wetlands. Discharge occurs almost continuously along the eastern perimeter of the conservation area. Run-off from the northern end of Pelican Bay is collected and discharged into Upper Clam Bay. Irrigation water for 27 holes of golf and landscaping in Pelican Bay has been reported as approximately 3.0 MGD, which approximates 26 inches per year of additional rainfall equivalent (Wilson, Miller et. al., 1996). According to the report, the irrigation water, when added to the average rainfall for South Florida of approximately 53 inches per year, yielded an effective rainfall of approximately 80 inches plus annually. This is significant, particularly when viewed in the context of predictable storm events that have the potential for altering the amount of average rainfall entering the Clam Bay system.

The "Pelican Bay Water Management System – Stormwater Detention Volume and Water Budget Analysis" (Wilson, Miller, Barton & Peek, Inc. April, 1996) describes the water management system as being divided into six watershed or drainage basins. Rainfall and irrigation water either seeps into the ground or runs off into the gravity-driven stormwater management system draining westward to the earthen dam (berm) through weirs that control discharges into the wetlands. The stormwater detention plan for Pelican Bay has a standard, permitted design capacity to hold the first inch of stormwater during a 25-year storm event. The stormwater management system was designed such that the post-development surface water run-off rates do not exceed pre-development rates. Stated differently, the system is designed to discharge stormwater in the development portion of Pelican Bay in the same manner that it discharged stormwater prior to development.

Stormwater runoff from an additional 130 acres of watersheds, outside of Pelican Bay, contributes a supplementary and significant volume of discharge to Clam Bay. This represents an estimated 7.9% of the total stormwater discharge contributing area to Clam Bay (1998 Management Plan).



Figure 15: Approximate locations of Drainage Basins within the Pelican Bay Development (photo is oriented with north to the left and west down).

As the area of Pelican Bay to the east has undergone development, it has increased the impervious surface area, with a concomitant increase in surface runoff, which is eventually discharged to Clam Bay wetlands. The daily irrigation water volume enhances the saturation of the uplands which reduces their ability to accommodate rainfall volume, thus effectively increasing surface and groundwater discharge.

Groundwater discharge can be commonly observed throughout the eastern side of Clam Bay and is discernible as a very slight sheet flow. Where this water encounters a discharge system, even one that is not operating at peak efficiency (from an engineering, not historical, standpoint), such as Outer Clam Bay, excess water is effectively removed from the system. However, during the mid-1990's in the northern section of the mangrove forest, sheet flow and stormwater run-off were not being efficiently removed due to lack of flow through the forest as a result of tidal restrictions in conjunction with soil impactions associated with road construction and development to the west (Worley, 2006). Freshwater accumulated within the mangrove basin by impounding water, increasing soil saturation and raising the mean water table elevation above ground level. This overwhelmed the black mangrove's anaerobic soil/gas exchange mechanisms. Mangroves in these areas became stressed and died. The construction of hand-dug flushing channels in the mangrove forest in addition to dredging of the Pass and interconnecting creeks, undertaken as part of the 1998 Management Plan, alleviated water impoundment and allowed mangroves to reestablish throughout the die-off area.

Inlet Dynamics

Clam Pass is a small wave-dominated inlet on the southwest coast of Florida that provides a tidal connection to approximately 560.05 acres of wetland preserve in the 560.05 acre Clam Bay NRPA.

The relatively small tidal prism of Clam Bay provides a critical balance between tidal flow in and out of the inlet channel and littoral processes moving to the inlet. This affects the inlet hydraulic efficiency over time, especially when littoral transport rates are high due to periods of high wave energy.

The morphologic features of a tidal inlet include ebb shoal, flood shoal, and inlet channel. The flood shoal includes the sand shoals on the bay side of the inlet channel. The flood shoal is less dynamic than the Gulf side of the inlet as it is influenced mainly by tidal flow and sheltered from the varying wave conditions on the open coast side. The ebb shoal features can be explained as a sand bar forming a delta on the open coast side of the inlet. The ebb shoal delta shields the inlet channel from waves and provides pathways for sand transport along the coast to bypass the channel without shoaling the inlet closed.

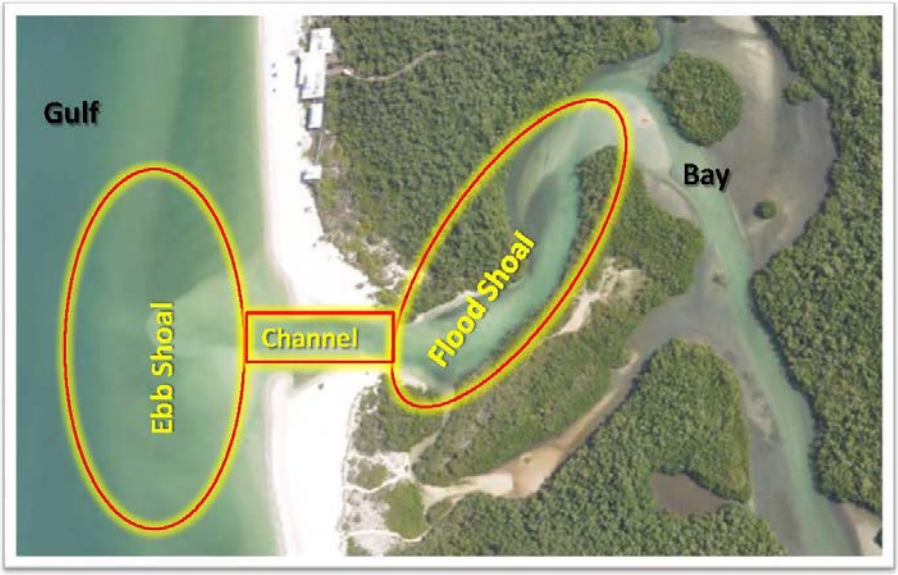


Figure 16: Ebb and Flood Shoals. Figure provided by Humiston & Moore

A stable inlet system requires an ebb shoal feature that prevents rapid shoaling at the inlet mouth. The inlet channel maintains its flow cross-section through tidal flow that scours the channel to required flow area while the waves are moving large amounts of sand along the coast. The stability and dynamics of a tidal inlet are based on the balance of the two forces of tidal flow versus wave-induced current and sand transport. The direction of wave action plays a significant role in the shape and dynamics of the inlet features.

Clam Pass is marginally stable but subject to shoaling, and therefore requires regular monitoring to determine if dredging is needed. The relatively small bay area compared to other estuaries in Southwest Florida provides adequate tidal flow to keep the Pass open under typical conditions. The narrow nature of the flood shoal area surrounded by the mangrove forest limits the flood shoal capacity to maintain an equilibrium volume and bypass additional sand to the Gulf and bay waters. The accumulation of sand over long periods of time, especially within the flood shoal and inlet channel,

creates additional resistance to flow. This additional resistance causes a reduction in the tidal range within the bay system and consequently reduces the flow through the Pass. If this occurs, maintenance dredging to restore flow rates may be needed.

During the 1990's Clam Pass was subject to channel migration as well as closure, and dredging was necessary to keep the inlet open. In 1998 the Pelican Bay Services Division developed the Clam Bay Restoration and Management Plan that was approved by the Collier County Board of Commissioners. The purpose of the plan was to address the mangrove die-off by improving tidal flushing into and out of the mangrove forest areas and drain excess water trapped within the mangrove forest. This was accomplished through the dredging of Clam Pass and portions of the interior creeks within the system, as well as the construction of a network of hand-dug channels throughout the original die-off area and several other areas that were exhibiting stress. While installation of the hand-dug channels assisted in die-off recovery, it also resulted in the death of several mature trees. To reach the die-off areas, hand-dug channels were cut through root systems of some mature mangroves. This action weakened the root systems of several trees, which could not withstand tropical storm winds and were subsequently blown down. The implementation of the Clam Bay Restoration and Management Plan resulted in a significant increase of the tidal prism compared to conditions prior to 1999 and the eventual recovery of over 90% of the original mangrove die-off area.

In addition to the 1999 dredging, dredging occurred in 2002, 2007, and 2013. The 2013 dredging took place following inlet closure in late 2012 after the passage of Tropical Storms Debbie and Isaac and high-energy wind and wave conditions. The inlet was reopened in April, 2013 and tidal exchange between the bay and the Gulf of Mexico was restored to near design levels.

Chapter 5.0 of this Management Plan outlines the scope of the monitoring efforts and factors that will be considered prior to a determination to dredge Clam Pass.

Water Quality

During the initial environmental permitting of Pelican Bay, the agencies required water quality testing within the Pelican Bay subdivision and the Clam Bay estuary to help evaluate the impact of development on Clam Bay. The water quality testing program was first implemented by the Pelican Bay Improvement District (PBID) starting in the early 1980's. In 1990 the PBID became the Pelican Bay Services Division (PBSD), a dependent Division of Collier County. The PBSD continued the testing program after 1990. The PBSD is currently the responsible entity for the testing program.

The water quality testing has been performed at several sample points within and adjacent to the Clam Bay NRPA. The historical sample point locations are shown on the Figure 17 on page 32. The sampling locations included 5 locations within the open waters of the system and 4 locations along the stormwater management berm. Sample points W-7 (located in the creek near the north Pelican Bay Foundation boardwalk); W-6 (located in the creek near the south Pelican Bay Foundation Boardwalk); W-1 (located near the kayak launch area at the southern end of Outer Clam Bay); North Seagate (located on the north side of the Seagate culverts between Venetian Bay and Outer Clam Bay); and Upper Clam Bay (located at the very north end of Upper Clam Bay) are within Clam Bay, and are

categorized as Class II waters by the Florida Department of Environmental Protection (FDEP). The remaining four sampling points are PB-13 (located north of the Marker 36 (fka Sandpiper) parking lot on both sides of the berm); PB-11 (located between the St. Maarten condominium and the Commons on the east side of the berm); Glenview (located between the Glenview and Stratford condominiums on the east side of the berm); and St. Lucia (located adjacent to the St. Lucia condominium on the west side of the berm), which are located in the stormwater treatment portion of the property (Class III waters) within Pelican Bay.



Figure 17: Historic Water Quality monitoring locations within and adjacent to the NRPA Boundary

Water quality sampling is conducted within the Clam Bay system on a monthly basis. The samples are collected by PBSD staff and transported to the Collier County Pollution Control laboratory for processing. Parameters sampled and collected, include:

- Field pH
- Field Temperature
- Field Salinity
- Field Dissolved Oxygen
- Ammonia
- Carbon – Total Organic
- Chlorophyll a
- Copper (*added to the parameter suite in 2013*)
- Nitrate-Nitrite (NO_3-NO_2)
- Nitrite (NO_2)
- Nitrogen – Total Kjeldahl
- Orthophosphate (OPO4)
- Pheophytin
- Phosphorus - Total
- Residues – Filterable (Total Dissolved Solids (TDS))
- Silica (SiO2)

Water quality sampling results of nutrient loading seem to indicate that Pelican Bay's stormwater management system is doing its job. No evidence of nutrient loading has been observed within the Class II waters though several spikes and elevated nutrient (nitrogen and phosphorus) levels have been observed from the testing locations along the berm. It is believed that the spikes observed are associated with fertilizer application within the community.

During the last several years Collier County and Pelican Bay Foundation consultants worked with FDEP to develop site specific alternative criteria (SSAC) for total nitrogen (TN) and total phosphorous (TP). These SSAC are now included in the State's adopted water quality standards in the Florida Administrative Code Chapter 62-302.532. The determination of whether or not the sites' nutrient levels meet the adopted criteria is based on an analysis of the relationship between TN and conductivity and TP and conductivity (Atkins North America, 2011). The State agreed to the establishment of these SSAC upon review of several studies related to sediments (PBS&J, 2010), fecal coliforms (Atkins North America, 2012), and dissolved oxygen (Cardno-Entrix, 2012), which all indicated that the Clam Bay NRPA exhibited healthy conditions for a natural, semi-enclosed, mangrove system.

The FDEP conducted water quality sampling within the Clam Bay NRPA in 2011 and 2012. Based on these sample results, FDEP made an initial determination that Clam Bay could be impaired for both dissolved oxygen (DO) and copper. As a result of coordination between FDEP, Collier County, the Pelican Bay Foundation, and involved consultants, FDEP made a determination that the oxygen levels in Clam Bay were natural, and the system was not listed as impaired for DO (FDEP letter, 2012).

FDEP did determine that the Clam Bay system was impaired for copper and placed the Clam Bay system on the Everglades West Coast verified list for copper with medium TMDL priority (5 to 10 years for TMDL development). TMDL (Total Maximum Daily Load) is defined by the FDEP as the maximum amount of a given pollutant that a surface water can absorb and still meet water quality standards. Subsequent copper testing undertaken by PBSD has also shown periodic elevated levels of copper within the Clam Bay Class II waters.

Beginning in 2015 PBSD's water quality monitoring program in the Clam Bay NRPA system will employ the sampling program used to establish the SSAC. Sampling locations within the open waters of the NRPA will be increased and relocated from the 5 historical locations to the 9 locations subsequently established. These 9 locations are shown on Figure 18. Sampling will continue to be collected on a monthly basis. The suite of parameters collected and analyzed from the water samples will also be amended as outlined below in order to provide the information necessary to more easily interpret the compliance with the newly established SSAC.

- Field pH
- Field Temperature
- Field Salinity
- Field Specific Conductance
- Field Dissolved Oxygen (mg/l)
- Field Dissolved Oxygen (% Saturation)
- Ammonia
- Chlorophyll a
- Copper
- Nitrate-Nitrite (NO_3-NO_2)
- Nitrite (NO_2)
- Total Nitrogen
- Orthophosphate (OPO4)
- Pheophytin
- Total Phosphorous

The PBSD is developing an upland stormwater and nutrient management program that builds upon the Nutrient Management Plan previously completed for the Pelican Bay Foundation (Turrell, 2013). The Foundation Plan and ongoing nutrient management efforts in process by the PBSD are designed to reduce nutrient and copper inputs into the stormwater system. Once completed, the PBSD program will be reviewed by the FDEP. If copper concentrations in the NRPA are reduced as a result of the implementation of the program, the FDEP could consider removal of the Clam Bay NRPA system from the impaired list. The information garnered from the PBSD's nutrient monitoring and management activities will be important in guiding future decision making associated with water quality concerns in the Clam Bay NRPA. PBSD will work closely with the Pelican Bay Foundation and adjacent communities on nutrient management issues to coordinate and share information that may be integrated into management decisions and activities undertaken through this Management Plan.

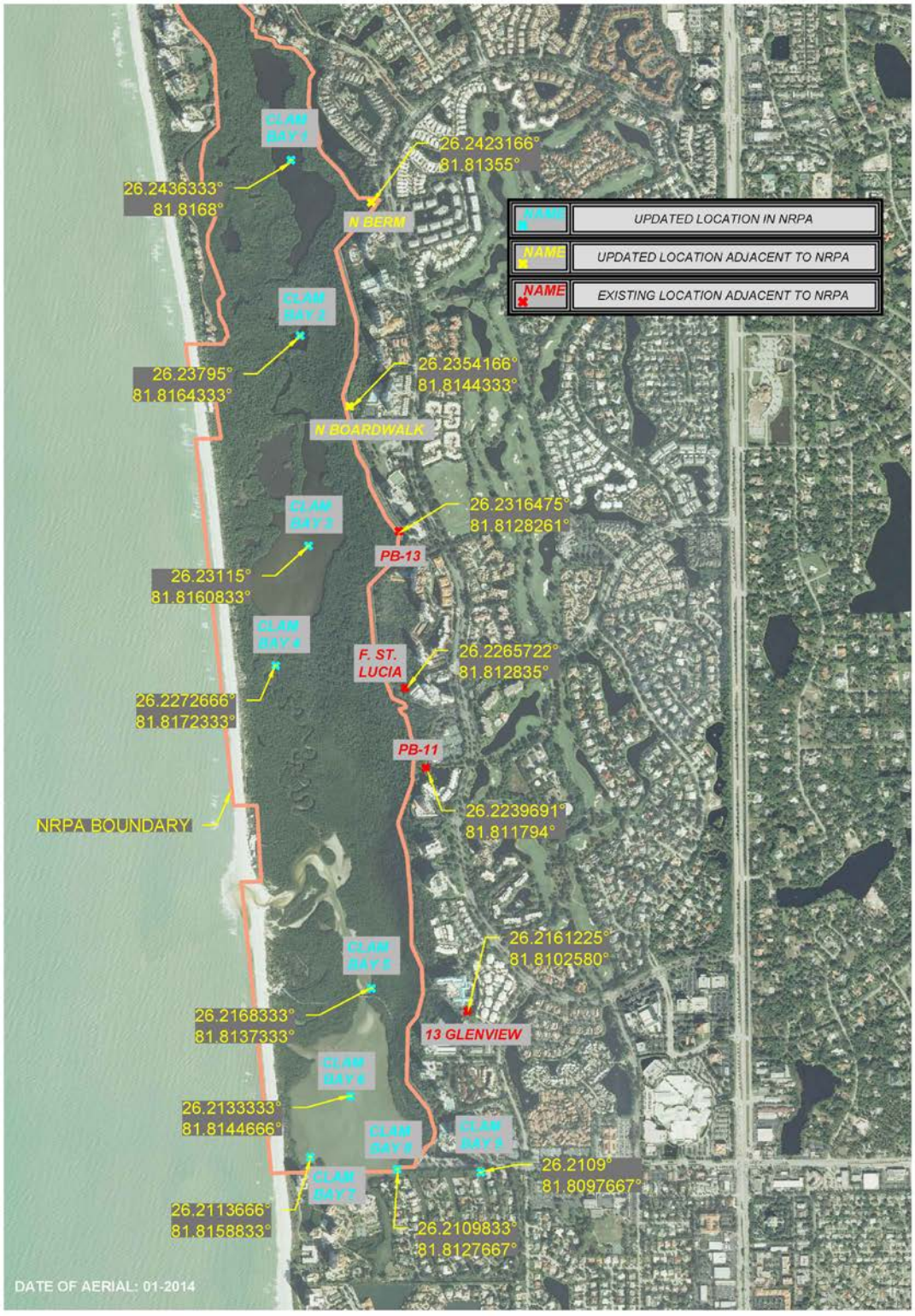


Figure 18: Proposed Water Quality monitoring locations within and adjacent to the NRPA boundary

Archaeological Resources

The Florida Division of Historical Resources Master Site File lists three known archaeological sites within the Clam Bay NRPA boundary. All three are located within or adjacent to the mangrove forest habitat. Two of the sites (CR476 and CR547) are located north of the Pass and south of Inner Clam Bay. The third site (CR576) is located south of the Pass and north of the Clam Pass Park boardwalk.

Site CR476 is identified as a prehistoric campsite and shell midden possibly supporting the use of several cultures dating from 8500 B.C. to A.D. 1700.

Sites CR547 and CR576 are identified as shell middens which were in use between 100 B.C. and A.D. 1700.

All three of the sites are outside of the footprint of any previous or future anticipated dredging activities.

Recreational Use

The Clam Bay NRPA provides a variety of opportunities for recreation. The main creek system between the Pass and the Bays is a multi-use waterway which at times sees swimmers, waders, fishermen, boaters, canoers, kayakers, and paddleboarders all sharing the waterways and the Pass. Many Collier County residents and visitors enjoy the natural environment of the preserve. Recent stakeholder input, as well as prior reports, supports the use of the Clam Bay NRPA for low-impact recreation. It is important that all who participate in recreational activities within the system do no harm to the flora, fauna and water quality of the Clam Bay NRPA.

Clam Bay's dense forest of mangroves significantly limits walking in the preserve. Most walkers seeking to enjoy the rich natural environment of Clam Bay use the three boardwalks that cross the preserve and provide access to the beach. Residents and guests of Pelican Bay use the northern and middle boardwalks. The southernmost boardwalk is open to the public and accessed from the parking lot at the south end of the system. Trams are used on all three boardwalks to transport those choosing not to walk on the boardwalk to the beach.

Fishing and swimming are popular pastimes. Fishing can be done from the boardwalks and canoes or by wading into the water. Swimming is usually confined to the beach areas, but some swimmers and waders, if conditions permit, venture into Clam Pass. Shell hunters, joggers and sunbathers are also familiar sights along the shoreline.

Kayaks, canoes, and paddleboards are used by those wanting to enjoy the natural setting and serenity of Clam Bay's waterways. There is a public launching area for non-motorized vessels adjacent to the parking lot at the south end of Outer Clam Bay. There is also a launch area for canoes and kayaks for Pelican Bay residents on the northern boardwalk. The canoe/kayak trail is clearly designated by canoe trail markers from Outer Clam Bay to Upper Clam Bay.



Figure 19: Existing Multi-use Waterway signs

There have been occasional disagreements between boaters and swimmers not understanding the mixed-use aspects of the waterway, and potentially unsafe motorboat operation has been occasionally observed. Ongoing education will continue to indicate the mixed use-aspects of the waterway. If necessary, County Ordinances or other management measures will be sought to promote safe and environmentally suitable utilization by all residents and visitors.

4.0 Management Plan Goal and Supporting Objectives

The following goal and supporting objectives for the management of the Clam Bay Natural Resource Protection Area (NRPA) were developed in accordance with the directives of the Collier County Board of Commissioners (BCC) and the Pelican Bay Services Division (PBSD), which serves as an advisory board to the BCC. The goal and supporting objectives were formed in conjunction with stakeholder input and are based on the management issues present in the NRPA as well as the purposes for which the land is held in public trust.

The Clam Bay NRPA requires active management to ensure its long term health. The goal and supporting objectives set forth in this plan should not appreciably change over time, but management techniques and strategies may be modified to appropriately manage the NRPA. Annual reports documenting the results and analysis of all monitoring activities over the course of the previous year will be completed, and the results presented at one of the PBSD's announced monthly meetings.

The ability to implement specific objectives of the management plan is dependent upon available administrative and financial support. Therefore, activities will require prioritization to remain within available funding. Management strategies will be reviewed annually by the PBSD and adapted as needed.

GOAL

The goal of the Clam Bay NRPA Management Plan is to establish the basis for management activities that will be undertaken to protect the health of the Clam Bay NRPA estuary.

Objectives to support this goal include:

1. ***Maintain and protect the native floral and faunal communities within the Clam Bay NRPA***
2. ***Ensure the estuary has adequate tidal and freshwater flows to maintain ecological health within the Clam Bay NRPA***
3. ***Monitor and maintain water quality within the Clam Bay NRPA***
4. ***Monitor archaeological sites within the Clam Bay NRPA***
5. ***Ensure recreational activities are environmentally compatible within the Clam Bay NRPA***

These objectives were formed to allow for adaptive management, whereby the compilation and analysis of all data will occur holistically and provide direction to adjust strategies to better achieve the goal.

Objective 1 – ***Maintain and protect the native floral and faunal communities within the Clam Bay NRPA***

This objective is focused on ensuring natural resource protection and long-term sustainability by evaluating and prioritizing available relevant information about the estuary in order to develop and implement a cohesive management strategy that protects the native floral and faunal communities.

A. **Maintain healthy, native floral and faunal populations.**
   1) Establish plots and photo points in Coastal Scrub and Cabbage Palm Hammock habitats and monitor periodically.
   2) Monitor established plots in the mangroves periodically.
   3) Monitor established transects in the seagrasses periodically.
   4) Monitor benthic organisms periodically.
   5) Monitor wildlife within the NRPA periodically.
   6) Determine through regular biological monitoring whether intervention strategies are necessary to protect the ecological health of the NRPA.

B. **Protect Listed Species.**
   1) Identify and determine the status of listed floral and faunal species and associated habitats to the extent possible.
   2) Monitor gopher tortoise burrows periodically.
   3) Acquire Collier County sea turtle nesting data as they become available.
   4) Update educational information on species, such as the Clam Bay Guide, as needed.

C. **Remove Exotic and Nuisance Flora and Fauna.**
   1) Locate and identify exotic and nuisance species within the Clam Bay NRPA.
   2) Remove, or report to the responsible entity for removal, Category I and II invasive exotic species and nuisance species as needed.

Objective 2 – ***Ensure the estuary has adequate tidal and freshwater flows to maintain ecological health within the Clam Bay NRPA***

This objective is focused on managing hydrology and evaluating freshwater inputs to the Clam Bay NRPA.

A. **Identify the minimum tidal flow necessary to ensure a healthy ecosystem. Provide sufficient tidal exchange to maximize benefits while minimizing negative environmental impacts.**
    1) Conduct periodic bathymetric surveys of Clam Pass.
    2) Conduct periodic analysis of tidal data.
    3) Maintain tidal gauges.
    4) Conduct bathymetric surveys of interconnecting waterways when needed.
    5) Determine whether ecological benefits of intervention activities outweigh potential negative ecological impacts.
    6) Monitor identified variables of Clam Pass conditions to determine when dredging is needed. (See Chapter 5.0 and Appendix 5 for information on variables.)
    7) Seek appropriate federal and state permits to dredge Clam Pass or interconnecting waterways if needed.

B. **Ensure appropriate freshwater inputs and drainage.**
    1) Identify freshwater inputs (quantity, quality, and timing).
    2) Evaluate effects of freshwater inputs on existing native communities and develop remediation strategies if needed.
    3) Conduct periodic monitoring of hand-dug channels.
    4) Perform periodic maintenance of selected sections of hand-dug channels.

Objective 3 – ***Monitor and maintain water quality within the Clam Bay NRPA***

This objective is focused on ensuring compliance with State and Federal water quality standards and reducing pollutant inputs to maintain ecological health.

A. **Develop a long-term water quality program that ensures a sustainable healthy environment for all users.**
    1) Follow a program of water-quality data collection and analysis that addresses the site specific alternative criteria and methodologies approved by the FDEP.
    2) Sample monthly from sites used to establish FDEP site specific alternative criteria.
    3) Ensure sampling and testing protocols comply with FDEP guidelines and standards.
    4) Develop intervention strategies when standards are not met.
    5) Enter data into STORET system annually
    6) Continue efforts to address copper impairment in the Clam Bay NRPA.

B. **Promote programs for controlling water pollution from point and nonpoint sources.**
    1) Promote Best Management Practices for fertilizer and irrigation use.
    2) Promote programs to reduce algae levels in upland stormwater ponds.
    3) Promote programs to reduce copper input into stormwater ponds.
    4) Investigate new methodologies for controlling water pollution.

Objective 4 – Monitor archaeological sites within the Clam Bay NRPA

This objective is focused on recognizing the presence and importance of archeological sites within the Clam Bay NRPA.

A. **Monitor conditions of known archaeological sites.**
    1) Review historical records of Florida Division of Historical Resources (DHR) on known archaeological sites.
    2) Inspect known archaeological sites periodically.
    3) Report findings as appropriate to DHR.

B. **Implement strategies for the protection of archaeological sites as needed.**

Objective 5 – Ensure recreational activities are environmentally compatible within the Clam Bay NRPA

This objective is focused on recognizing recreational uses, ensuring that public use facilities are maintained, monitoring associated impacts to the estuary, and promoting public awareness and stewardship of this sensitive area.

A. **Monitor access and the condition of the facilities for recreational uses.**
    1) Report vegetation needing to be trimmed to the responsible entity.
    2) Report litter needing to be removed to the responsible entity.
    3) Report facilities needing to be repaired or replaced to the responsible entity.

B. **Maintain existing canoe trail.**
    1) Inspect signage periodically.
    2) Repair or replace trail marker signage as needed.
    3) Repair or replace caution seagrass and shoaling signs as needed.
    4) Revise and/or reprint the Canoe Trail Guide as needed.

C. **Maintain existing signage for safe swimmer and boater usage.**
    1) Inspect signage periodically.
    2) Repair or replace signage as needed.

D. **Monitor use of facilities/area for recreational uses.**
    1) Encourage citizens to report unsafe or environmentally harmful use.
    2) Coordinate with responsible entity to enforce the laws and regulations as needed.

3) Continue to support the use of the Clam Bay NRPA for low-impact recreational uses.

E. **Maintain materials to educate visitors about the unique features of the Clam Bay NRPA.**
   1) Inspect educational signage periodically.
   2) Report signage needing repair or replacement to the responsible entity.
   3) Update Clam Bay Guide as needed.

Reporting

Regular reports will be prepared at least annually, summarizing the data collection and management activities. Reports will evaluate datasets by comparing results to baseline conditions (if known) or through trending analysis. Additionally, reports will recommend whether any intervention strategies or actions are necessary to meet the objectives.

The goal and all objectives will be evaluated at least annually in conjunction with past and present research programs conducted within the Clam Bay NRPA to determine ecosystem status. If progress in achieving objectives is not favorable, then the methods will be re-evaluated and updated as needed. Alternative methodologies will be explored, if warranted, to achieve progress in meeting the goal of maintaining the health of the Clam Bay NRPA.

5.0 Clam Pass Dredging

A. Dredging Policy

There are two circumstances that could necessitate dredging Clam Pass.

1. Clam Pass closes or is in imminent danger of closure following a weather driven event. In this situation the inlet should be dredged as soon as possible.

2. The inlet has lost hydraulic efficiency and is jeopardizing the long-term health of floral and faunal communities of the Clam Bay NRPA. The scope and timing of any proposed dredging activity will be determined by reviewing and comparing current and past hydraulic, bathymetric and ecological monitoring data.

In both cases the PBSD Board would, after consultation with and advice from qualified coastal engineers and biologists, approve and recommend an appropriate set of construction drawings for the dredging event to the BCC for its approval prior to the submittal to the regulatory agencies.

Dredging will only be done for the health of the Clam Bay NRPA, not for navigation or beach renourishment. Beach-compatible sand removed as part of the dredging event will be spread on adjacent area beaches, as required by the permitting agencies.

B. Hydraulic and Bathymetric Dredging Criteria

The purpose of regular hydraulic and physical monitoring is to evaluate inlet characteristics on a comprehensive long term basis with less emphasis on short term or seasonal changes.

To monitor the stability of Clam Pass, data on the variables listed below will be regularly collected and reviewed by qualified engineers. If data are not within the identified target ranges for the variables, further monitoring and/or intervention will be considered in conjunction with current ecological data. See Appendix 5 for additional information on the dredging criteria.

1. Bay Tide Range

Tidal range data have been collected annually since 1999 and will continue to be collected and reported to the consulting engineer at least quarterly. An annual tidal analysis report will be included with the annual report.

Data are collected from gauges at four locations (Clam Pass Park Boardwalk, Pelican Bay South Boardwalk, Pelican Bay North Boardwalk, and Upper Clam Bay). These gauges provide a record of the tidal range within Clam Bay and are one indication of the tidal prism or volume of water flowing through Clam Pass at each tidal cycle.

Based on an analysis of data from the gauges at the South Boardwalk and Clam Pass Park Boardwalk from 1998 to the present when the inlet was hydraulically stable, the ratio between Clam Bay and Gulf tide was between 0.6 and 0.7 over 90% of the time. Therefore, if the ratio between Clam Bay and the Gulf tide falls below 0.6, but above 0.5, further monitoring will be considered once it has been established that other types of blockage are not causing the problem. If the tidal range ratio falls below 0.5, physical monitoring of, or interventions to, potential shoaling areas that could be impeding flow will be considered.

2. Cross Section of Flow Area and Volume of Shoaled Material

Annual bathymetric surveys and reports were completed from 1999 to 2008. Bathymetric surveys provide data on the physical conditions of the inlet channel, ebb shoal and flood shoal. Post-dredging bathymetric surveys and reports were completed at 3-month, 6-month, and 12-month intervals following the opening of Clam Pass in April 2013. Beginning in 2014, bathymetric surveys and reports will be issued at least annually. Additional surveys will be considered if the hydraulic efficiency falls below target levels.

To establish benchmarks or targets for flow area and volume of shoaled materials, the data analysis included evaluation of the flow cross-section areas in the three main sections of the dredging region. Section A represents the inlet channel, Section B the seaward part of the flood shoal, and Section C the bay side part of the flood shoal.

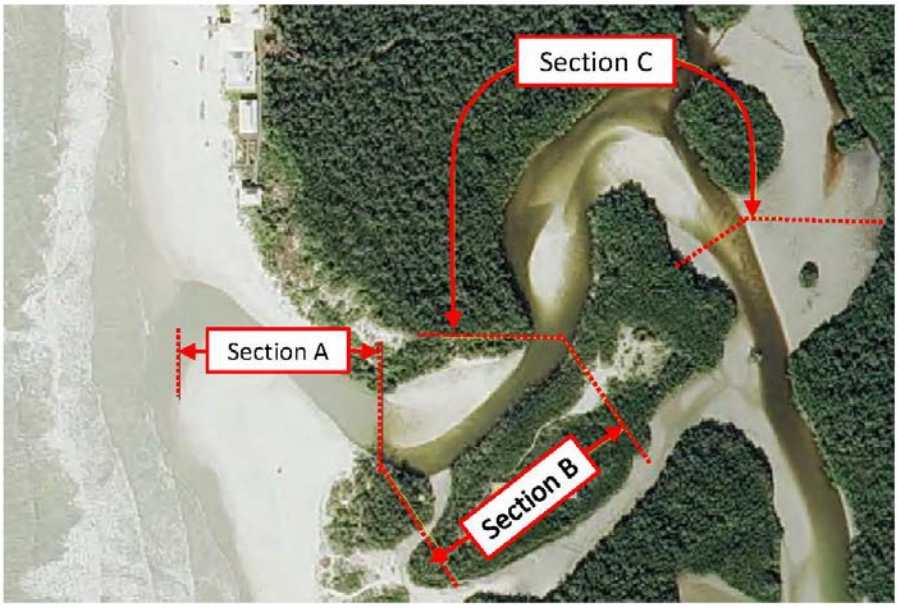


Figure 20: Sections A, B and C of Clam Pass

The analysis included evaluation of the cross-section of flow between mean high water and the volume of sand within each segment. The cross-section of flow was computed at each survey station spaced approximately 50 feet apart. The average and minimum cross-section areas were used as indicators of

the physical condition of the flow area of the three segments. The cross-sections were compared to the design cross-section area of the 2013 dredging and the inlet conditions in 2004 and 2008 when inlet conditions were near equilibrium 24 months and 16 months, respectively, following dredging events.

Targets for the average cross-section of flow areas below MHW:
Section A greater than 300 sq. ft.
Section B greater than 450 sq. ft.
Section C greater than 450 sq. ft.

Targets for the minimum cross-section of flow areas below MHW:
Section A greater than 250 sq. ft.
Section B greater than 350 sq. ft.
Section C greater than 350 sq. ft.

Targets for volume of shoaled materials:
Section A less than 3000 cu. yds.
Section B less than 2500 cu. yds.
Section C less than 4000 cu. yds.

Therefore, if the average cross-section of flow area falls below these numbers or the volume of shoaled material exceeds these numbers, further monitoring or intervention may be needed.

3. Inlet Channel Length

The channel length is an important factor in inlet stability. A longer inlet channel will provide greater resistance to flow. Higher flow resistance will reduce the tidal range and increase the phase lag with the Gulf tide that reduces the tidal prism and flow through Clam Pass.

To establish a benchmark for channel length a selection of aerial photos of Clam Pass from 2004 to 2013 was studied as well as data on the approximate length of the channel following dredging events in 2002, 2007, and 2013.

Based on this analysis, the benchmark for inlet channel is to stay under 400 feet in length. Inlet channel length will be recorded at least annually and included in the annual report.

4. Ebb Shoal

The size and shape of the ebb shoal is a key factor to the stability of the inlet that, in turn, supports the stability of Clam Pass. The ebb shoal helps to keep the inlet open when facing storms and big wave events. The ebb shoal provides sheltering to the channel and a sand bypass pathway around the inlet without filling in the Pass. The shape and volume of the ebb shoal are additional indicators of the stability of the inlet. Critical conditions include onshore collapse of the ebb shoal that can be indicated by significant change in ebb shoal offshore distance, volume, and increase in dry beach areas adjacent to the inlet.

To determine a target for the ebb shoal delta, data from April 2013 to April 2014 were reviewed. The ebb shoal position offshore is measured from a line connecting the north and south channel banks at mean high water out to the -4.0 foot contour line.

The recommended length of the seaward extent of the ebb shoal is at least than 250 feet. The ebb shoal distance from shore will be recorded at least annually and included in the annual report.

A summary of criteria for dredging is presented in the table below.

Dredging Criteria Parameter Summary			
	Location	Target	Description
Bay Tide Range Ratio		> 0.6	ratio comparison of the interior and Gulf tidal ranges
Cross Sectional Area	A	Average >300 sq ft Not less than 250 sq ft	area in different locations of the Pass through which water can flow
	B	Average >450 sq ft Not less than 350 sq ft	
	C	Average >450 sq ft Not less than 350 sq ft	
Volume of Shoaled Material	A	< 3000 cu yds	quantity of sand and sediments within channel that can restrict flow
	B	< 2500 cu yds	
	C	< 4000 cu yds	
Inlet Channel Length		< 400 feet	distance water must flow through the beach and ebb shoal areas
Ebb Shoal		> 250 feet	distance from shore to the outer ebb shoal limits

C. Ecological Considerations

A critical consideration in all dredging decisions is to ensure the ecological health of the Clam Bay NRPA. Before any dredging event, the direct and indirect impacts on the flora and fauna of the NRPA including mangroves, benthic communities (including seagrass), and other important species, such as fish and birds, will be considered. Every effort will be made to minimize any negative impact to the flora and fauna. The pros and cons of dredging will be weighed in regards to both hydrologic and ecological consequences.

D. Dredging Construction

1. Typical Cross-Sections for Dredging

Typical cross-sections for the suggested dredge design are provided below. When dredging is deemed necessary, the design cross-section area as stated in the design range, with consideration to existing conditions, will be followed. Minor modifications to this dredging template may be needed for future permitting. Typical cross-sections are shown for open areas in Sections B and C where the waterway

is wider than the target cross-section. In areas where the waterway is lined with mangroves appropriate buffers will be established. Where the substrate surface is shallower than -2' MHW a minimum of a 15' buffer from the mangroves will be maintained. Where substrate surface is deeper than -2' MHW a minimum of a 5' buffer from mangroves will be maintained. Post-dredge monitoring of mangrove impacts will be conducted to determine if these minimum buffers should be modified for future dredging events. If changes to these buffers are proposed in pre-dredging plans a biological review will be conducted to ensure potential mangrove impacts are minimized. Where seagrasses may be present every effort will be made to avoid dredging activities that would be harmful to seagrasses.

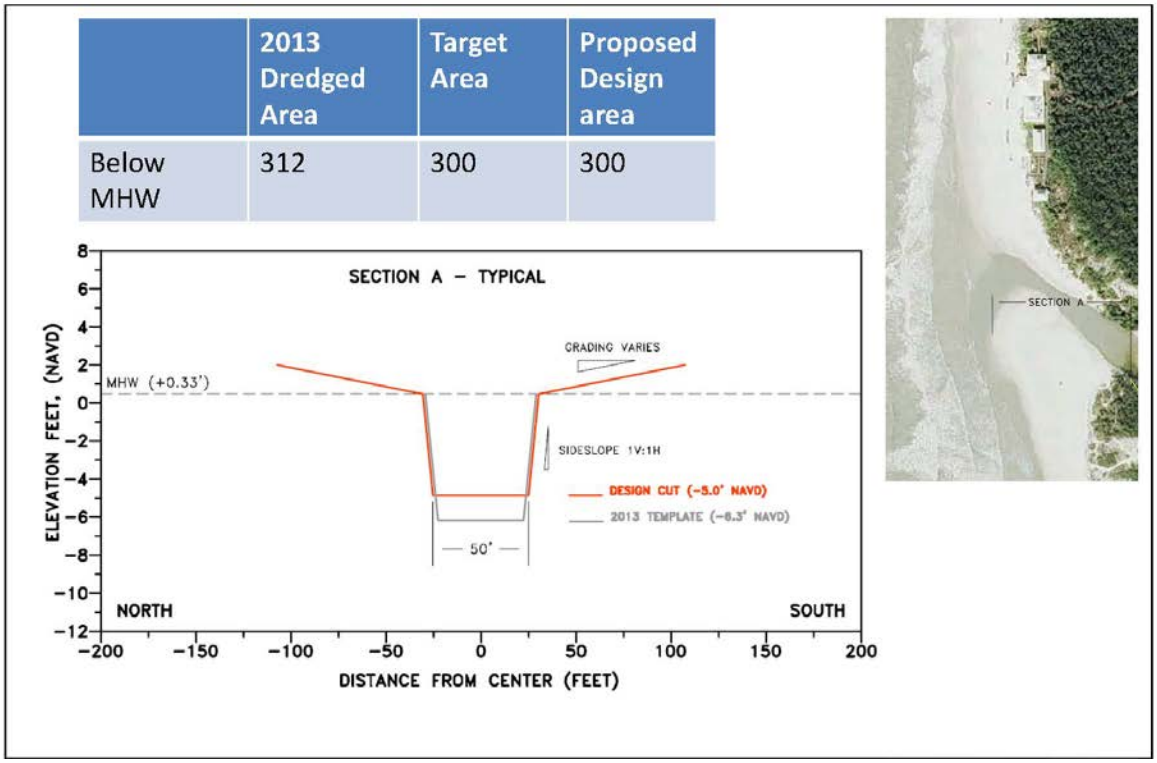


Figure 21: Typical maintenance dredging cross-section – Inlet Channel – Section A (figure provided by Humiston & Moore)

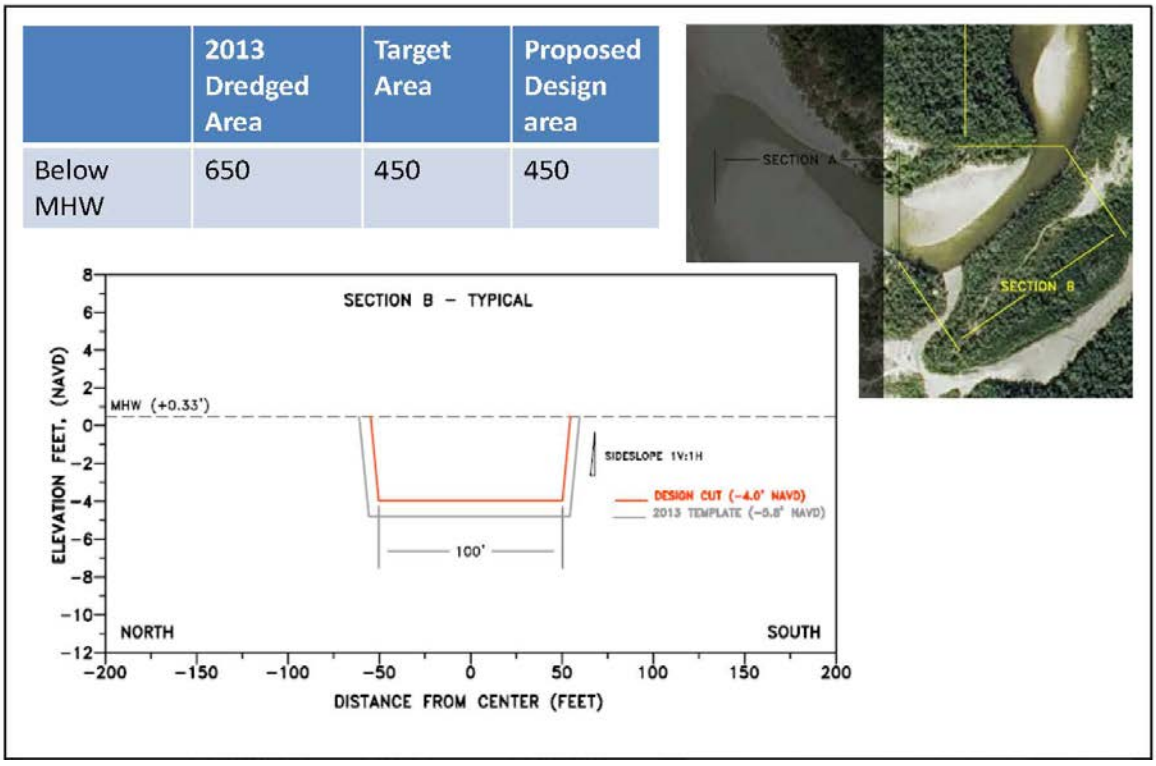


Figure 22: Typical maintenance dredging cross-section – Seaward Flood Shoal – Section B (figure provided by Humiston & Moore)

Cubic yards

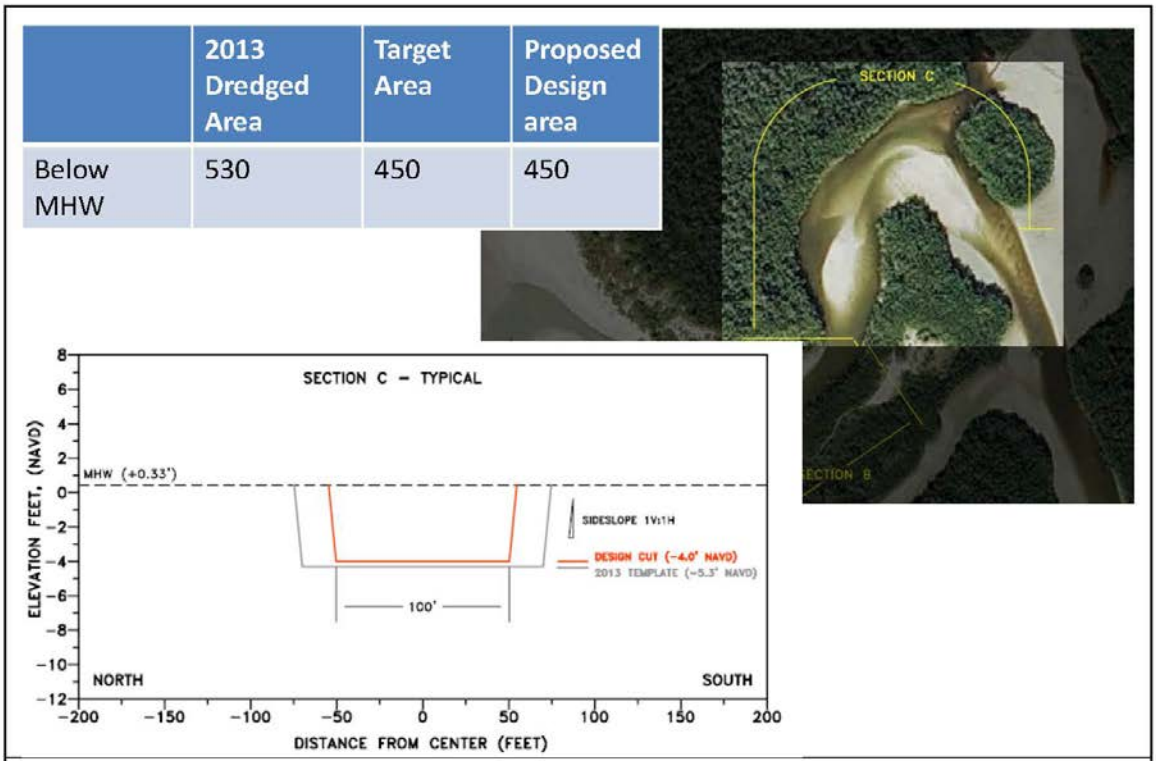


Figure 23: Typical maintenance dredging cross-section – Bayside Flood Shoal – Section C (figure provided by Humiston & Moore)

6.0 Authorized Construction Activities

The Management Plan, after approval by the PBSD and the BCC, will become an integral part of future dredging and other relevant permit applications. The permits will allow for ongoing maintenance activities to continue along with occasional removal of material by dredging within a discreet area of Clam Pass in order to maintain the existing tidal regime within the system. Any changes to the submitted dredging scope or other new management initiatives will be reviewed by the PBSD Board and Collier County Commissioners before seeking any additional permit(s) which may be necessary for the modified activities. Additional investigations which may be undertaken at a later date to look at, for example, faunal investigations, more in-depth water quality concerns, or other issues that may arise as a result of stakeholder discussions could also necessitate permitting which will have to be reviewed by the PBSD and BCC prior to any such permit applications being submitted. This Management Plan is specifically tasked to maintain the improvements and benefits already realized and to insure that the restoration success observed to date is continued. Dredging for navigation or beach renourishment will not be done.

Appendix 1 contains the timeline of important events within the Clam Bay system and a list of authorizations and brief details related to existing and historical permits issued for the Clam Bay system.

7.0 Clam Bay NRPA Management Plan Amendments

The Management Plan is not expected to be a static document, and ongoing research will be conducted and data collected related to water quality, hydrographic changes in the various areas of the system, benthic community health, mangrove community health, exotic and nuisance vegetation control, and public education. Conclusions, recommendations, or alternative management activities that come about as a result of future studies will be examined and considered by the Pelican Bay Services Division and qualified engineers and biologists for their relevance to the Management Plan. Those modifications that are found to be relevant and economically feasible will be incorporated into the Management Plan for approval by the BCC.

Clam Bay NRPA Management Plan Stakeholder Groups and Review Agencies

Review Agencies

City of Naples Michael R. Bauer, J.D., Ph.D. 295 Riverside Circle Naples, FL 34102	Collier County Natural Resources Bill Lorenz 2800 N Horseshoe Dr Naples, FL 34104
Collier County Parks and Recreation Maura Kraus / Barry Williams 15000 Livingston Rd Naples, FL 34109	Florida Dept. of Environmental Protection Megan Mills P.O. Box 2549 Fort Myers, FL 33902
Florida Fish & Wildlife Conservation Comm. Habitat & Species Conservation Div. 3829 Tenoroc Mine Rd Lakeland, FL 33805	Florida Fish & Wildlife Conservation Comm. Boating & Waterways Section 620 South Meridian St Tallahassee, FL 32399
National Marine Fisheries Service 263 13th Avenue S St. Petersburg, FL 33701	South Florida Water Management District Laura Layman 2301 McGregor Blvd Fort Myers, FL 33901
U.S. Army Corps of Engineers Tunis McElwain 1520 royal Palm Square Blvd, Ste 10 Fort Myers, FL 33919	U.S. Fish and Wildlife Service 1339 20th Street Vero beach, FL 32960

Stakeholder Groups / Individuals

Collier County Audubon 1020 8th Avenue S, Ste 2 Naples, FL 34102	Conservancy of Southwest Florida 1495 Smith Preserve Way Naples, FL 34102
Mangrove Action Group P.O. Box 770404 Naples, FL 34107	Naples Cay Association 40 Seagate Dr, Ste 1206 Naples, FL 34103
Paradise Coast Paddlers Club 2392 Clipper Way Naples, FL 34104	Pelican Bay Foundation 6251 Pelican Bay Blvd Naples, FL 34108
Pelican Bay Property Owners Association 801 Laurel Oak Dr, Ste 600 Naples, FL 34108	Seagate Property Owners Association P.O. Box 3093 Naples, FL 34106-3093
Sierra Club – Calusa Group 6075 Pelican Bay Blvd, #703 Naples, FL 34108	Southwest Florida Paddling Club 20991 S Tamiami Trail Estero, FL 33928-2838

Tall Tales Bait and Tackle 841 Vanderbilt Beach Rd Naples, FL 34108	The Ritz-Carlton Naples 280 Vanderbilt Beach Rd Naples, FL 34108
The Seasons at Naples Cay Condo. Assoc. 81 Seagate Dr, #3000 Naples, FL 34103	Waldorf Astoria Naples 475 Seagate Dr, Naples, FL 34103
Diane Solomon Brown & Stuart Brown dianesolomonbrown@me.com	Sandra J Doyle naplespatriots@comcast.net
Anne Georger ageorger1@gmail.com	Brandon Lampe brandonlampe@rocketmail.com
Diane Lustig & Leon Lustig lustigl@embarqmail.com	Linda Roth LOR3LOR3@aol.com
Missy Travis & Pat Travis missy.travis@gmail.com ptravis@delotte.com	Mary McLean Johnson 6573 Marissa Loop #1501 Naples, FL 34108

Clam Bay NRPA Management Plan Bibliography

1. Atkins North America, David Tomasko and Emily Keenan. Clam Bay Numeric Nutrient Criteria – Proposed Technical Guidance. Technical Note to Collier County. August 31, 2011.

2. Atkins North America, David Tomasko. Clam Bay Fecal Coliform Technical Note. Report to Collier County. March 2012.

3. Cardno-Entrix, Dan Hammond et al. Clam Bay Dissolved Oxygen Draft Impairment Listing, Proposed Guidance. Technical memorandum to Florida Department of Environmental Protection. July 25, 2012.

4. Cardno-Entrix, Dan Hammond et al. Proposed Copper Impairment Listing for Clam Bay (WBID 3278Q1). Letter to Florida Department of Environmental Protection. July 31, 2012.

5. Collier County Natural Resources Department. Clam Bay Natural Resources Protection Area Management Plan Draft, technical paper-4th rev. Nov 21, 1994.

6. Collier County. Executive Summary – Approval of Clam Bay Natural Resources Protection Area (NRPA). 21 Feb 1995.

7. Crewz, David W., 1989, Clam Pass Park mangrove damage, Department of Natural Resources Interoffice Memorandum.

8. Crewz, David W. Florida. Department of Natural Resources. Clam Pass Mangrove Damage. Interoffice Memo, May 1989.

9. Department of Environmental Regulation, 1981, Diagnostic and Feasibility Study for Moorings Bay, Collier County, Florida.

10. Devlin, D. J., Gore, R.H., and Proffitt, C.E. 1987. Natural Resources of Collier County. Preliminary Analysis of Seagrass and Benthic Infauna in Johnson and Clam Bays, Collier County Natural Resources Dept. CM 169. Technical Report No. 87-2.

11. Florida Department of Environmental Protection. FDEP Letter re Clam Bay copper levels and dissolved oxygen levels dated October 8, 2012. Response to Cardno-Entrix letters of July 25 and 31, 2012.

12. Gee & Jensen Engineers, Architects and Planners, Inc., 1978, Hydrographic Study Clam Bay System Collier County, Florida for Coral Ridge- Collier Properties Inc., report.

13. Hartwell, Richard W., Hatcher, James M., Grabe, Stephen, August 1994, Clam Bay Natural Resources Protection Area (NRPA), Collier County Environmental Services Division, Publication Series NR-SP-94-01, technical paper.

14. Hawkins, Mary Ellen, Obley, Ross P., "Pelican Bay-Visit and Revisit." Urban Land Vol. 40, No 11. (December 1981) 21-27.

15. Heald, Eric J., Tabb, Durbin C., Roessler, Martin A., Beardsley, Gary L., Ward, Gerlad M., Durrance, Dallas H., Yeend, John S., 1978, Carbon Flows in Portions of the Clam Pass Estuarine System, Collier County, Florida, Tropical BioIndustries Company and Gee and Jenson, Engineers-Architects-Planners, Inc., technical paper.

16. Heald, Eric J., Roessler, Martin A., December 1979, Invertebrate Population Studies in the Vicinity of Upper Clam Bay, Collier County, Florida, Tropical BioIndustries, technical paper.

17. Heald, Eric J., July 1983, Populations of Melampus coffeus and Cerithidea scalariformis West of Upper Clam Bay, Collier County, Florida, Tropical BioIndustries, Inc., technical paper.

18. Heald, Eric J., July 1983, Fish Populations of Tidal Ponds West of Upper Clam Bay Collier County, Florida, Tropical BioIndustries, technical report.

19. Humiston and Moore Engineers. 2007. Clam Pass Restoration and Management Plan Bathymetric Monitoring Report No. 8.

20. Humiston and Moore Engineers. 2010. Clam Pass Restoration and Management Plan Bathymetric Monitoring Report No. 12.

21. Humm, H.J. and Rehm, A.E. 1972. Ecological Appraisal an Ecological Study of the Clam Pass Complex. Study for the Collier Company at Clam Pass Properties. Tri-County Engineering, Inc. TCE Project No. 1516.

22. Lewis, Roy R., and Marshall, Michael J. Lewis Environmental Services. First Annual Report, #2; One year after flushing channel construction. 1997.

23. Natural Resources Conservation Service. United States Department of Agriculture. Soil Survey of Collier County Area, Florida. 1998.

24. PBS&J, Inc., Clam Bay System Data Collection and Analysis. October 2009.

25. PBS&J, Inc. Summary of Preliminary Findings on Sediment Studies. Report to Collier County Coastal Advisory Committee. October 2010.

26. Tackney & Associates, Inc., Preliminary Hydrographic Assessment Clam Bay Systems. August 1996.

27. Tri-County Engineering, Inc., 1971, Tidal Datum Plane Determination for the Collier Company.

28. Tri-County Engineering, Inc., Sarkar, Chiranjib K. Hydrographic Investigation of the Clam Bay System, Technical paper. October 1972.

29. Tropical BioIndustries and Missimer and Associates, Inc., A Comparative Study of the Water and Carbon Flows of Upper Clam Bay, technical paper. June 1979.

30. Tropical BioIndustries. Environmental Assessment Northwest Fill Area for Pelican Bay, technical paper. February 1979.

31. Turrell and Associates, Inc. and Humiston & Moore. "Clam Pass Inlet Management Plan Interim Report No. 1". July 1995.

32. Turrell, Hall & Associates, Inc. 2009. Clam Bay Restoration and Management. Biological Monitoring Report. Eighth Annual Report No. 11.

33. Turrell, Hall & Associates, Inc. Pelican Bay Nutrient Management Plan. Prepared for the Pelican Bay Foundation. July 2013.

34. Wilson, Miller, Barton & Peek, Inc. Pelican Bay Mangrove Investigation, Pelican Bay Water Management System-Stormwater Detention Volume and Water Budget Analyses. April 1996.

35. Worley, K. 2006. Relating Mangrove Die-offs to Encroaching Human Development in Southwest Florida. NOAA Technical Report 1602407. Conservancy of Southwest Florida. Naples, Florida. Pp 59.

36. Worley, Kathy and Jeffrey R. Schmid. "Clam Bay Natural Resource Protection Area (NRPA) Benthic Habitat Assessment - Report for the Contract Agreement Between Pelican Bay Property Owners Association (PBPOA), Pelican Bay Foundation, Inc. (PBF), and the Mangrove Action Group (MAG), and the Conservancy of Southwest Florida (CSWF). Dec 2010.

APPENDIX 1 – TIMELINE OF IMPORTANT EVENTS WITHIN THE CLAM BAY NRPA AND A LIST OF PERMITS FOR WORK UNDERTAKEN IN AND AROUND THE CLAM BAY NRPA

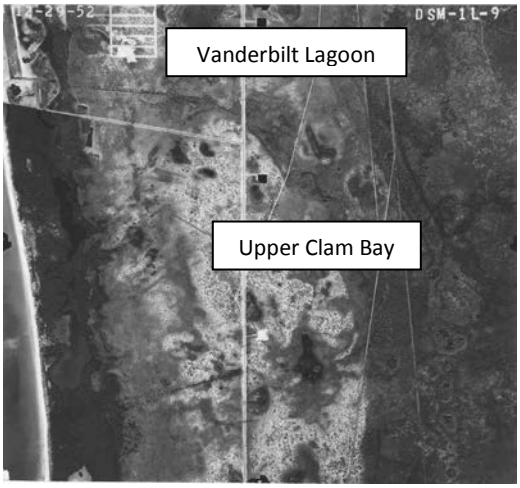
Appendix 1 – Timeline of Important Events within the Clam Bay NRPA and a List of Permits for Work Undertaken in and Around the Clam Bay NRPA

Timeline of Important Events Within the Clam Bay System

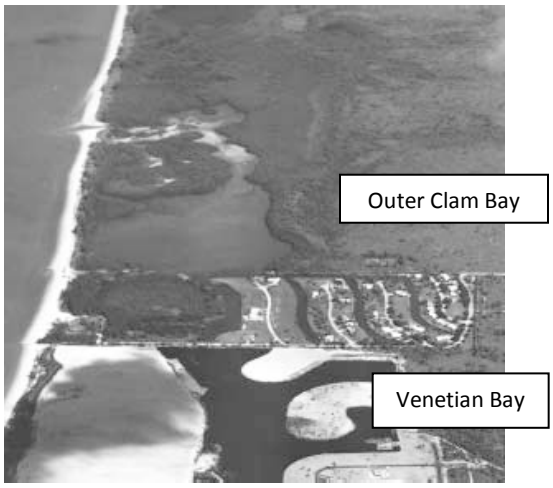
1920
A dirt road is built by Forest Walker running from the northeast to the south portion of Pelican Bay, a forerunner of US 41.

1952
Vanderbilt Beach Road is constructed, eventually severing connection with the Wiggins Pass system to the north.

1958
Construction of Seagate Drive is completed severing flow into and out of the mangrove swamps to the south. This area was subsequently dredged and excavated to become Venetian Bay.



Circa 1952 Aerial Photograph



Circa 1960 Aerial Photograph

Figure 2: Historic aerials

1972
Tri-County Engineering produces reports:

- An Ecological Study of the Clam Pass Complex, published by Humm & Rehm
- Hydrographic Investigation of the Clam Bay System

Coral Ridge-Collier Properties, Inc. (a partnership between Westinghouse and Collier Properties) acquires the property and initiates development of Pelican Bay.

1974
Pelican Bay Improvement District (PBID) is formed to manage common property in Pelican Bay and provide for long-term sustainable infrastructure.

1976
Three, bi-directional 24-inch culverts are placed under Seagate Drive to provide hydrologic connection to Venetian Bay.

The report "Environmental Assessment for Development Approval" is prepared for Pelican Bay.

Clam Pass closes and is mechanically dredged by dragline to re-open the entrance; no records of quantities or dredge limits are available.

1977
Pelican Bay PUD is approved, and construction commences.

1977-1979
Gee & Jensen Hydrographic Engineers conduct a series of tidal studies within the system and distribute "A Hydrographic Study Clam Bay System" in 1978.

1978
Tropical BioIndustries produces a report: Carbon Flows in portions of the Clam Pass estuarine system.

Ecological assessment work by Tropical BioIndustries for permitting of the northwest fill area notes a small area of stressed and dead mangroves close to Upper Clam Bay.

1979
An Environmental Assessment of the northwest fill area is distributed (Turrell, 1979).

Tropical BioIndustries produces biological reports:

- A comparative study of the water and carbon flows of Upper Clam Bay
- Invertebrate Population Studies in the vicinity of Upper Clam Bay

1981
Clam Pass closes and is mechanically dredged by dragline to re-open the entrance; no records of quantities or dredge limits are available.

WCI, the developers of Pelican Bay, transfers title to Clam Bay to Collier County with the stipulation that Clam Bay shall remain a conservation/preservation area in perpetuity.

1982
WCI deeds Clam Pass Park and Clam Bay to Collier County, and in accordance with the Pelican Bay PUD, requires the County to seek approval of WCI or its successors for any modifications to Clam Bay.

1983
Tropical BioIndustries produces biological reports:

- Fish populations of tidal ponds west of Clam Bay
- Populations of Melampus coffeus (Coffee bean snail) and Cerithidea scalariformis (Ladder hornsnail) west of upper Clam Bay.

1986
Collier County constructs a 2,900 foot boardwalk to provide access to the county park, south of Clam Pass.

1988
Clam Pass closes twice, first in the spring and again in the late fall after Tropical Storm Keith (November 23, 1988).

1989
Small areas of stressed and dying mangroves are noted by residents in the basin west of Upper Clam Bay and east of The Strand in Bay Colony. A Department of Natural Resources (DNR) interdepartmental memo highlights the cause of the stress as "the lack of adequate water circulation resulting from the closure of Clam Pass".

The first emergency dredging permit is received from DNR to re-open a clogged Clam Pass, following a memo by David Crewz to the DNR highlighting problems and danger if the Pass was not reopened.

Clam Pass is mechanically dredged to re-open. Approximately 700 cubic yards of material are removed from the mouth of the inlet and the south bend of the channel. Material is placed south of the Pass. Multiple closures of the inlet occur during the construction process.

1990
PBID becomes a dependent district of Collier County called the PBSD.

1992
The area of dead mangroves is reported to be 7 acres.

1994
Twenty acres of mangroves are reported dead.

1995
Clam Bay is approved by the BCC as Collier County's first NRPA (See NRPA boundary map on page 6 of this report).

Clam Pass closes following a winter storm event. An emergency dredging permit is issued allowing for the opening of the Pass, but no work farther back than 600 feet. Mechanical dredging is undertaken removing approximately 5,000 cubic yards of material from the entrance of the pass.

1996
Clam Pass closes following a winter storm event. Permits to open Clam Pass are received from the Florida Department of Environmental Protection (FDEP), formerly DNR, and US Army Corps of Engineers (USACE). Mechanical dredging is carried out at the entrance of the Pass.

Blasting and hand excavation to connect isolated waterbodies in Upper Clam Bay were permitted and completed in 1997.

Mangrove die-off area is estimated to be 50 acres.

1997
Clam Pass, on the verge of closing following a winter storm event, is mechanically dredged again under modification to the 1996 Permits. Interior portions of the flood shoal are dredged to station 6+10.

1998
Clam Pass is on the verge of closing again following a winter storm event. A mechanical maintenance dredging event is carried out under modification to the 1996 Permits. Interior portions of the flood shoal are dredged to station 6+10.

Ten-year permits are received from FDEP and USACE for dredging Clam Pass and the interior channels, including adjustments to the Seagate culverts and installation of hand dug channels throughout the system. Associated monitoring work and storm and freshwater studies are required.

1999
Dredging work associated with the CBRMP is implemented (managed by the PBSD) in the spring by Ludlum Construction Company. Hydraulic dredging of Cuts 1, 2, 3, and 4 (see Appendix 6 - Exhibits) are carried out. A 30 foot entrance cut is dredged.



A one way flap valve is installed on the Seagate culverts to allow flow from south to north.

Staff at The Conservancy of Southwest Florida commences a 3-5 year study of the mangroves, surface water level and elevation within the mangrove die-off area.

2000
Hurricane Gordon impacts the area with no inlet closure.

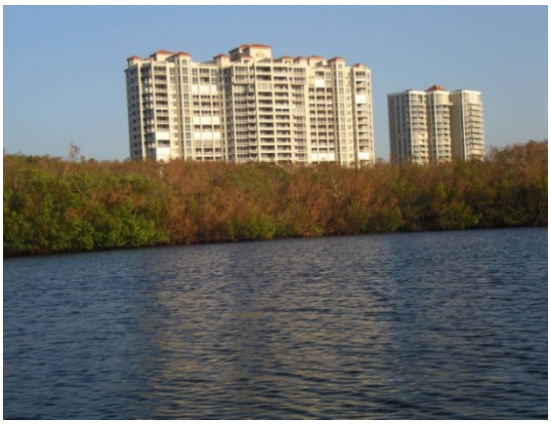
2002
Hydraulic maintenance dredging of Clam Pass flood shoals between stations 3+10 and 17+50 by the PBSD is completed to improve tidal circulation (see Appendix 6 - Exhibits). The entrance of the Pass is not dredged during this event.

Flap valves on the Seagate culvert are removed due to insufficient head differential causing them to act as plugs instead of valves.

Canoe trail markers are permitted and installed throughout the Clam Bay System.

2004
Hurricane Charley passes approximately 30 miles west of Clam Pass. A lot of sand is redistributed, but the Pass does not close. Extensive limb and leaf loss is documented within the mangrove forest.

2005
Hurricane Wilma comes ashore about 30 miles south of Clam Pass. More limb and leaf loss is noted. The Pass does not close.


Hurricane damaged mangroves along the bay in 2005


Same mangroves along the bay in 2007

2007
Hydraulic maintenance dredging of the Pass and entrance channel is conducted between Stations 0+00 and 18+00 (see Appendix 6 - Exhibits). The entrance to the Pass is dredged to an 80 foot width by Collier County Coastal Zone Management Dept. This dredging is conducted for sand for beach renourishment.

2008
Tropical Storm Fay comes ashore about 30 miles south of Clam Pass. The area receives over 10 inches of rainfall. The Pass is not affected.

2009
The 1998 FDEP and USACE permits for maintenance of the Pass expire after 1-year extensions.

2010
Permits are issued to continue maintenance of hand-dug flushing channels throughout the system.

2011
White mangrove die-off is observed in the central portion of the system and is found to be caused by a bark beetle infestation of trees that had suffered cold temperature stress.

A Benthic Habitat Assessment study is completed within the Clam Bay NRPA by the Conservancy of Southwest Florida. The study provides comprehensive mapping of benthic habitat compositions and distribution throughout the Clam Bay NRPA.

2012
Canoe trail markers and informational signage are permitted and installed throughout Clam Bay.

The mouth of Clam Pass moves to the north near the Pelican Bay Beach Store. The northern shoreline of the Pass is temporarily reinforced with the installation of concrete barriers.

Impacts from tropical storms Debby and Isaac, along with numerous winter storm fronts, cause the closure of the Pass.

2013
A single event mechanical dredge permit is acquired from the FDEP and USACE. The entrance cut is 45 feet, and the Pass is dredged between Station 0+00 and 10+00, limited by permit and equipment constraints. Beach-compatible material is placed north and south of the Pass above the mean high water line. Due to weather events the Pass is required to be opened again one week later.

Development of a new Management Plan is initiated through stakeholder input and multiple public meetings.

Timeline Specific to the Establishment of the Clam Bay NRPA

1976
Collier County Ordinance 76-30 zoned coastal areas environmentally sensitive lands as ST (Sensitive Treatment).

1977
Approval of the Pelican Bay PUD (Ordinance 77-18) by Collier County. The PUD identifies 98 acres of coastal mangrove wetlands to be filled in for development while preserving 570 acres of ST lands as the Pelican Bay Conservation Area (35 acres in the south and 5 acres in the north would become parks providing public beach access).

1981-82
Department of the Army Permit (79K-0282) authorizes the fill of the 78 acres of coastal wetlands (76 acres for residential development and 2 acres for public parking area). It requires 570 acres, including Upper, Inner, and Outer Clam Bays, and their adjacent wetlands to be conveyed to Collier County and to remain a conservation/preservation area in perpetuity for the use of the public. It also prohibites dredging Clam Pass except to keep it open to the Gulf of Mexico.

1988
The Pelican Bay Conservation Area (570 acres) is approved and recorded as FL-64P by Congress and becomes part of the Federal Coastal Barrier Resources System (CBRS).

1995
The BCC approves the County Natural Resources Department's recommendation to establish the County's first NRPA, stipulating that it would have the same boundaries as the Pelican Bay Conservation Area within the Pelican Bay PUD.

The Collier County Manatee Protection Plan is approved. It contains the recommendation to establish an "Idle Speed/No Wake" zone throughout the Clam Bay/Clam Pass System.

1996
Collier County Ordinance 96-16: "The Clam Bay System Water Safety and Vessel Control Ordinance" is approved. It establishes that the Clam Bay System is an "Idle Speed/No Wake" zone.

1998
The CBRMP is developed, implemented, and managed by the PBSD and their consultants.

FL Admin. Court Case No. 98-0324GM provided an interpretation that certain elements of the Collier County Growth Management Plan (Conservation and Coastal Management Element) require protection of habitats within NRPAs which support existing and potential uses by wildlife.

2008
Public Law 110-419 is adopted identifying the CBRS, Clam Pass Unit, FL-64P to be entirely located within the existing boundaries of the Clam Bay NRPA.

2013
Work begins on new Clam Bay NRPA Management Plan under the PBSD direction.

List of Permits for Work Undertaken in and around the Clam Bay NRPA

Eighteen years ago, Collier County processed a permit to dredge limited areas of Clam Pass to facilitate the movement of tidal water in and out of Clam Bay. The FDEP permit for this activity was issued on March 28, 1996 with the companion USACE permit being issued on April 2, 1996. The FDEP permit was modified on April 10, 1996 with the authorized work being undertaken and completed on April 17, 1996. The practical effect of implementing this Permit was to reopen the Pass, but it was clear that without a more comprehensive strategy, this effort, standing alone, would not revitalize the Clam Bay ecosystem.

A permit to improve the channel flow within defined areas of the Clam Bay system by a combination of blasting and hand excavation was issued on June 26, 1996. The work was undertaken and completed in two segments. The first channels were opened in August 1996, and the second channels were opened in November 1996. The results of these two initiatives were positive in that measurable improvements in tidal flow were discernible and with that have come improved conditions for natural re-vegetation.

A permit was issued on January 5, 1997 to construct a portable pump and pipe system as an interim measure to divert impounded freshwater within the Clam Bay system to the Gulf while a more permanent solution contemplated by the construction of an outfall structure was reviewed. This plan was never implemented and is no longer being considered. It envisioned two pumps that would be operational when the water surface elevation within Clam Bay exceeded a specified threshold. The Management Plan anticipated the direct discharge of excess water into the Gulf with the expectation that this system would augment the natural discharge through the tidal mechanism after severe storm events.

Subsequently, Collier County authorized the pursuit of a ten-year permit to allow the County, or its designee (which in this case was the Pelican Bay Services Division), to maintain Clam Pass in an open condition. The application, as filed, did not address any other issues affecting the operational characteristics of Clam Bay and essentially mirrored the 1996 Permit described in the first paragraph above. Agency comments and concerns which arose as part of the permit review led to the creation of the 1998 Clam Bay Restoration and Management Plan. The Management Plan addressed agency concerns at the time and included provisions for adding one-way flap gates to the Seagate culverts, dredging within three sections of the creek north of Clam Pass, a network of hand dug channels throughout the forest area, in addition to the dredging of the Pass. This permit was issued in 1998 and the Management Plan created in support of the permit has been the guiding document for the maintenance activities undertaken in the Clam Bay system since then.

Permit Details

South Florida Water Management District Surface Water Permit No.: 11-00065-S
Date of Issue: August 10, 1978
Expiration Date: Operational phase doesn't expire
Project Description: To construct and operate water management systems 1 and 2 serving 539 acres of residential lands discharging by westerly sheet flow to Inner, Outer, and Upper Clam Bays.

Department of Environmental Regulation Construction Permit/Certification No.: 11-50-3769
Date of Issue: May 23, 1979
Expiration Date: May 15, 1984
Project Description: To provide construction sites for residential development in a planned community by: placing approximately 700,000 cy of clean upland fill material onto approximately 94 plus acres of submerged lands of waters of the state landward of the line of mean high water.

Department of the Army Corps of Engineers Permit No.: 00754929
Date of Issue: November 18, 1981
Expiration Date: November 18, 1984
Project Description: This permitted the filling of 75± acres of mangrove wetlands north, east, and west of Upper Clam Bay and south of Vanderbilt Beach Road.

Department of Environmental Regulation Modification Permit No.: 11-50-3769
Date of Issue: December 23, 1981
Expiration Date: November 18, 1986
Project Description: This modification extended the expiration date of the permit to November 18, 1986.

Department of the Army Corps of Engineers Permit No.: 79K-0282
Date of Issue: August 2, 1983
Expiration Date: November 18, 1986
Project Description: This was an extension of the permit authorizing the filling of 75± acres of mangrove wetlands north, east, and west of Upper Clam Bay and south of Vanderbilt Beach Road, plus approximately 2 acres of mangroves at the existing Collier County beach access at Vanderbilt Beach Road. The request was reviewed, and no objections were raised to the proposed work schedule; therefore, the completion date of the permit was extended for 2 years until November 18, 1986.

South Florida Water Management Plan Modification of Surface Water Management Permit No.: 11-00065-S
Date of Issue: December 15, 1983
Expiration Date: Operational phase doesn't expire
Project Description: Approved modifications to 1.) Revise system V, drainage area 3; 2.) Construction and operation of water management system number VI.

Department of Environmental Regulation Permit/Certification No.: 110974055
Date of Issue: September 12, 1985
Expiration Date: September 11, 1987
Project Description: To construct approximately 2900 linear feet of 10' wide public access elevated boardwalk and pier with a 6' wide navigation access lift gate in Outer Clam Bay.

Department of the Army Corps of Engineers Permit No.: 86IPT-20328
Date of Issue: December 18, 1986
Expiration Date: December 18, 1991
Project Description: Discharge ±2.3 acres of clean fill to construct an access road.

Department of Environmental Regulation Modification Permit: 11-50-3769
Date of Issue: January 7, 1987
Expiration Date: December 18, 1991
Project Description: This permit modification extended the expiration date and reduced the amount of fill in the area extending south along the coastal edge from approximately 13 acres, as permitted, to 2.43 acres in order to construct a linear access road (for The Strand in Bay Colony).

Department of Environmental Protection Permit/Certification No.: 112659015
Date of Issue: March 14, 1995
Expiration Date: March 14, 2000
Project Description: Re-establish the connection between the Gulf of Mexico to the Clam Bay system, by dredging from the mouth of Clam Pass and spoiling the sand over an upland beach site.

Collier County Ordinance No.: 96-16
Date of Issue: April 9, 1996
Expiration Date: n/a
Project Description: To impose idle speed/no wake zones in the Clam Bay system.

Department of Environmental Protection Permit/Authorization No.: 0128463-001-JC
Date of Issue: July 6, 1998
Expiration Date: July 6, 2008
Project Description: This Permit authorized activities to improve the hydrodynamics of, and thus restore and manage, the Clam Bay ecosystem.

Department of the Army Corps of Engineers Permit No.: 199602789 (IP-CC)
Date of Issue: August 11, 1998
Expiration Date: July 8, 2008
Project Description: This Permit authorized the following works: 1.) Replacement of Seagate Drive Culverts and installation of one-way check valves on the culverts (pages 45-50 of the CBRMP); 2.) Clam Pass main channel dredging for Cuts 1, 2, 3 and 4 (pages 49-65 of the CBRMP); 3.) Excavation and maintenance of Interior Tidal Creeks (pages 65-71 of CBRMP).

Department of Environmental Protection Permit Modification for Permit No.: 0128463-001-JC
Date of Issue: February 16, 1999
Expiration Date: July 6, 2008
Project Description: Authorize minor revisions to the mangrove trimming procedures pursuant to site verification.

Department of the Army Corps of Engineers Modification for Permit No.: 199602789 (IP-CC)
Date of Issue: February 26, 1999
Expiration Date: July 8, 2008
Project Description: This application requested modification to: 1.) discharge dredge material from Cut #1 to new disposal area identified as an upland parking area; 2.) increase the width of channel cut #4; 3.) remove native vegetation and excavate a portion of upland Disposal Site #2; 4.) remove native vegetation and excavate a portion of upland Disposal Site #3. The proposed modification to widen channel Cut #4 is to be done without any additional seagrass impacts. Based on the review and coordination with Fish and Wildlife Service (FWS), the permit was modified in accordance with these requests.

Department of Environmental Protection Permit Modification for Permit No.: 0128463-001-JC
Date of Issue: May 19, 1999
Expiration Date: May 28, 1999
Project Description: Re-grade beach fill material during the marine turtle nesting season to remove pockets of fine silty material and to remove an escarpment which may interfere with nesting marine turtles.

Florida Fish and Wildlife Conservation Commission File No.: 2003-0511-016BS for Permit No.: CO-016
Date of Issue: March 24, 2000
Expiration Date: n/a
Project Description: This Permit granted approval for placement of canoe trail markers in Clam Bay.

Department of the Army Corps of Engineers for Permit No.: 200001076 (NW-EF)
Date of Issue: April 13, 2000
Expiration Date: February 11, 2002
Project Description: Approved the installation of 32 waterway markers for a canoe trail in the Clam Bay System.

Department of the Army Corps of Engineers modification for Permit no.: 199602789 (IP-CC)
Date of Issue: May 5, 2000
Expiration Date: July 8, 2008
Project Description: This application requested modifications to the monitoring and reporting schedule reference on page 93 (Biological Monitoring) of DA Permit (CBRMP). The request was to submit annual reports instead of semi-annual reports. The permit was modified as requested.

Department of Environmental Protection Permit No.: CO-732
Date of Issue: October 25, 2002
Expiration Date: October 25, 2003
Project Description: Perform dune and beach restoration, and plant salt-tolerant native dune vegetation in association with interim maintenance dredging event.

Department of the Army Corps of Engineers Permit No.: 199602789 (IP-CC) Extension
Date of Issue: May 8, 2008
Expiration Date: July 8, 2009
Project Description: This Permit authorized the extension of the expiration date for a period of one year.

Department of Environmental Protection Permit/Extension No.: 0128463-001-JC
Date of Issue: June 5, 2008
Expiration Date: July 6, 2009
Project Description: This modification extends the expiration date for a period of one year.

Department of Environmental Protection Permit No.: 11-0128463-005
Date of Issue: December 17, 2010
Expiration Date: December 17, 2015
Project Description: Continue maintenance activities to the hand-dug channels and mangrove trimming in the Clam Bay system originally permitted under Permit No. 0128463-001-JC.

Department of the Army Corps of Engineers Permit No.: SAJ-1996-02789 (IP-LAE)
Date of Issue: February 8, 2011
Expiration Date: February 8, 2021
Project Description: Continue maintenance activities to the hand-dug channels and mangrove trimming in the Clam Bay system originally permitted under Permit No. 1996-02789 (IP-CC)

Department of Environmental Protection Permit No.: 11-0295193-004
Date of Issue: November 2, 2011
Expiration Date: November 2, 2016
Project Description: Install 32 canoe trail markers and informational signage.

Department of Environmental Protection Permit No.: 0296087-001-JC
Date of Issue: August 14, 2012
Expiration Date: August 14, 2022
Project Description: Restore the alignment of Clam Pass to the previously approved location and conduct periodic maintenance dredging of a portion of Clam Pass in order to maintain tidal exchange between Clam Bay and the Gulf of Mexico.

United States Fish and Wildlife Service Biological Opinion Activity Code No: 41420-2010-CPA-0395
Date of Issue: February 22, 2013
Expiration Date: n/a
Project Description: FWS analysis of the potential effects of the dredging of the Pass on the threatened piping plover (*Charadrias melodus*), threatened loggerhead sea turtle (*Caretta caretta*), endangered hawksbill (*Eretmochelys imbricate*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles, and the endangered West Indian Manatee *Trichechus manatus*).

Department of the Army Corps of Engineers Permit No.: SAJ-1996-02789 (NWP-WDD)
Date of Issue: February 28, 2013
Expiration Date: March 18, 2017
Project Description: Dredging of Clam Pass and tidal creek to restore tidal exchange into Clam Bay.

Department of Environmental Protection Permit Modification to Permit No.: 0296087-002-JN
Date of Issue: March 1, 2013
Expiration Date: August 14, 2022
Project Description: Modification of August 2012 permit to re-open Clam Pass by mechanical dredging of the Pass and flood shoal areas.

APPENDIX 2 – A RECENT HISTORY OF MANGROVE MANAGEMENT IN CLAM BAY

Appendix 2 - Recent History of Mangrove Management in Clam Bay

According to detailed field surveys performed in the early 1970's mangrove tree densities within the Clam Bay NRPA ranged from 726 to 7,580 per acre and maximum canopy height was estimated at 39 feet. Within the black mangrove dominated basin forest west of Upper Clam Bay, 16% of the black mangrove trees were reported as dead and others as severely stressed; evidenced by a high incidence of dead limbs on trees of all sizes (Tropical BioIndustries and Gee and Jenson, 1978).

Humm & Rehm (1972) indicated that some mangrove areas near Upper Clam Bay were under stress. Oyster bars in the channel restricted tidal flow to the upper reaches of Inner Clam Bay except during high tide. Oyster bars between Inner and Outer Clam Bay restricted water flow to the extent that Upper and Inner Clam Bays were considered non-tidal. Humm & Rehm in 1972 concluded that productivity of the estuary was reduced due to low salinity preventing development of seagrasses, which in turn killed intertidal algae and consequently stressed the mangroves. Widespread grazing of mangrove roots by fish and radular snails in Upper Clam Bay resulted in the destruction of the mangroves by undercutting the shoreline and spread of disease.

In 1982, west of Upper Clam Bay intermittent ponds were connected by a series of man-made ditches in an attempt to increase tidal flow. Subsequent studies indicated that fish populations increased in diversity, however tidal influence only extended to an area 150 feet from the pond margins (Heald 1983).The lagoon ponds of Outer, Inner and Upper Clam Bay are relatively viable, although evidence of slow deterioration in the mangroves around Inner Clam Bay has been documented for over twenty years (Heald et al. 1978, Benedict, 1984). In 1984, the development of Pelican Bay was predicted to have adverse impact on the northern areas of this system since a large coastal bay mangrove forest is present along the margin of this area (Benedict, 1984).

Dead and stressed mangroves were again reported for Clam Bay in 1989 when David W. Crewz, a biologist with the Florida Marine Research Institute, was asked to inspect Clam Pass Park by Mary Ellen Hawkins, then a Collier County representative to the legislature (letter to Don Duden dated April 3, 1989). Mr. Crewz concluded that the "dead and stressed mangroves were caused by lack of adequate water circulation resulting from the closure of Clam Pass.... allowing toxin and salt buildup."

Westinghouse Communities, Inc. employees in February 1992 noted additional mangrove die-offs north of Clam Pass Park on the west side of Upper Clam Bay. This area was inspected by Dr. Eric Heald, a consultant to WCI in April 1992. He hypothesized that the die-offs were probably due to hypersalinity, although 1991 was an above average rainfall year. The same conclusion was reached by Robin Lewis of Lewis Environmental Services, Inc., after an inspection in May 1994. At this time

the die-off area was approximately 6 acres. A widespread mortality of mangroves in Florida Bay was also reported in the summer of 1991 (Yarboro et al. 1994), and it was attributed, in part, to natural drought conditions and unusual tidal inundation patterns.

After above average rainfall in the summer of 1995, The Conservancy of Southwest Florida, Inc.'s staff and residents in Pelican Bay reported additional mangrove deaths which continued through 1995 and 1996. The total area of the die-off through July 1999 was around 50 acres.

The death of trees occurred around hyper saline ponds and is consistent with conditions caused by periods of excessive inundation of freshwater followed by periods of continuous dry down, particularly where the mechanism for flushing is impaired. (Lugo, et. al. 1976). During the period immediately preceding the observed die-off and after, Clam Bay received record amounts of rainfall. This rainfall, combined with an admittedly impaired circulation system, encroaching development of the Strand community to the west, and intermittent pass closure, resulted in water levels that were high enough for a long enough period of time to adversely impact the mangroves (CBRMP 1998).

The die-off galvanized the Pelican Bay community into action. Dissatisfied with the response of county and state officials to the degradation of the mangroves, a group of residents formed a grass-roots campaign which led to the creation of the Mangrove Action Group (MAG). MAG lobbied the PBSD and WCI to undertake the restoration on their own and this collaboration eventually resulted in the creation of Clam Bay Restoration and Management Plan and the 10-year permits which allowed the restoration activities to be undertaken.

The Clam Bay Restoration and Management Plan was finalized in 1998 to address the mangrove die-off. In assessing a variety of alternatives to the restoration of Clam Bay, the original need was not so much to restore the system to a mangrove forest (although that remained the primary goal) as it was to stabilize and restore the system as a thriving natural resource. This was accomplished through the dredging of Clam Pass and portions of the interior channels within the system, as well as construction of a network of hand-dug flushing channels throughout the original die-off area and a few other areas that were exhibiting stress. It was recognized that with changes to naturally induced flushing rates and hydrological regimes the mangroves would likely adjust by altering zonation patterns, species compositions, rates of growth and mortality, etc. (CBRMP 1998).

Summary of annual monitoring by Turrell, Hall & Associates, Inc. and Lewis Environmental Services since the implementation of the CBRMP

Provided below is a brief, annual summary of the overall health of the Clam Bay mangrove system. This recent history of the mangrove management spans from 1999 to 2013. These summaries include key events, such as major weather occurrences, flushing

channel construction and maintenance, as well as documentation of areas of improvement and calculations of die-off acreages.

1999

An estimate of 42.67 acres of dead or stressed mangroves was provided by Turrell, Hall & Associates, Inc. consisting of the main basin area adjacent to The Strand and several, smaller, discrete areas possibly attributed to lightning strikes or where slight depressional areas allow ponding and salinity/oxygen stress. Little change was noted later in the summer at the time-zero survey although most mangrove plots showed significant standing water which could be a function of the dredging work as well as tides and rains around the survey time.



The main die-off area (NW Clam Bay, adjacent to The Strand) 1999

2000

A full year after the dredging work no dramatic changes were apparent. Some mangrove plots had declined while others appeared in slightly better health. Seedling recruitment was good throughout. Heavy rains in late 1999 were thought to have contributed to a dieback in groundcover noted by Lewis Environmental Services. No new mangrove die-offs or expansion of stressed areas were noted. Work planned for 2001 included the experimental Riley encasement method for mangrove propagules.



Main die-off area 2000



Riley encasements and flushing cut

2001

Mapping of the die-off area was repeated and estimated to have increased in size, spreading to the north. It encompassed just under 50 acres. Additionally, a few new stressed areas were identified through aerial photographs. Individual plots showed some additional tree losses but consistent seedling recruitment. Channel construction in the main die-off area and close to Plot 7 is thought to have contributed to the recovery process underway and illustrated by extensive *Batis* and dramatic seedling recruitment.

The observations generated sufficient concern amongst project managers in 2001 that a suggestion for additional flushing channel construction in the die off area was made.



Main die-off area 2001

2002

Additional flushing channels were constructed in the die-off area during late 2001. The 2002 surveys show that these efforts appeared to have been successful with a reduction of 12 acres in the die-off area. *Batis* growth and seedling recruitment was good. The problem of exotic vegetation growth in many areas was highlighted, and two new diffuse areas of stressed trees were identified. The presence of standing water and bacterial mats suggested lack of flushing was responsible. The one-way culverts installed at Seagate, thought to have reduced tidal exchange in Outer Clam Bay, were removed in October to determine whether tidal exchange between Venetian Bay and Outer Clam Bay could be achieved without affecting Clam Pass.



Main die-off area 2002 with notable re-growth

2003

Stressed areas identified in 2002 were revisited, and no changes were noted in 2003. One of the aerially depicted mangrove stress locations was found, upon groundtruthing, to be actually an infestation of exotic plant species. A reduction in the calculated die-off area to just over 17 acres total was significant. 14 acres in this main die-off region was now classified as recovering.



Main die-off area 2003

2004

Die-off acreage was estimated at 18 acres total in 2004, with the addition of a new area adjacent to the Contessa condominium building in Bay Colony. Several new small lightning strike areas were noted throughout the system. Plot 7 continues to show the most dramatic change. Most exhibited slow change in existing tree number, some losses, some growth and size-class change, but consistent seedling recruitment. Storm events in 2004 (Charlie, Frances, Ivan, and Jeanne) had minimal effects with some leaf loss and limb breakage. Additional flushing channels were constructed during dry the season of this year. Water level monitors put in place last year were removed due to repeated equipment failures.



Main die-off area 2004

2005

Several stressed areas were noted to be recovering this year including the area adjacent to the Contessa building where a drainage channel was in need of maintenance and clearing, work which alleviated the problems. A new die-off area was identified near the County boardwalk and it is suggested that clogging of channels due to Hurricane Charley may be responsible. Total die-off acreage in 2005 is estimated at 24.7 acres. Plot 7 and Plot 8 continue to show significant re-growth.

Hurricane Wilma in October of 2005 caused considerable leaf loss, limb breakage and leaf browning throughout Clam Bay. The constructed flushing channels alleviated extensive ponding that could have occurred, and the system weathered the storm well. Work completed in 2005 included the last component in flushing channel construction. In total, approximately 13 miles of hand-dug channels were installed since 1999.



Main die-off area 2005

2006

Stress damage from the 2005 hurricane season necessitated the need for a division of the classification system that was used to define the status of the mangroves in the system. Stressed mangrove zones were now classified as “die-off area” for mangroves stressed by some factor other than storm events or “area of concern” for mangroves stressed by storm events. It was estimated in 2006 that 23 acres of recovery, 12.3 acres of stressed areas of concern and 23.4 acres of die-off area were present. The total area of stressed mangroves were 74.7 acres. Since the last mangrove channels were dug in 2005 and dredging work continues when needed, most of the monitoring plots have shown improvements and there was a significant reduction of die-off in the original locale.



Main die-off area 2006

2007

The storm damage of 2005 added a level of difficulty to subsequent classification of areas within the system. Extensive defoliation and falling of individual trees meant that areas that could be termed stressed by the flow issues thought to have been responsible for the original die-off in Clam Bay were in fact affected by the high winds and storm surge. Approximately 4.9 acres of formerly classified 'die off' area have been reclassified to 'recovered' this year. Stressed areas of concern that are likely not related to storm damage totaled about 15 acres while areas of concern that we suspect are due to the storm events were estimated at about 25 acres. An additional 20 acres within the original die off area had not yet fully recovered and was also included in this category. A total of 10.6 acres of mangroves were still considered dead, a significant reduction from the original die-off of over 50 acres in the late 1990's. This brings the total aerial estimate of mangroves that are not at optimum health to be about 70 acres.



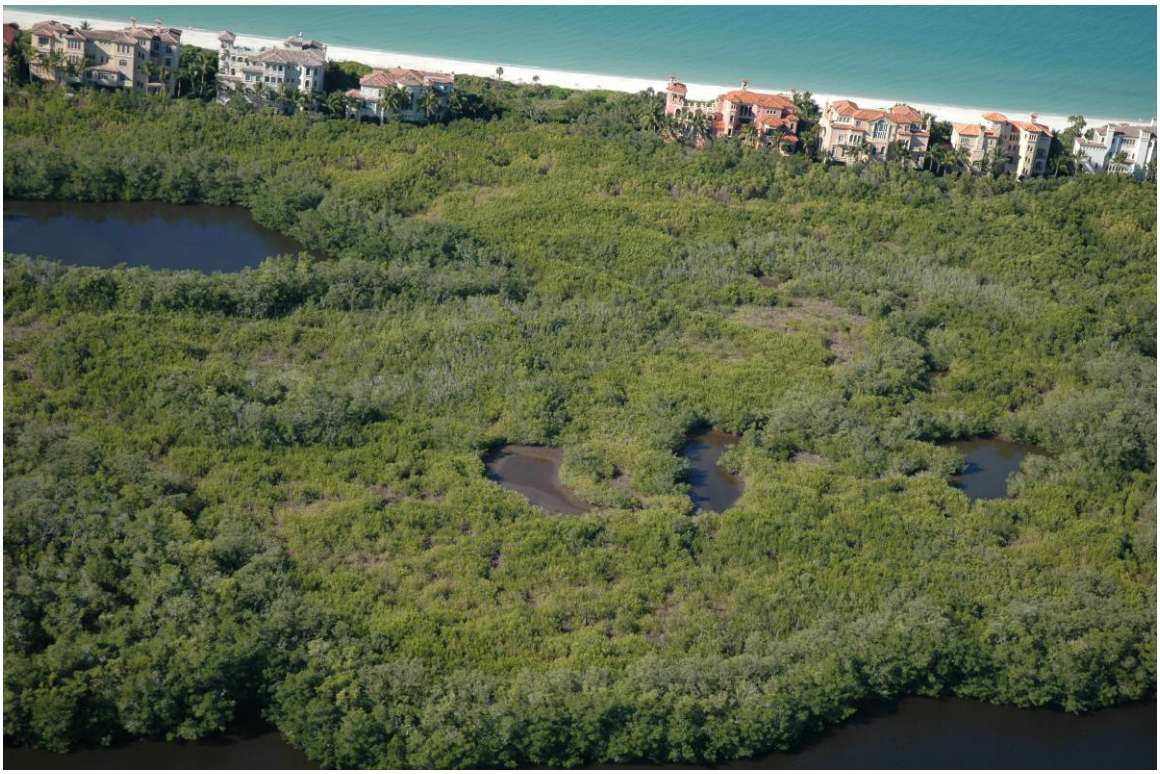
Main die-off area 2007

2008

The 2008 monitoring report was the final report associated with the original 1998 restoration permits. Effects of the storms of 2005 still added a level of difficulty to the classification of areas within the system. While the defoliation associated with the storms had mostly recovered, falling debris affected several of the monitoring plots throughout the system.

Approximately 35.4 acres of forest area have been removed from the die-off classification since the implementation of the project. Stressed areas of concern that may still be related to storm damage or other factors (such as ponding or drying) added up to about 7.1 acres. Areas throughout the system that have not yet fully recovered but that have flushing channels and have shown marked increases in mangrove recruitment and new growth have been removed from this category (approx. 20 acres).

A total of 7.3 acres of mangroves were still considered dead. This included three main areas: the initial die-off area east of the Strand where about 5.5 acres were still dead, the damage from a tornado in the extreme north of the system accounted for about 0.8 acres, and the Hurricane Charley damage that resulted in a tidal restriction just south of the Pass accounted for about 0.75 acres. Several lightening strikes and small discrete die-offs spread throughout the estuary made up the remainder of the die-off acreage.



East of the Strand Die-off area, 2008

2010

Even though the permit requirement for monitoring reports ended with the expiration of the 1998 permits, the PBSD continued to monitor the mangrove health within Clam Bay and document the positive results within the mangrove forest. Exotic eradication activities were also continued to allow for natural regeneration of mangroves observed elsewhere in the system.

Construction of the last component of the flushing channels was completed in the 2005-06 season. Inspection of these flushing cuts this year showed that they were still operating as designed and contributed to the continued growth of new mangroves within the system.

Stress in mangrove forest areas was still apparent, although in several areas this may have been attributable to storm damage or to frost damage brought about by a couple of very cold temperature nights. The spectacular recruitment of white mangrove seedlings (8 to 10 feet tall saplings) throughout the original die-off area is testament to the efforts undertaken with the initial dredging. That work was considered a success.



Main die-off area 2010

2011 - 2012

An infestation of boring beetles was discovered in the early months of 2011. Observations within the system and research into the life habits of many boring beetles led to the conclusion that white mangroves stressed by sustained cold temperatures in December 2010 and January 2011 were most susceptible to the beetle attack. Cold stress reduced the abilities of these trees to fight off the boring activities and many trees succumbed to them. Yellowing leaves, leaf drop, and eventual death of the tree was the result. The dead trees were easily visible in the rooftop photos taken periodically from the Grosvenor and Montenero condominiums. Efforts to hatch beetle larva led to the identification of at least two species, a round-headed (Longhorned beetles) and a flat-headed borer (Metallic beetles). No further loss of trees was documented after 2012 as a result of the borers.



White Mangroves affected by cold and borers



Borer damage to stressed tree

2013

The lack of harsh weather, hurricanes or freezing temperatures over the past year seemed to have allowed the areas impacted by the boring beetles to begin to recover. A total of 4.02 acres of mangroves are still considered dead or stressed, a significant reduction from the original die-off of over 50 acres in the late 1990's. Typical flushing channel maintenance was conducted to ensure that the channels were operating as designed and continue contributing to the growth of new mangroves within the system.



Main die-off area 2013



In 1999, a total of twelve plots were established throughout the Clam Bay system, in areas that provided diversity in terms of substrate, hydrology, species, topography and tree condition (dead, stressed or alive) and are being monitored annually. A gradsect stratified random sampling regime was employed to establish the 12 plots in the spring of 1999.

Plots 2, 3, 6 and 11 were located in mangrove die-off areas. Plots 5, 8, 9 and 12 were in stressed mangrove areas. Plots 1, 4, 7 and 10 were located in mangrove areas that were relatively healthy.

Three out of the 4 plots originally located in die-off areas, had signs of recovery following restoration and have been reclassified as stressed. These three plots began showing signs of recovery within five years of Collier County and the PBSD's restoration project. Forest recovery in these emerging mangrove areas was only setback slightly by natural disturbances, as the storms had less effect on young supple trees present in these plots. Only one plot which started off classified as a die-off, still remains in a relatively similar state 14 years later.

In the 1980's, Plot 2 was a very old mature black mangrove forest and by 1995 was completely wiped out. Plot 2 initially showed signs of recovery but had a setback in 1999-2000, when 237 of the 238 white and red mangrove seedlings died. The County and the PBSD responded by installing hand-dug channels in the area to drain off standing water and by 2003 mangrove seedling recruitment into the area commenced again. Plot 2 has shown significant improvement as a result of restoration activities. Freshwater impoundment has decreased and the plot gradually filled up with white mangroves. Numbers have peaked and then receded as competition for resources ensued. Today this plot is showing the beginnings of a shift in mangrove species as more red and black mangroves have become established. Since the hand dug channels were put in to the west of plot 2 and the topography slopes downward to the east into this plot, there is a tendency for standing water to accumulate during heavy rains. The questions now are

how saturated the soil will become, how heavy the rainfall and runoff is and how long it takes to recede. The answers to these questions will play a significant role in whether or not this particular area will continue to recover.

Plot 3 2012



Plot 3 has shown the most significant improvement as a result of restoration and is an excellent example of a die-off due to development and altered hydrology whose demise can be reversed by abating flood water levels and retention periods. Plot 3 started off dead as a doornail in the spring of 1998 and within two years was flooded with white mangrove seedlings (over 2500 at one point), some of which are now trees and by 2003 was recruiting red mangrove seedlings. Today, some red seedlings have attained tree status and are slowly outcompeting the young white mangrove trees over time. This plot exemplifies the process of mangrove regeneration with basal area and canopy cover steadily increasing overtime. First, the area was naturally seeded with white mangroves. White mangroves acted as a pioneer species invading the disturbed areas. Since white mangroves grow quickly, putting most of their energy into shooting upward (attaining tree height sometimes within 6 months), tons of recruits inhabited this plot appearing as a multitude of thin tall stems with a few leaves. The presence of so many white mangroves within a small area causes the individual trees and seedlings to show signs of stress, (approximately 60% as of 2003) due to competition for space and resources. The taller and healthier white mangroves quickly outcompete their siblings and recruitment drops and mortality increases. In 2003, this plot began to show the early signs of "succession" as red mangrove seedlings are becoming established in the area. Red mangroves grow much slower as they put the majority of their energy into their roots systems and then develop thick stems and a more bush like appearance and slowly inch their way up to treehood. The current status of an abundance of white trees and seedlings is perhaps paving the way for subsequent changes to a red mangrove dominated area and perhaps even overtime a reemergence of the original black mangrove forest that was present prior to the die-off.

Plot 11, like plot 3, in the spring of 1999, was almost barren and overtime has successfully recruited both white mangrove seedlings and trees. Actual numbers in plot 11 were not as impressive as in plot 3 as forest recovery is occurring at a slower pace. Slowly white mangrove recruitment has shifted to red and black mangrove propagule recruitment. Heavy white mangrove mortality in 2006, due in part to Hurricane Wilma, lessened as seedling recruitment numbers leveled off. White mangroves are currently the dominant species.

Plot 6 never got a chance to grow up; it is continually subjected to tidal surges, which naturally keeps this area in check. Dredging events tend to exacerbate mangrove washout as the tidal surge velocity often increases dramatically after a dredging event. More than

50% of the individual trees and seedlings are in a constant state of stress and this area remains unchanged, still classified as a die-off area.

Plots 5, 8, 9 and 12 were initially classified as stressed areas prior to restoration and continue to be classified as stressed after 14 years post-restoration. Plot 5 remains in a state of arrested development. Tree mortality over the years is similar and successful recruitment of mangroves is very slow and consists primarily of red mangroves. In Plot 8 has regressed to an earlier stage as mature red mangrove trees died and recruitment shifted to primarily white mangroves after Hurricane Wilma. The forest has shifted from a more mature grove to a young developing forest, reflected in lower average DBH and a young white mangrove dominated plot.


Plot 8 2007

In plot 9, basal area remained fairly consistent throughout the early periods of monitoring, primarily due to the existence of a few mature black mangrove trees. Approximately 40% of the remaining trees showed visible signs of stress after 5 years of monitoring and some trees have actually been knocked over by nearby construction debris. Development pressure from the surrounding residential neighborhood contributed to the death of 17 trees. This plot suffered damage from Hurricane Wilma. As a result the canopy opened up and high white mangrove recruitment occurred. Plot 9 regressed to a younger stage of development evident in overall lower average DBH and the higher numbers of white mangrove trees becoming established in this plot. This plot also has high fresh water inflow as evident in the establishment of freshwater ferns within the area.

Plot 12 2003



In plot 12, freshwater plants are fast replacing the mangroves. Seedling recruitment is practically nonexistent and mangrove mortality is higher than recruitment rates. This plot is in a steady state of decline reflected in the plethora of freshwater vegetation. This area is headed toward total mangrove depletion unless fresh water inflows are alleviated to stem the tide of freshwater immigrants.

Plots 1, 4, 7 and 10, initially classified as relatively healthy have been downgraded to a stressed condition. Plot 1 was located within a very old mature black mangrove forest. Hurricane Wilma hit this area particularly hard as a tornado touched down in center of the plot devastating it. Since the hurricane, Plot 1 has been inundated and has not successfully shown signs of recovery. There has been a recent attempt at restoration to abate inundation in this area that will need to be evaluated overtime.



Plot 4 was a relatively healthy red mangrove dominated area until 2001, when the trees began to die of an infestation of *Cytospora rhizophorae*, which caused the death 40 of the 100 red mangrove trees in this plot. *Cytospora rhizophorae* is a fungus that attacks trees that are already stressed. The outbreak in Plot 4 lasted for approximately 5 years and recovery has been slow. It was lucky that this fungus did not spread throughout the Clam Bay system as this could have been devastating to the mangroves if this infestation had run unchecked. Plot 7 during the early years of monitoring was a relatively healthy plot of black and red mangroves. There has been minimal mortality in this plot, but over time the canopy opened up, after Hurricane Wilma, allowing an influx of young red mangrove tress. This plot is only slightly stressed today and the canopy appears to be filling in over time.



Channel cut through Plot 10. Note prop roots have been severed during construction and a horizontal black mangrove tree. 2008

Plot 10 was a relatively healthy mature grove of black and red mangroves during the early years of this study. A channel was placed through this Plot 10 to drain water out of a die-off area located to the west. Installation of the channel damaged the root system of adjacent mature mangroves. This caused the trees to fall over during Hurricane Wilma due to increased instability, since similar trees near this plot, but with intact root systems easily weathered the storm. Today, Plot 10 is stressed and attempting to recover as white seedlings and trees are being recruited.



The channels increased tidal flushing and successfully removed a substantial amount of standing freshwater from the die-off areas. As water levels subsided, the die-off areas were again suitable for mangrove In the interim, between the baseline assessment and 2013, several severe weather events including Hurricane Wilma (2005), Tropical Storm Fay (2008) and an extended cold snap (2010) caused additional damage to the mangroves. In Clam Bay, the larger more mature trees in plots 1, 7, 8, 9, 10 and 12 were more impacted than the younger trees in plots 2, 3, 4, 5, 6, and 11. Since gaps in the canopy were created during Hurricane Wilma and Tropical

Storm Fay it was expected that the maturity of the forest in that area would be forced to revert to an earlier stage, and cause a subsequent rise in mangrove recruitment.

After the cold snap in the winter of 2010, some parts of the Clam Bay system became infested with boring beetles. The presence of wood boring beetles, (xylovores) are still of some concern. Some beetle species feed on only dead trees. However, other species feed on living trees and can become problematic if infected rates substantially increase and tree mortality rates increase as a result.

Mortality caused by inundation is still of concern in the Clam Bay mangrove system, given its previous history of mangrove die-offs caused by altered hydrology. Given that since 2005 there has been an extended period of drought, vigilance will be necessary especially during summers with higher than average rainfall to make certain that the hydrology is not being impeded. Overall, this mangrove system has improved in the sense that the die-off areas present in 1999 have been greatly diminished. However, weather events, disease and other stressors have impacted the mangroves as well. A number of plots that were relatively healthy in 1999 are now stressed in 2013 due to either natural or anthropogenic stressors. Mangrove trees can live for hundreds of years, yet it is evident that even in this short period of annual monitoring that many changes have occurred within the forest. Some of these changes have been favorable such as the restoration of the die-off area. Other changes have been unfavorable, such as increased tidal surges from dredging which caused some areas to be stressed or die. Therefore, it is critical to continue annual monitoring within this system to spot problems early, in hopes of curtailing large-scale die-offs in the future.

APPENDIX 3 – A RECENT HISTORY OF SEAGRASS PRESENCE IN CLAM BAY

Appendix 3 - Recent History of Seagrass presence in Clam Bay

Reports of field surveys from the early to mid-1970's document the presence of seagrasses within the Clam Bay NRPA but do not give any estimation of coverage or densities within the system. It is noted that seagrasses are present only in Outer Clam Bay, and there is some hypothesizing that the lack of seagrasses in Inner and Upper Clam Bays is the result of lower salinity levels and lack of water exchange with the Gulf. (Heald, 1972, Tropical BioIndustries and Gee and Jenson, 1978).

The Collier County Department of Natural Resources produced an analysis of the seagrasses and benthic infauna in Clam Bay in 1987. In this report it is stated that a 15m x 15m plot encompassed most of the grass beds in Clam Bay. The seagrasses were described as monospecific shoal grass seagrass beds located on the east side of the waterway between the Pass and Outer Clam Bay, much in the same location of seagrass beds which exist today.

A DNR memorandum produced by David Crewz in 1989 also mentions "some seagrass and algal beds" being present in Outer Clam Bay but again offers no information on location, aerial extent, or densities.

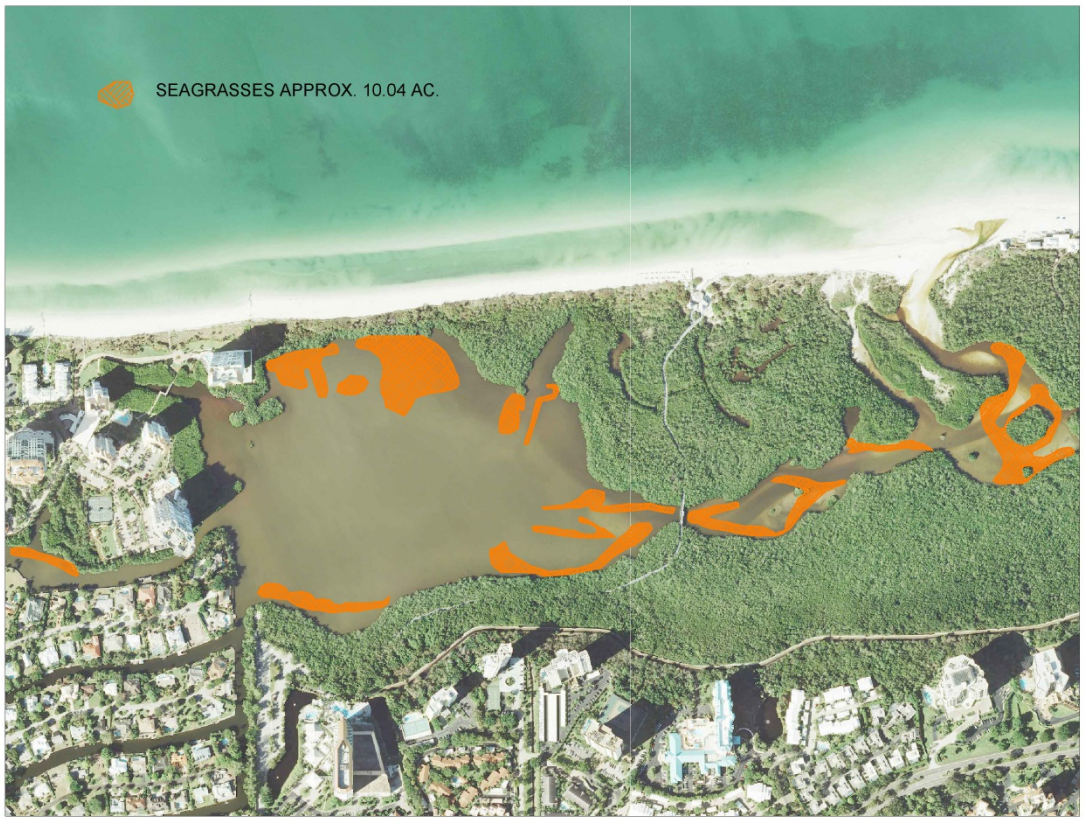
The 1991 Collier County Seagrass Protection Plan states that "Outer Clam Bay contains one of the densest and most extensive seagrass beds in Collier County," though it does not quantify aerial extent or density within the report. The dominant species was turtle grass in contrast to shoal grass, which was reported as the dominant seagrass feature by Devlin et al. in 1987. This shift in dominant seagrass species could indicate that the flushing rates increased allowing turtle grass to dominate, since this species prefers clearer water and higher salinity than shoal grass (Coastal Zone Management Plan, 1991). An exhibit associated with the report shows the entirety of Outer Clam Bay from the Pass to the Seagate culverts as seagrasses (almost 60 acres).

A 1994 report documenting conditions in the proposed Clam Bay Natural Resources Protection Area by the Collier County Environmental Services Division documented that seagrass coverage in Outer Clam Bay was approximately 10 acres.

In 2007, PBS&J conducted a seagrass assessment in Outer Clam Bay for the Collier County Coastal Zone Management Department. Of the 30 randomly selected sampling sites observed, seagrasses were found in 13 sites and consisted paddlegrass except for one sprig of turtle grass. No conversion to an acreage estimate was made in this report. At the locations where seagrasses were observed, the estimated density relative to bottom coverage was between 5 and 25 percent.

Annual Estimates of Seagrass Coverage since implementation of CBRMP

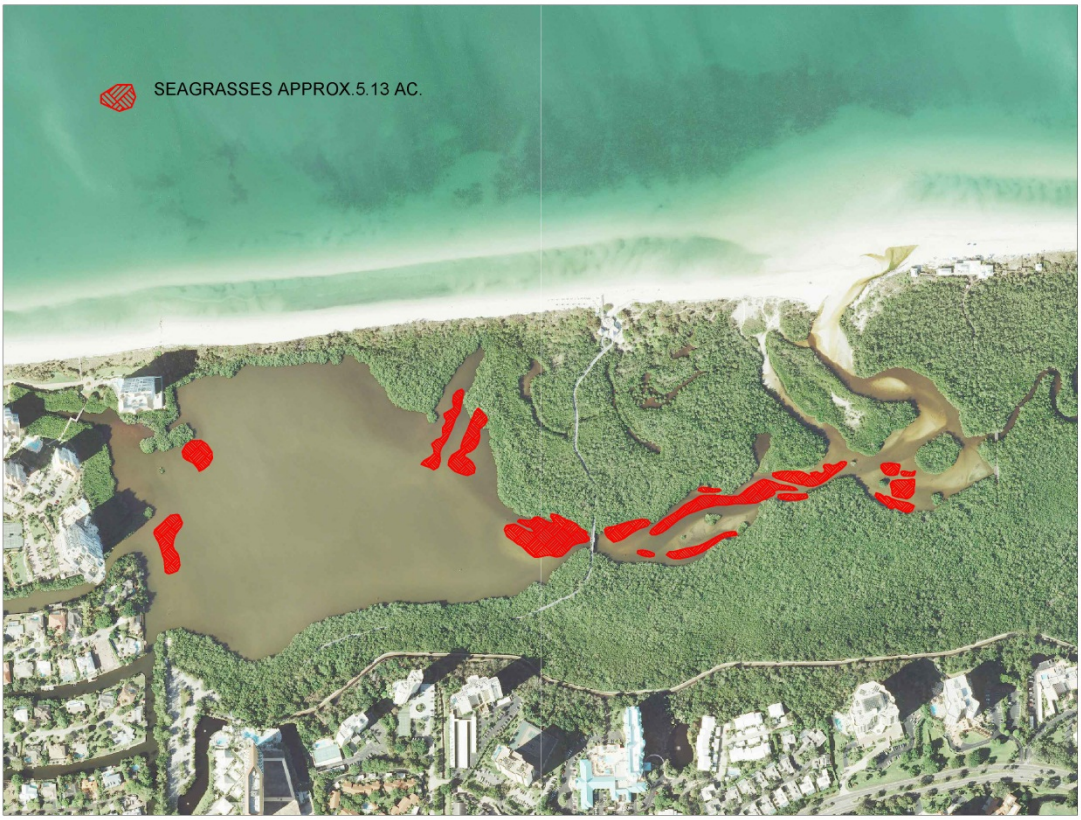
The following annual summaries provide general observations of the presence of seagrasses within Outer Clam Bay since the implementation of the Clam Bay Restoration and Management Plan.



Approximation of 1994 Seagrass Coverage

1999

Prior to the initial dredging associated with the 1998 Clam Bay Restoration and Management Plan, seagrass acreage was estimated at 5.13 acres, and restricted to Outer Clam Bay and the channel leading to Clam Pass.



1999 Seagrass Coverage

2000 – 2004

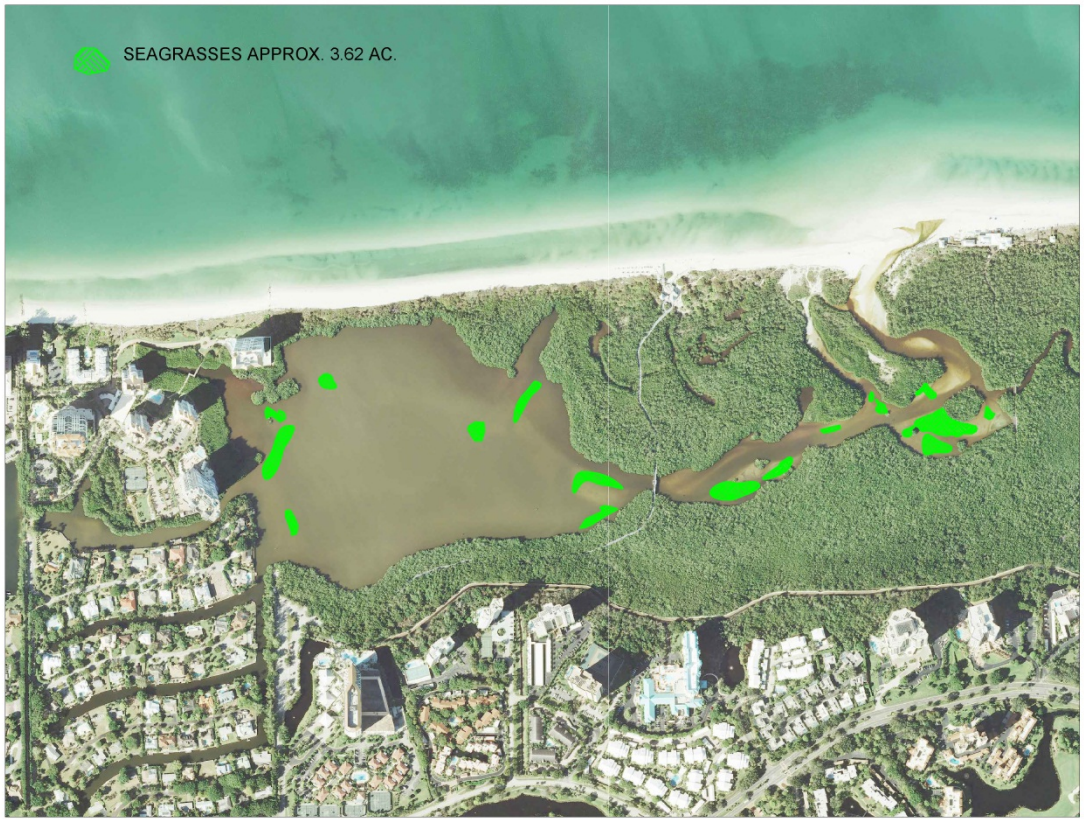
Seagrasses show a slow decline during this time frame. Water quality testing within the system did not indicate chronic degradation. The decline was attributed to the increased tidal range caused by the dredging work, which results in longer exposure at low tides of the shallow areas where seagrasses were present. The one-way culverts installed at Seagate, thought to have reduced tidal exchange in Outer Clam Bay, were removed in October 2002 to determine whether tidal exchange between Venetian Bay and Outer Clam Bay could be achieved without affecting Clam Pass. Seagrass beds in the southernmost portion of Outer Clam Bay began to expand in 2003 after removal of flap gates.

2005

An increase in the seagrass coverage within the channel transects was documented. Increased density of the beds within the bay area east of Clam Pass was also noted.

2006

Shoal grass patches were still present in ecologically significant densities within the channel north of the County boardwalk and just inside Clam Pass mouth. Sea grass beds in Outer Clam Bay were still reduced compared to the 1999 pre-dredge conditions, but their steady improvement since 2004 seems to have continued into 2006. Approximately 3.6 acres of seagrasses were noted along the transects.



2006 Seagrass Coverage

2007

Concerns related to the seagrass coverage within the bay were raised by adjacent property owners this year, and Collier County contracted an additional study by Post, Buckley, Schuh, & Jernigan Inc. (PBS&J) to investigate seagrasses and nutrient inputs within the Clam Bay System, and Venetian Bay, Moorings Bay and the entire Doctors Pass area.

Some of the results of the PBS&J study relevant to the Clam Bay System were:

- Seagrasses were present within Outer Clam Bay. Paddle Grass *(Halophila engelmannii)* was observed at 13 of the 30 randomly generated points within Outer Clam Bay.
- Residents' concerns that seagrass coverage had declined from 60+ acres to the present were unfounded as early estimates of 60+ acres were likely erroneous.
- Nutrient and chlorophyll-a levels within Outer Clam Bay had increased over the past 20 years but were still below median values for Florida estuaries.

As a result of these increased concerns regarding seagrasses, Turrell, Hall & Associates expanded the annual seagrass survey to cover the entire bay and not just the defined transects. Additional seagrass beds and macroalgae were observed in areas where they had not previously been documented. Though all of THA observations were of shoal grass, it was noted that all of the PBS&J observations were of paddle grass. It has been observed in the past that paddle grass is very ephemeral in this system and it is likely that the 2 months between the PBS&J and the THA surveys was enough time for the paddle grass to disappear.

2008

This was the final monitoring event of the seagrasses associated with the 1998 Clam Bay Restoration and Management Plan permits.

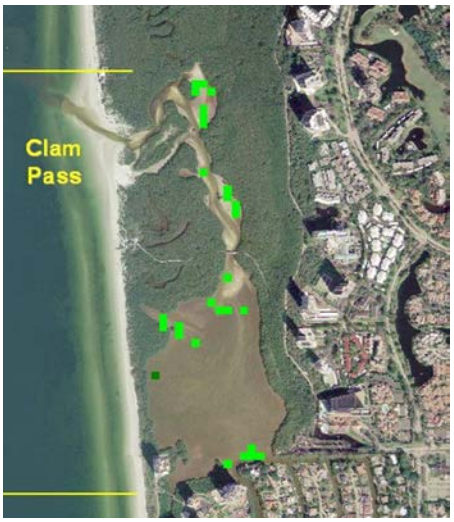
Increases in seagrass coverage that were noted in 2007 continued through this year. A small area of paddle grass was observed along Transect #2 which had been devoid of grasses in the past. Other transect areas that have been devoid of grasses until this year include the western shoreline of the channel between Clam Pass and Outer Clam Bay (Transect 5). Seagrasses had been present along this area prior to the dredging but were replaced by black mangrove propagules when the increased tidal range led to extended drying times of the shoals where the grasses had been located. New grasses this year have been observed along the edges of the channel in areas that do not dry out so much during low tides.

In addition to the seagrasses, other observation made along transects indicate that the biological diversity of the macro-invertebrate fauna within the system has increased.

Several mollusk species, including Florida horse conchs, southern hard clams, stiff pen shells, tulip snails, cockles, oysters, and several others were all observed.

2011

The Conservancy of Southwest Florida completed a benthic habitat assessment where seagrass species were only found in Lower Clam Bay at 6.6% (*n* = 28) of the sampling sites within Lower Clam Bay. Shoal grass (*Halodule beaudettei* syn *Halodule wrightii*), the principle component of the seagrass assemblage, was patchily distributed in the northern and southern areas of Lower Clam Bay, and was primarily collected on muddy sand and sand substrate. Paddle grass (*Halophila decipiens*) was collected at 1 site in the west-central portion of Lower Clam Bay on sandy mud substrate. Seagrass coverage was estimated at 4.3 acres; however, this estimate should be viewed cautiously given the patchy distribution and variable abundance within the 25 x 25 m sampling grids.



Distribution of shoal grass (green) and paddle grass (dark green) in the Clam Bay Study area

2012

Seagrass coverage within Outer Clam Bay has continued to increase. The initial decline noted immediately following the 1999 dredging activities appears to have been reversed over the past 8 years. The decrease stabilized around 2004 and has reversed in the past few years to where the grass beds are re-establishing previous areas and new areas appropriate for the grasses (in terms of water depths and light penetration) are being colonized. Approximately 4.27 acres of seagrasses were noted within the system this year. Most of the seagrass observed was shoal grass though small patches of paddle grass and turtle grass were also observed. Future monitoring of the seagrasses will be conducted to see if this trend continues.



2012 Seagrass Coverage

2013

Seagrass coverage overall totaled approximately 2.85 acres along the monitored transects within the Clam Bay system. The past thirteen years monitoring has shown that there was a decrease in the monitored seagrass beds immediately following the initial 1999 dredging activities. This decrease appears to have stabilized around 2004 or 2005. It has reversed in the past few years to where the grass beds are re-establishing previous areas and new areas appropriate for the grasses (in terms of water depths and light penetration). Future monitoring of the seagrasses will be conducted to see if this trend continues.



2013 Seagrass Coverage

APPENDIX 4 – PHYSICAL AND NATURAL RESOURCES

Appendix 4 – Physical and Natural Resources

Soils

Based on the National Resource Conservation Service (NRCS) "Soil Survey of Collier County Area, Florida" (NRCS, 1998) there are 2 different soil types (soil map units) present within the NRPA boundary.

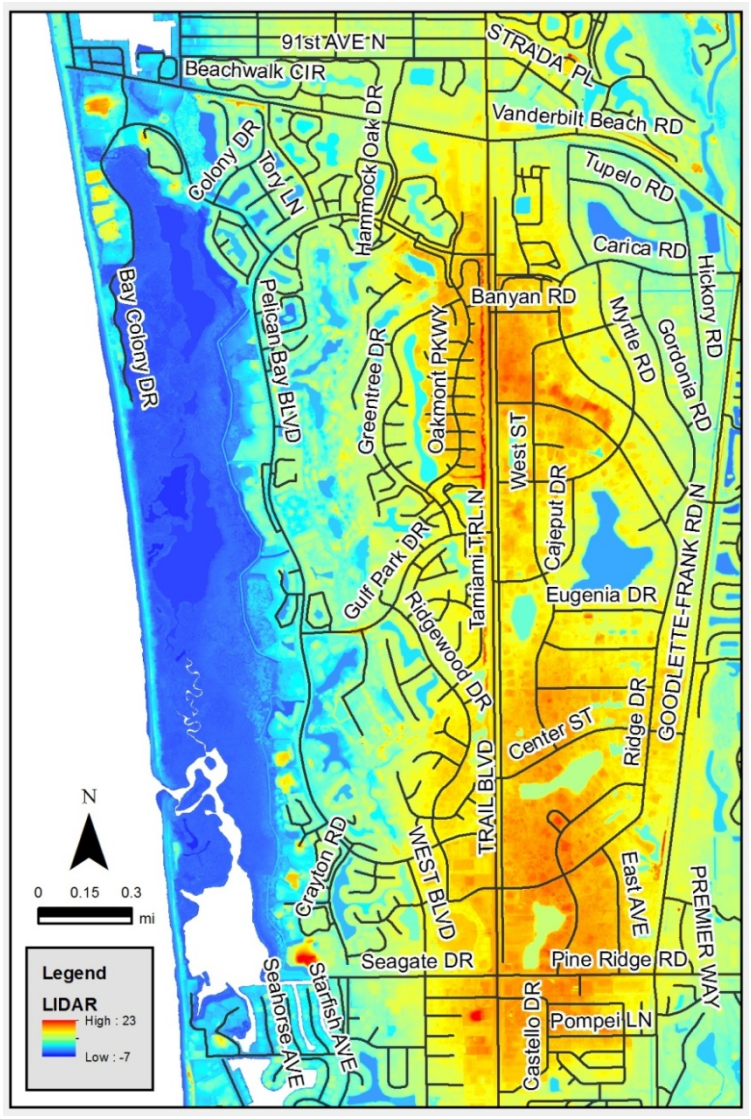
It is important to understand that where the soil survey shows mapping units named for soil series, the units represent the dominant undisturbed soils in that landscape that existed predevelopment. The unit descriptions do not recognize or appropriately interpret the drastically disturbed nature of urban landscapes created after the soil survey was completed.

Durbin and Wulfert mucks, frequently flooded (Map Unit #40), covers approximately 66% of the NRPA. These level, very poorly drained soils are most often found in association with tidal mangrove swamps. Mapped areas can consist entirely of either Durbin or Wulfert or any combination of the two soils. Individual areas are elongated and irregular in shape and range from 50 to 1000 acres. The slope is 0 to 1 percent. The permeability of the Durbin soil is rapid, and the available water capacity is high. The permeability of the Wulfert soil is rapid, and the available water capacity is moderate. The water table fluctuates with the tide and is within 12 inches of the surface most of the year. The soil is subject to tidal flooding. The natural vegetation within these areas consists of red, white and black mangroves.

Canaveral-Beaches Complex (Map Unit #42) covers approximately 9 % of the NRPA.
This map unit consists of the nearly level, moderately well drained Canaveral soil on low ridges and beaches. Individual areas are elongated and irregular in shape and range from 20 to 300 acres. The slope is 0 to 2 percent. Typically, beaches consist of sand mixed with shell fragments and shells and are subject to frequent wave action. The permeability of the Canaveral soil is rapid to very rapid. The available water capacity is very low. In most years, the seasonal high water table is at a depth of between 18 to 40 inches for 1 to 4 months. This soil is subject to tidal flooding under severe weather conditions. Natural vegetation consists of sea oats, seagrape, cabbage palm, and salt grasses. They are commonly invaded by exotics such as Australian pine and Brazilian pepper.

Topography

Topography is shown below using a Light Detecting and Ranging map (LIDAR) obtained from Collier County. The elevations within the NRPA boundary range from +5.0 to -7.0 NAVD88. The surrounding lands are generally higher than the NRPA and generate the freshwater flows into the preserve (see attached Exhibits).



LIDAR map of the Clam Bay NRPA

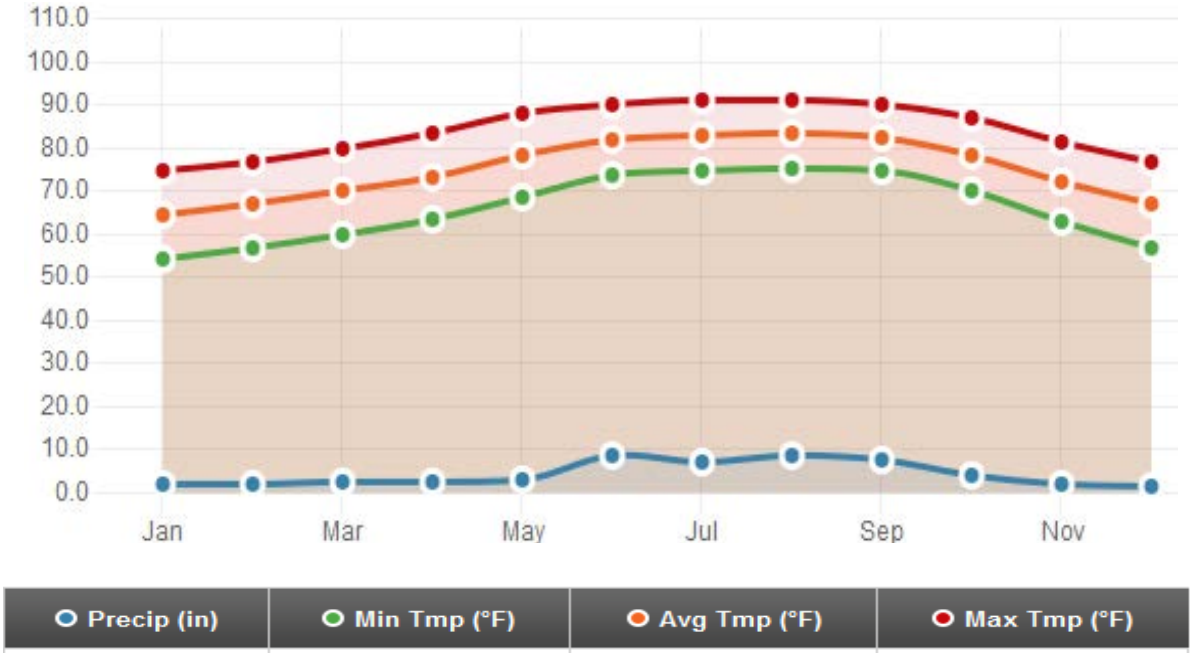
Climate

Clam Bay's climate falls within the United States Department of Agriculture (USDA) subtropical classification. There are essentially two seasons experienced. The wet season occurs in the summer, and the dry season occurs in the winter. Typical rainfall and temperature data are provided in Tables 1 and 2.

In the summer the center of the trade winds shift north and moisture-laden breezes blow from the east or south-east. In winter the trade winds shift southward and the winds are less constant. Weather is then more influenced by fronts advancing from the northwest. This brings cooler conditions, although temperatures rarely reach freezing, due to the fact that they are being moderated by the surrounding waters. Cold fronts are typically preceded by winds from the southwest, which clock to the west then northwest as the front passes, with strong winds of 20-25 knots and cooler air. In general terms, winds are predominantly southeast during the summer and northeast during the winter.

Historical meteorology for Clam Bay is based on data collected for 30 years (from 1981 to 2010) from Naples Municipal Airport by the Florida Climate Center (NOAA & FSU). The following charts present meteorological statistics for temperature and precipitation.

1981-2010 Temperature and Precipitation Normals Graph



Temperature

The monthly average temperatures range from 64.5°F to 83.2°F. The lowest monthly minimum temperature is 54.2°F while the highest monthly maximum temperature is 91.2°F. The data reflect a humid subtropical climate with a narrow fluctuation in air temperature.

Precipitation

Average annual rainfall for the Naples Municipal Airport NOAA station is documented at 51.89 inches. The data in the table indicate the highest rainfall occurs during the summer months of June, July, August, and September.

1981-2010 Temperature and Precipitation Normals Graph

	Precip (in)	Min Tmp (°F)	Avg Tmp (°F)	Max Tmp (°F)
January	1.85	54.2	64.5	74.7
February	2.10	56.8	66.9	76.9
March	2.38	60.0	70.0	79.9
April	2.36	63.4	73.3	83.2
May	3.16	68.5	78.2	87.8
June	8.82	73.9	81.9	89.9
July	7.27	74.9	83.1	91.2
August	8.58	75.3	83.2	91.0
September	7.69	74.8	82.4	89.9
October	4.19	70.0	78.5	86.9
November	2.04	62.9	72.1	81.2
December	1.45	57.0	66.8	76.6

Winds

Winds are predominantly easterly throughout the year, but with a tendency to become northeasterly from October to April and southeasterly from May to September. Winds speeds, not including storm events are, on average, below 10 knots. During the winter months when fronts move through for a day or two at a time, winds out of the northwest to northeast may increase to about 25 knots.

Sea breeze

As the land surface around Naples and Clam Bay warms, the air above is heated. The warm air is less dense and tends to rise creating a lower air pressure over the land than the water. The cooler air over the water then flows inland creating a sea breeze. In the evening the reverse occurs and the cooler air over the land will flow back toward the water creating a land breeze.

The incoming sea breeze acts as a lifting mechanism, resulting in the warmer air rising up to higher altitudes. This creates cumulus clouds that begin to build which leads to the development of afternoon showers and thunderstorms in the area.

Storms

Naples and Clam Bay specifically are within the Atlantic Tropical Cyclone basin. This basin includes much of the North Atlantic, Caribbean Sea, and the Gulf of Mexico. On average, 6 to 8 tropical storms form within this basin each year. The hurricane season lasts from June 1st to December 1st. The formation of these storms and possible intensification into mature hurricanes takes place over warm tropical and subtropical waters. Eventual dissipation or modification, averaging 7 to 8 days later, typically occurs over the colder waters of the North Atlantic or when the storms move over land and away from the sustaining marine environment.

Saffir–Simpson Hurricane Scale

Category	Wind speed mph (km/h)	Storm surge ft (m)
Five	≥156 (≥250)	>18 (>5.5)
Four	131–155 (210–249)	13–18 (4.0–5.5)
Three	111–130 (178–209)	9–12 (2.7–3.7)
Two	96–110 (154–177)	6–8 (1.8–2.4)
One	74–95 (119–153)	4–5 (1.2–1.5)
Additional classifications		
Tropical storm	39–73 (63–117)	0–3 (0–0.9)
Tropical depression	0–38 (0–62)	0 (0)

Due to the destructive nature of these storms, landfall can result in significant damage to upland development and facilities from storm surge, waves, and wind. A good example of this would be Hurricane Wilma which formed in 2005.

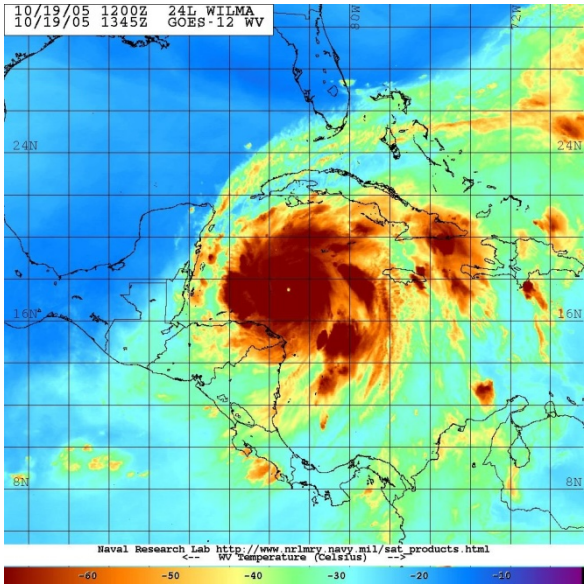
A tropical storm is defined by maximum sustained winds from 35-64 knots (40-74 mph). A hurricane has maximum sustained winds that exceed 64 knots (74 mph). Hurricanes are classified into different categories according to the Saffir-Simpson scale. Hurricanes can also spawn severe weather such as tornadoes as they move inland.

The table below lists the number of tropical storms and hurricanes that passed through or near Naples over the past 20 seasons including 1992 through 2012 as reported by the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center and Hurricane City (www.hurricanecity.com). Analysis of the available information indicates that Naples, on average, is brushed or hit by a tropical storm or hurricane once every 2.71 years and is directly hit once every 7.05 years.

Number of Named Storms Passing through or near Naples

Year	# of Storms	Names	Strength closest to Naples
1992	1	Andrew	Hurricane Cat. 3
1993	0		
1994	1	Gordon	Tropical Storm
1995	1	Jerry	Tropical Storm
1996	0		
1997	0		
1998	1	Mitch	Tropical Storm
1999	1	Harvey	Tropical Storm
2000	1	Gordon	Tropical Storm
2001	0		
2002	0		
2003	0		
2004	1	Charley	Hurricane Cat. 3
2005	1	Wilma	Hurricane Cat. 2
2006	0		
2007	0		
2008	1	Fay	Tropical Storm
2009	0		
2010	0		
2011	0		
2012	0		
2013	0		

Hurricane Wilma image



Waves

Clam Pass connects the Clam Bay system to the Gulf of Mexico's tidal water fluctuations and open coast wave energy. Clam Pass is subjected to relatively low wave energy. Significant wave heights in deep water commonly range between 1 to 3 feet (0.3 to 1m). Predominant wave directions are from the northwest to west, especially during the winter months, while summer and tropical storm events include wave energy from the south and southwest. The beach material is composed of fine sand having an average median grain size of 0.2 mm. The average net sediment transport along the southwest Florida coast is approximately 30,000 to 60,000 cubic meters per year to the south. The relatively small tidal prism for Clam Bay provides a critical balance between tidal flow in and out of the inlet channel and littoral processes moving alongshore. This affects the inlet hydraulic efficiency over time, especially when littoral transport rates are high due to periods of high wave energy.

The wave climate at Clam Pass was obtained from the NOAA Wave Watch III (WWIII) model. Wind and wave data were extracted at the nearest station, located approximately 2 miles offshore of the Pass. The data included significant wave height, wave period and direction, as well as wind direction and speed. A total of 8 years of data were extracted from the beginning of 2006 to the end of 2013. Figure 5 shows the wave/wind roses for the 8 year record. The wave and wind rose graphs show a color coded percentage of occurrence in wave height or wind speed in incremental direction bins of 12.5 degrees. The wave direction notation is where waves are originating from, while wind direction is where it is heading. The combined annual wave rose shows that largest waves and highest frequency waves typically originate from the northwest to west direction. Because the annual wave rose does not describe seasonal variations, the wave data of 2013 were evaluated monthly and represented by wave roses to assess variations in wave energy direction. Figure 6 shows comparisons of the monthly wave roses for the 2013 data indicating the temporal variation in the incoming waves during the winter and summer months.

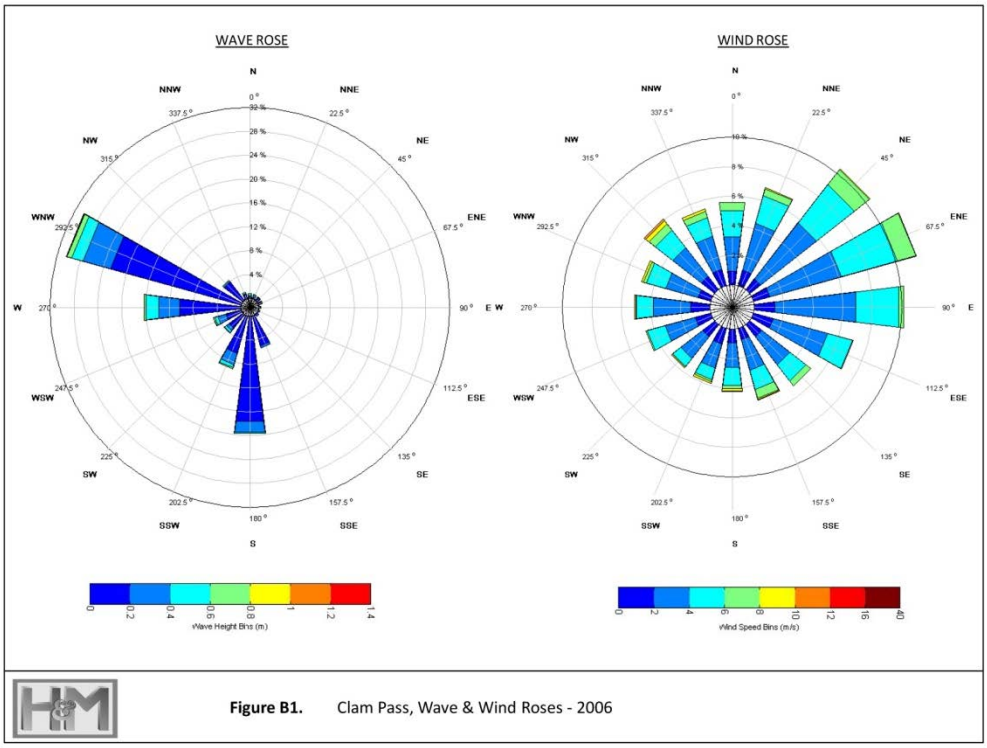


Figure B1. Clam Pass, Wave & Wind Roses - 2006

Wind and Wave Roses – 2006-2013 (Provided by Humiston and Moore)

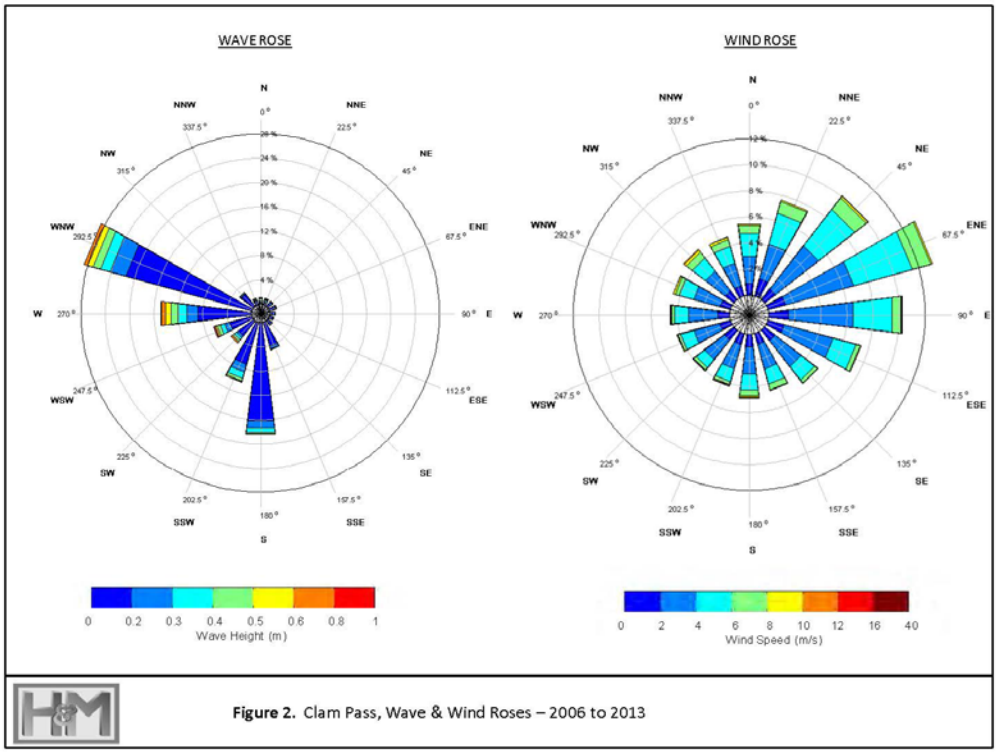


Figure 2. Clam Pass, Wave & Wind Roses – 2006 to 2013

Wind and Wave Roses – 2013 (Provided by Humiston and Moore)

Natural Communities

In this Section, a natural community refers to the mix of plant and animal species that form the natural basis of the Clam Bay NRPA. A combination of factors including geology, climate, hydrology, soils, and anthropogenic influences determines the specific types of plants found in any given area. These plants are a major factor in what type of animal species that may be present. The Florida Department of Transportation's Land Use, Cover and Forms Classification System (FLUCFCS 1999) has been used to identify the plant communities found within the Clam Bay NRPA. See the attached Exhibits for an overall FLUCFCS map of the Clam Bay system and the existing monitoring plots within these habitats.

List of FLUCFCS Communities within the Clam Bay NRPA
Based on 2014 mapping by Turrell, Hall & Associates, Inc.

FLUCFCS Code	Community Description	Upland or Wetland	Acreage within the NRPA	% of Clam Bay NRPA
181	Swimming Beach	Upland	33.35	5.95
186	Community Recreation Facilities	Upland	2.06	0.37
322	Coastal Scrub	Upland	22.31	3.98
428	Cabbage Palm Hammock	Upland	2.50	0.45
510 and 540	Interior Creeks and Bays (with and without direct connection to Gulf or Ocean)	Wetland	129.73	23.16
612	Mangrove Swamp	Wetland	359.56	64.20
642	Saltwater Marsh	Wetland	2.35	0.42
651	Tidal Flat	Wetland	8.05	1.44
814	Roads and Highways	Upland	0.14	.03
911	Seagrasses**	Wetland	2.85**	0.84**

**included in the Bays (510 and 540) category

Several other components of the Clam Bay NRPA ecosystem are also addressed below. These components include offshore hardbottom, oyster, and other benthic faunal communities that are not specifically addressed in the FLUCFCS classification system. Additional historical information on the Clam Bay mangrove and seagrass habitats is included as appendices to the Management Plan.

FLUCFCS Code 181- Swimming Beach

Beaches form when offshore sand deposits are moved landward by wave action usually during the spring and summer. Sand, which is stirred up as the wave breaks on the shore, drops out of suspension as the water moves up the beach face. Thus, the beach becomes gradually higher, wider, and steeper. In the wintertime, larger, higher energy waves associated with winter storms overflow the beach area and stir up the sand deposited earlier in the year. The sand is pulled off the beach as the wave recedes and is deposited in an offshore sand bar. If these two forces are in equilibrium, the beach area will be stable from year to year. However, naturally occurring

factors, such as storm events, littoral drift (lateral movement of sand because waves approach the beach at an angle), and offshore winds, upset this equilibrium and result in the ever shifting nature of the beach environment.

Dunes form because of onshore wind action on beach and sand. When wind speeds are sufficient, individual grains of sand start to roll and bounce along the surface. This windborne sand is transported landward until the wind speed drops below that needed to move the sand. Coastal vegetation is critical for slowing wind speeds and causing sand to be deposited.

Landward of the highest tides, pioneer or frontal zone sites are stabilized by sand trapping action of various rhizomatous grasses and low growing shrubs that are tolerant of salt spray. Only a few plant species can tolerate the stresses of a dune environment, particularly frontal dune sites. Foredune plants must be able to survive being buried by blowing sand, sand blasting, salt spray, and saltwater flooding, drought, heat, and low nutrient supply. Coastal plants colonizing the dunes are key players in trapping windblown sand and preventing coastal erosion as the first defense against heavy winds and surge of tropical storms.

Many plant species that occur on dune areas have developed specific attributes to help them survive these harsh environments. These include high growth rates, dense root systems, low profiles, and high flower and seed production rates. Species common on the beaches of the Clam Bay system include: sea oats (*Uniola paniculata*), seagrape (*Coccoloba uvifera*), and railroad vine (*Ipomoea pes-caprae*).

FLUCFCS Code 322 – Coastal Scrub

Landward of the frontal (beach) zone area is the back dune zone (also often called the coastal shrub or scrub zone), a portion of the dune that is more stable, has greater organic matter, and supports less salt tolerant grasses and shrubs as well as some trees.

Many of the woody species found in coastal scrub are low growing and shrubby due to low nutrient and droughty conditions of sandy soils. High winds and salt spray often prune the terminal buds of the trees and shrubs growing on the dunes and result in salt-pruned, windswept canopies.

Coastal scrub is represented by a conglomeration of coastal species generally found in a narrow band between the mangrove forest and the beach areas. Species common in the coastal scrub zone of the Clam Bay system include: seagrape (*Coccoloba uvifera*), cabbage palm (*Sabal palmetto*), buttonwood (*Conocarpus erectus*) and Spanish bayonet (*Yucca aloifolia*). This is an important habitat as it helps anchor the back dune sands and provides habitat for several listed plant and animal species including the gopher tortoise (*Gopherus polyphemus*).



FLUCFCS Code 428 – Cabbage Palm Hammock

This forested zone is composed of the more protected dune vegetation farthest from the Gulf of Mexico. The Cabbage Palm Hammock habitat is identified by the preponderance of cabbage palms (*Sabal palmetto*). It is generally found in pockets located between the mangrove forest and the coastal scrub zone or beach areas. Aside from the cabbage palms, seagrapes (*Coccoloba uvifera*), buttonwood (*Conocarpus erectus*), and several other hammock species, such as wax myrtle *(Myrica cerifera*) and myrsine *(Myrsine guianensis*), are common. A hammock is a habitat that is densely shaded by a canopy of trees. Hammocks usually have sparse groundcover that leaves the forest floor mostly open for animals to travel through. Hammocks also provide a reprieve from the sun for animals and humans alike. In Clam Bay, this habitat is also susceptible to infestation by exotic vegetation, such as Australian pine (*Casurina equisetifolia*) and Brazilian pepper *(Schinus terebinthifolius*) which are addressed later in this Section.

FLUCFCS Code 510 and 540 – Interconnecting Creeks and Bays (with and without connection to the Gulf)

The Clam Bay NRPA contains the three larger bays associated with Clam Pass (Outer, Inner, and Upper) as well as the interconnecting shallow creeks and small open water areas. Second in extent of aerial coverage within the NRPA boundary, it is the bays and interconnections which serve as the life blood of the estuary.

These open water habitat serves as the basis for many other communities. Seagrass beds, oyster bars, clam beds, and other benthic communities can all be supported to varying degrees with the open waters of the bays and interconnecting creeks. As outlined below, several of these

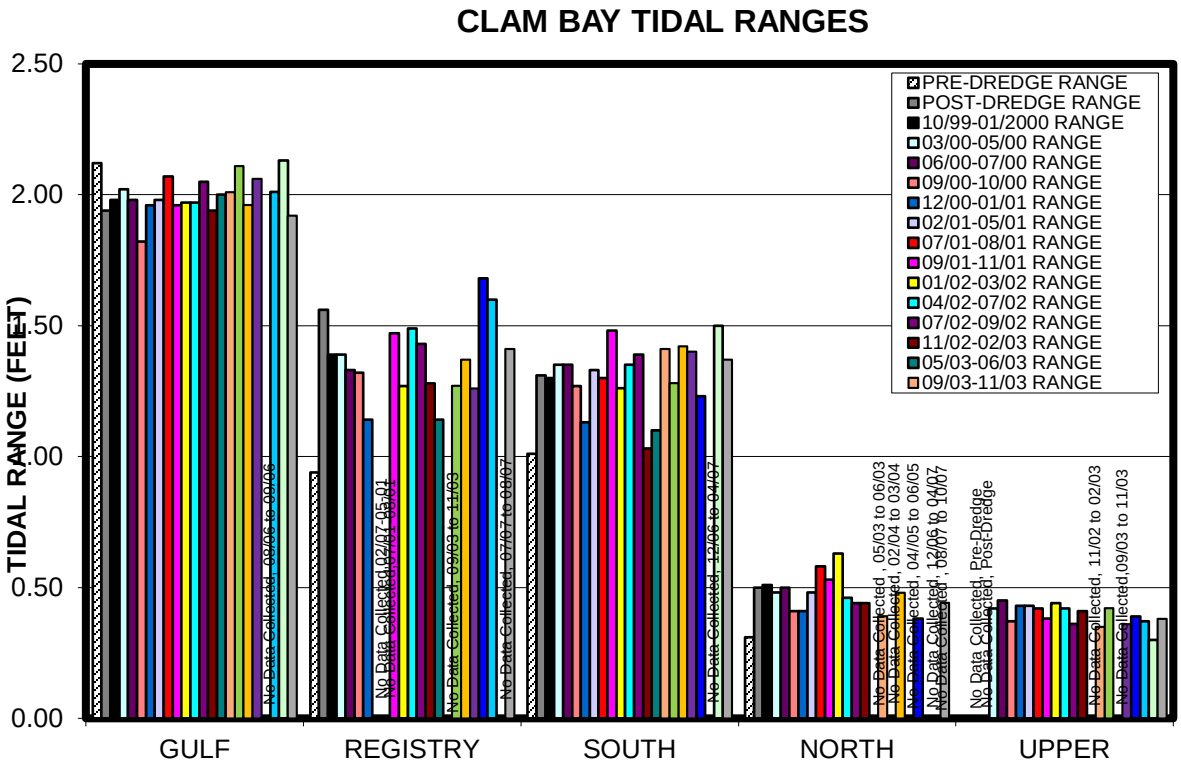
communities are present within the Clam Bay NRPA and will be considered when deciding on management activities outlined within this Management Plan.

Multiple studies have indicated that the single most important thing that can be done to restore the health of the Clam Bay system is to improve the total tidal flushing capacity of the system (Tackney 1996; Lewis 1997; Wilson Miller, et al 1996; Turrell 1995). The dredging conducted within the Pass and the interconnecting creeks, as well as the hand-dug flushing cuts, have been seen as the major contributing factors to the restoration of the mangrove forest community within the system (Turrell 2008; Humiston & Moore 2003).

Tidal Pass

Clam Pass is the only open water connection to the Gulf of Mexico for the Clam Bay NRPA. The exchange of seawater between Clam Bay and the Gulf is critical to the ability of the estuary to export organic matter, as well as to help regulate excess salt and freshwater. It also supplies oxygen rich water from the Gulf. In the absence of surface water circulation or tidal activity, estuarine habitats, such as mangroves, can slowly die due to deleterious changes in the sediment because in the absence of oxygenated water the sediments become anaerobic or anoxic, and metabolic wastes and hydrogen sulfide accumulate in the anoxic sediment (CBRMP, 1998).

Tides in the Gulf of Mexico are mixed, with the norm being two high tides and two low tides experienced per day and normal amplitude (range) of approximately 2 feet. The highest tides (springs) are experienced twice per lunar month at full and new moons when the gravitational pull on the Earth's surface waters is greatest. Neap tides also occur twice per lunar month when the planetary (gravitational) influences of earth, moon and sun are perpendicular.



It can be seen that the health of the mangrove forests is directly related to the efficiency of the tidal pass. Clam Pass and its associated waterway is a very dynamic creek whose location has varied over time (Turrell 1995; Tackney 1996). Because of this, it is susceptible to outside events and can periodically close, such as has happened at least six times in the last 25 years.

Tidal creeks are passageways for fish and marine invertebrates between the open waters of the Gulf and the protected embayments of Clam Bay. Manatees, dolphins, and turtles may also use the Pass. Scouring action of the fast flowing tide generally prevents colonization by seagrasses and other benthic plants, and the substrate is typically sand and shell with the finer sediments carried in suspension and deposited just outside the mouth of the Pass (the ebb shoal delta) or to the interior of the system on the incoming (flood) tide.

FLUCFCS Code 612 – Mangrove Swamp (Forest)

Mangroves are salt tolerant trees that grow in tidal areas of the tropics and are legally protected for their ecological value with such functions as:

- Providing habitat for marine, terrestrial, and avian wildlife.
- Protecting coastal areas from storm surges and coastal erosion.
- Improving water quality by acting as a natural filter for land based freshwater run-off.

- Forming the basis of a highly productive estuarine food chain which includes many commercially valuable species.
- Enhancing the atmosphere by absorbing carbon dioxide and reducing greenhouse gasses.

Special attention has been given to the mangrove community in the past because of the die-off which occurred between 1991 and 1997 (though stress in the community was documented as far back as the late 1970's). The die-off affected black and red mangroves initially but eventually ended up encompassing some white mangroves as well. More details on the recent history of the mangrove management are provided in Appendix 3 included with this plan.

Red Mangroves

Red mangroves (*Rhizophora mangle*) are recognized by their tangle of reddish looking prop roots, long cigar shaped seedlings (propagules) and their large, pointed evergreen leaves. Red mangroves flower all year but reach maximum propagule production during the late spring and early summer months. They are typically the most seaward of the three species with the prop roots and vertical drop roots providing support. Small pores on the trunks called lenticels allow oxygen exchange via air as the waterlogged soils become rapidly oxygen depleted. Salt is excluded from the plants cells through a process called ultra-filtration roots. The characteristic propagules germinate on the parent tree and drop and float for up to a year, finally becoming heavier at one end so that when encountering a suitable substrate they are ready to root upright. The mass of prop and drop roots forms extensive surface area under water for attachment of sessile, filter feeding marine species (such as sponges, tunicates, and mollusks) as well as hiding places for juvenile fish. Birds, butterflies, insects, and mammals find home and food within the canopy.



Red Mangroves and Propagules (inset)

Black Mangroves

Black mangroves (*Avicennia germinans*) are typically found a little further inland. Key identification features include the snorkel like pneumatophores which radiate upwards out of the soil from the base of the trunk, a grey-black rough bark and slightly pointed, oval leaves which are silvery with salt deposits on the undersides. The pneumatophores play an important role in oxygen exchange and unlike the red mangroves, which keeps salt out of the body cells through filtration in the roots, the black mangrove excretes salt out of the backside of the leaves. They are also reliant on adequate tidal exchange but lack the supporting prop roots that typify the red mangrove. Small white flowers and lima bean shaped propagules are typically apparent during the late spring and early summer months. Black mangroves are cryptoviviparous as the embryo develops within the fruit while on the parent plant. When these propagules fall from the parent tree, they are able to float for a short period before rooting in the mucky soil.



Black Mangrove Pneumatophores

White Mangroves

White mangroves(*Laguncularia racemosa*) are the third mangrove species and are often found further inland than the other two species, Although zonations described are typical they can frequently vary. Since they often occur in drier areas, white mangroves do not exhibit the adaptations to soft, anaerobic soil of the other species. The bark is characteristically grooved and furrowed, and leaves are oval, mid-green and leathery with two small glands on the petiole at the base of each leaf. White mangroves also flower in the spring and early summer, and the small seedlings have the shortest floating dispersal stage of the three species. White mangroves are semi-viviparous and germinate inside the fruit during the approximately five-day dispersal, but not while attached to the parent plant.



White Mangrove leaves and fruit

The mangrove communities are composed of both riverine (along the creeks) and basin forest components. The species composition of mangroves within these two community components is very distinctive. Riverine mangrove areas are almost exclusively composed of red mangroves within the Clam Bay NRPA while all three species, along with buttonwood (*Conocarpus erectus*), are found in the forest component.

Riverine (Creeks) Mangroves

On the waterward edges of small islands and the tidal creeks, passes and estuarine waterways that make up the Clam Bay system, a fringe of red mangroves will be found growing up to 25 feet in height. This zone can be just one or two trees in depth or extend landward for some distance, depending on topography. The habitat provided by the prop roots of these red mangroves is of great importance to many fish and other aquatic organisms.

Forests

The majority of the Clam Bay mangrove habitat is low-lying basin forest where the dominant mangrove species varies between red, white, and black through the forest habitat. This forest community was the habitat affected by the mangrove die-off. The hand dug flushing channels

were constructed throughout this community to increase the flushing capacity through tidal inundation.

Associated plants within the mangrove habitat include: buttonwood (*Conocarpus erectus*), the succulent ground covers, saltwort (*Batis maritima*) and glasswort (*Salicornia cervicornis*), (especially where a fallen tree provides a break in the canopy and light penetration to the forest floor) and, further inland and closer to freshwater sources, the leather fern (*Acrostrichum danaefolia*).

FLUCFCS Code 642 – Saltwater Marsh

At the interface between forested mangrove areas and the water management berm are depressional areas that have become colonized by aquatic freshwater plants, such as cattails (*Typha latifolia*), Carolina willow (*Salix caroliniana*), bulrush (*Scirpus californicus*), needlerush (*Juncus romerianus*), and leather fern (*Acrostichum danaeifolium*). For a more complete list of common plant species found in this habitat see page 30. Wildlife, such as otters (*Lutra canadiensis*), alligators (*Alligator mississippiensis*), various turtles, and wading birds can be commonly observed. These areas require regular maintenance to prevent the spread of nuisance and exotic plant species and ensure optimal functioning and interface between the natural mangrove forest and the water management system.

FLUCFCS Code 651 – Tidal Flats

Tidal flats are flat bottomed, sub- or intertidal habitats that lack an oyster or seagrass community and are located inside the outer coastal margin. The two most significant environmental characteristics that control a flat's infauna (benthic organisms that live within the substrate) and epifauna (benthic organisms that live on the surface of the substrate) are: the height of the substrate relative to mean sea level and the sedimentary consistency of the substrate. The position relative to mean sea level dictates whether the habitat is emergent (in air) for part of a tidal cycle or how deep below the water it is. This latter characteristic controls other physical water quality measures, such as dissolved oxygen, the frequency and duration of hypoxic events, and light penetration. Firmness of the substrate affects the capacity to support an epifauna by both supporting the organism on the substrate and permitting the burrowing of the infauna.

The sand and mudflats of Clam Bay are rich feeding grounds for many species of fish and wading birds. These organically rich sediments support a variety of mollusks, worms, and invertebrates that scavenge detritus or, in the case of many bivalve mollusks, extend siphons at high tide and filter vast quantities of water. Birds, such as a variety of herons, ibis, egrets, and spoonbills pick through the sediment for the invertebrate food sources.

The dredging of the Pass associated with the 1998 Restoration and Management Plan resulted in an increase of exposed tidal flats within the southern portion of the system. Increased tidal range resulting from the dredging allowed more area to be periodically exposed during the tidal cycle. Some of the area that had supported seagrasses prior to the dredging work were converted into the tidal flats by the increased range and reduced phase lag. Management concerns related to the

tidal flats include the templates established for the dredging, the resultant currents that could be expected as a result of dredging, and the frequency of disturbance.

FLUCFCS Code 911 – Seagrass Beds

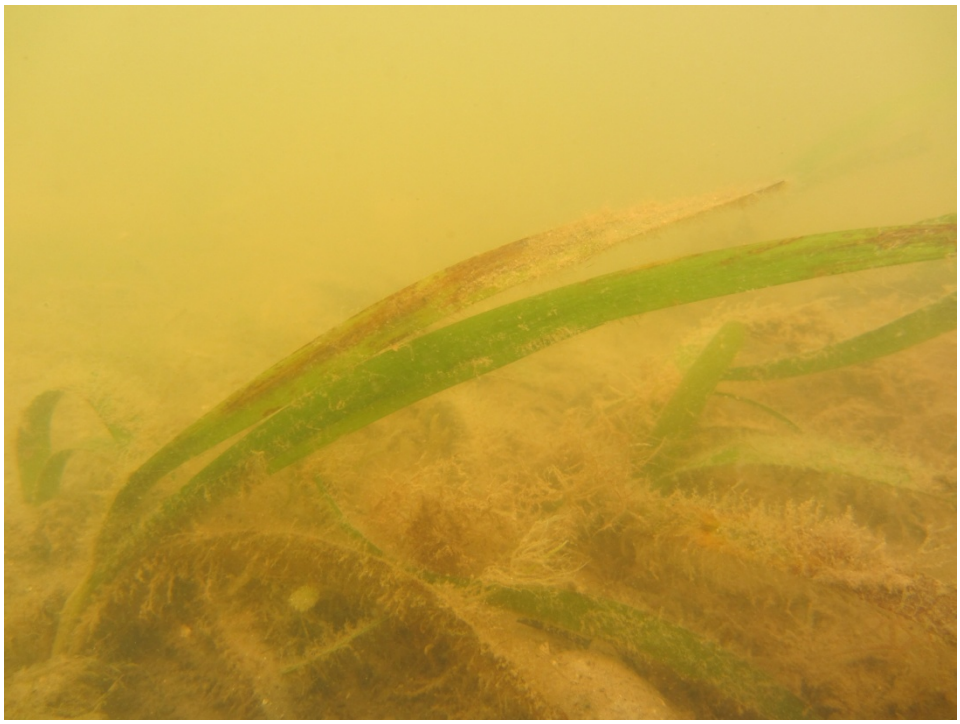
Seagrasses are flowering marine plants of shallow, tropical regions. With a creeping growth form connected by horizontal rhizomes they serve to trap and anchor sediment. Both the grass blades themselves and the surface area they represent provide food and attachment for marine species. Seagrass beds are renowned for their value as nursery habitats and are legally protected.



*Shoal grass (*Halodule beaudettei*) along interior channel south of Clam Pass*



*Paddle grass (*Halophila decepiens*) in the center of Outer Clam Bay*



*Turtle grass (*Thalassia testundinum*) just south of County boardwalk in Outer Clam Bay*

Seagrasses rely on good light penetration to enable photosynthesis and are sensitive to reduced tidal water quality. Growing in shallow regions, they are also vulnerable to physical damage by boats. A variety of marine algae can be associated with grass species, differing in the lack of a

true rooting and vascular system. Several species of both brown and green alga have been observed.

Other Benthic Habitats

Oyster Bars

Oysters (*Croassostrea americana*) are filter-feeding bivalves, which were once common within the tidal creeks of Clam Bay (Humm and Rehm 1972). Oysters play a significant role in shaping the environment in which they live by forming a hard structure upon which an intricate biological community is built. Similar to coral reefs, oyster reefs are 'biogenic' (formed by the accumulation of colonial animals) and provide structure and surface area for numerous other temporary and permanent species.

Providing complex habitat structure is the most fundamental of ecosystem services that oysters provide. The structure provides a place for algae and non-mobile invertebrates to attach, as well as a place for mobile invertebrates and fishes to be protected from predators. Although the relationships between sportfish and oyster habitats are not as well studied as in other estuarine habitats, such as seagrass beds, they are considered essential fish habitat.

The numerous ecosystem services provided by oysters can be summarized into three general categories: habitat provision, water quality improvement, and shoreline stabilization. Oyster reefs provide habitat to a diverse array of flora and fauna. The role of oyster habitat to the estuarine food chain is highly significant, as discussed in the previous paragraph. Through their feeding process oysters filter large quantities of water which transfers energy and material from the water column to the benthic community, subsequently reducing turbidity and water column nutrients. Through bio-deposition, nutrients are made available to the flora and fauna which comprise the complex oyster bar food web. Additionally, oyster reefs stabilize sediments, shorelines and adjacent habitats by buffering wave energy, further aiding water quality.



*Oysters (*Croassostrea americana*) along the mangroves near the canoe ramp in Outer Clam Bay*

A 2011 benthic habitat assessment conducted by the Conservancy of Southwest Florida found living oyster clusters in the upper reaches of Upper Clam Bay (a single cluster), in the tributary between Outer and Inner Clam Bays (a single cluster), and throughout the shoreline of Outer Clam Bay.

Other bivalve mollusks

In addition to oysters, the 2011 benthic habitat assessment conducted by the Conservancy of Southwest Florida also found two other bivalves within the Clam Bay system. The pointed venus clam (*Anomalocardia auberiana*) and the stout razor clam (*Tagelus plebeius*) were both observed. Turrell, Hall & Associates, Inc. benthic surveys found several beds of southern hard clams (*Mercenaria campechiensis*) also present in the system.



*Southern hard clam (*Mercenaria campechiensis*) from waterway south of Clam Pass*

These mollusks are generally found within the shoal and tidal flat areas of the system and could be susceptible to impact during dredging or other disturbance operations. Management concerns would be protection from recreational users, water quality, flushing and dredging.

Tubiculous Polychaetes

Tubiculous polychaetes (tube worms) are typically the most abundant biological assemblage in Clam Bay and are primarily associated with muddy and sandy substrates. Polychaetes, including worm tubes and mud tubes, shell-encrusted polychaete tubes (Polychaeta) and trumpet worm (Pectinaria gouldi) tubes, are a vital component of the estuarine food web, providing key linkages between primary producers and higher trophic levels. Polychaetes create habitat and food for many organisms, such as mollusks, fish and even sea turtles. These worms are usually filter or deposit feeders that keep the substrate aerated and free of waste accumulation. Polychaetes tend to dominate Inner and Outer Clam Bays, with lower occurrences in Upper Clam Bay, the Lower Tributary, and, to a lesser extent, the Upper Tributary.

Hardbottom Communities

Another important marine habitat marginally associated with the estuarine system is the hard bottom reef community found just seaward of Clam Pass. In about 10-15 feet of water a variety of sponges, stony corals, gorgonians, fish and associated invertebrates can be found within a system of rocks and ledges. Outcroppings of similar habitat type occur along the length of Collier County and are a little known resource of regional significance.



Hardbottom outcrop off of Clam Pass

Collier County has mapped this resource through side scan sonar surveys in 2005 and 2009 as part of its beach renourishment project. The information received from the County shows that the landward edge of this habitat is located approximately 250 to 300 feet offshore from the Pass.

Invasive, Non-native and Problem Species

In an ecological context, an invasive species is one that is aggressive in growth and expansion of range and tends to dominate other appropriate native species. Its establishment and dominance can cause widespread harm to an ecological system by altering the species composition, susceptibility to fire and hydrology of an area. Non-indigenous species (i.e., non-native or exotic species) are those that have been introduced purposefully or accidentally to an area outside their normal range. The characteristics of some of these species (high rate of growth/reproduction, no natural predators, easily dispersed, able to out-compete native species) make them invasive. Some indigenous species (a species whose natural range included Florida at the time of European contact circa 1500 AD or a species that has naturally expanded or changed its range to include Florida) may also become invasive. Invasions by native and non-native species often follow an alteration to ecosystem function, disruption of the food web, large-scale fragmentation of an ecosystem and/or disturbance (e.g., clearing, fire, drought, etc.) of an area. While some native species may become invasive, the establishment and dominance of non-native species is of particular concern. The exotic species documented within the NRPA and those that have a potential to occur within the NRPA are discussed in the following section.

Invasive and Problem Plant Species

The Florida Exotic Pest Plant Council (FLEPPC) maintains a list of exotic plants that have been documented to (1) have adverse effects on Florida's biodiversity and plant communities, (2) cause habitat loss due to infestations, and (3) impact endangered species via habitat loss and alteration. To date, 9 non-indigenous plant species have been detected within the Clam Bay NRPA which are listed by FLEPPC as Category I exotics. FLEPPC defines Category I plants as

those that alter native plant communities by displacing native species, change community structures or ecological functions, or hybridize with natives. Category II plants have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species. These definitions do not rely on the economic severity or geographic range of the problem, but rather on the documented ecological damage caused by these plants (FLEPPC 2013).

FLEPPC Category I plants observed within the Clam Bay NRPA boundary:

- Brazilian Pepper (*Schinus terebinthifolius*)
- Melaleuca (*Melaleuca quinquenervia*)
- Australian Pine (*Casuarina equisetifolia*)
- Beach Naupaka (*Scaevola taccada*)
- Earleaf Acacia (*Acacia auriculiformis*)
- Shoebutton Ardisia (*Ardisia elliptica*)
- Air Potato (*Dioscorea bulbifera*)
- Lantana (*Lantana camara*)
- Old World Climbing Fern (*Lygodium microphyllum*)

FLEPPC Category II plants observed within the Clam Bay NRPA boundary:

- Coconut Palm (*Cocos nucifera*)
- Wedelia (*Sphagneticola trilobata*)
- Oyster Plant (*Tradescantia spathacea*)
- Mahoe (*Talipariti tiliaceum*)

Listed Species

Smalltooth Sawfish (*Pristis pectinata*)
A juvenile smalltooth sawfish was observed by Turrell, Hall & Associates, Inc. biologists in 2008 in the connector creek between Inner and Outer Clam Bays. Smalltooth sawfish are found in the tropical and subtropical Atlantic Ocean. In the western Atlantic they have historically ranged from New York to Brazil, including the Gulf of Mexico and Caribbean Sea. Habitat destruction and overfishing have succeeded in eradicating the smalltooth sawfish from the majority of its former range. Consequently, it survives in small pockets throughout its current range. The last remaining population in U.S. waters is off south Florida, a small remnant of a population that once ranged from New York to Texas.

This sawfish primarily occurs in estuarine and coastal habitats such as bays, lagoons, and rivers. It does at times occur in deeper waters, however, and may make crossings to offshore islands. It can tolerate freshwater. This fish is easily recognized by its flattened body and wing-like pectoral fins. The mouth is located ventrally, and the eyes are positioned dorsally. The “saw” is approximately 25% of the body's total length. It is widest at the base, with teeth more broad than long, and spaced apart. The tips of the teeth are sharp, becoming blunt over time. Dorsally, it is brownish or bluish gray body with a white underside. The maximum length recorded is 24.7 feet (7.6 m); however, a length of 18 feet (5.5 m) is considered average. The average lifespan for the smalltooth sawfish is unknown.

On April 1, 2003 the U.S. National Marine Fisheries Service placed the smalltooth sawfish on the Endangered Species List, making it the first marine fish species to receive protection under the Endangered Species Act. Florida has also designated critical habitat areas to further protect its habitat.

Mangrove Rivulus (*Rivulus marmoratus*)
This small fish has not been identified within the Clam Bay system in previous surveys or field work but the mangrove habitat is appropriate, and they could be present in the upper reaches of the mangrove forest. The mangrove rivulus is primarily a saltwater or brackish water species, with limited occurrence in freshwater. Within the Everglades and along Florida's west coast, this fish occurs in stagnant, seasonal ponds, and sloughs as well as in mosquito ditches within mangrove habitats. The mangrove rivulus is able to survive in moist detritus without water for up to 60 days during periods of drought, anaerobic, or high sulfide conditions.

This fish can reach a maximum size of 2 inches (5 cm) in length, however it is more commonly observed at lengths between 0.4-1.5 inches (1.0-3.8 cm). The head and body are maroon to dark brown or tan, with small dark spots and speckling on the body, particularly the sides. The dorsal surface is always darker than the creamy ventral surface. The color of the body is reflective of the habitat, with light coloration in areas of light colored sediments and darker coloration in environments with dark leaf litter substrates. A large dark spot surrounded by a band of yellow is located at the upper base of the caudal fin in hermaphroditic individuals. Males lack this dark spot and have a red-orange cast to their flanks and fins.

The mangrove rivulus was once listed as a threatened species in the Gulf of Mexico. However, recently additional surveys have revealed the existence of numerous populations. In Florida it has been downlisted to a species of special concern. In 1999, it was submitted by the National Marine Fisheries Service as a candidate for protection under the Endangered Species Act. As of yet, it has not been officially listed as endangered or threatened.

The main threat to the survival of the mangrove rivulus is habitat degradation and destruction as well as exposure to pollutants. Disturbances that alter salinity and temperature as well as vegetation cover may also reduce naturally occurring populations.

Loggerhead Sea Turtle *(Caretta caretta*)
Loggerhead sea turtles have been documented nesting on beaches within the Clam Bay NRPA. Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific and Indian Oceans. They are the most abundant species of sea turtle found in the U.S. coastal waters. In the Atlantic, the loggerhead turtles range extends from Newfoundland to as far south as Argentina.

During the summer, nesting occurs primarily in the subtropics. Although the major nesting concentrations in the U.S. are found from North Carolina through southwest Florida, minimal nesting occurs outside of this range westward to Texas and northward to Virginia. Adult loggerheads are known to make extensive migrations between foraging areas and nesting beaches. During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and through the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán.

Loggerheads were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The top shell (carapace) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the bottom shell (plastron) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom.

In the southeastern U.S., mating occurs in late March to early June and females lay eggs between late April and early September. Females lay three to five nests, and sometimes more, during a single nesting season. The eggs incubate approximately two months before hatching sometime between late June and mid-November.

Loggerheads occupy three different ecosystems during their lives: beaches (terrestrial zone), water (oceanic zone), and nearshore coastal areas ("neritic" zone). Because of this, NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) have joint jurisdiction for marine turtles, with NOAA having the lead in the marine environment and USFWS having the lead on the nesting beaches.

The loggerhead turtle was first listed under the Endangered Species Act as threatened throughout its range on July 28, 1978. In September 2011, National Marine Fisheries Service (NMFS) and USFWS listed 9 Distinct Population Segments of loggerhead sea turtles under the Endangered Species Act (ESA). The population in the Northeast Atlantic Ocean Segment is listed as endangered. The agencies are currently proposing Critical Habitat designations on several areas which contain a combination of nearshore reproductive habitat, winter area, breeding areas, and migratory corridors. The Clam Bay NRPA is contained within the LOGG-N-27 segment of this proposed critical habitat area.

Gopher Tortoise (*Gopherus polyphemus*)
Gopher tortoises and their burrows are found along the coastal strand portions of the Clam Bay NRPA. The range of the tortoise includes southern portions of Alabama, South Carolina, Louisiana, Mississippi, and Georgia as well as most of Florida.

Gopher tortoises are one of the few species of tortoise that dig burrows. These burrows can be up to ten feet deep and 40 feet long, and are as wide as the length of the tortoise that made it. In addition to providing the tortoise a home, it has been documented that as many as 350 other species also use the burrows including the indigo snake, Florida mouse, gopher frog, and burrowing owl.

Gopher tortoises can live 40 to 60 years in the wild and average 9 to 11 inches in length. These tortoises are superb earth-movers, living in long burrows from 5 to 45 feet long and up to 10 feet deep that offer refuge from cold, heat, drought, forest fires, and predators. The burrows maintain a fairly constant temperature and humidity throughout the year and protect the gopher tortoise and other species from temperature extremes, drying out, and predators. The mating season generally runs from April through June and gestation for the eggs is between 80 and 100 days.

The shell or "carapace" of the gopher tortoise is mostly brownish gray and the underside of the

shell, or "plastron," is yellowish tan. Their front legs are shovel-like which helps them when digging their burrows.

The gopher tortoise has been regulated in Florida since 1972 and has been fully protected since 1988. Despite the afforded protection, gopher tortoise populations throughout the state have declined. As a response to the continuing decline of the species, a new management plan was drafted and approved in September 2007 as a precursor to reclassifying the gopher tortoise from a "species of special concern" to a "threatened species." The threatened status was approved and went into effect on November 8, 2007.

Piping Plover (*Charadrius melodus*)
Piping plovers have been rarely sighted foraging or resting along the shoreline within the Clam Bay NRPA boundaries. No nesting activities have been documented within the NRPA.

Piping plovers are small shorebirds approximately seven inches long with about a 19 inch wingspan. They have sandy/grey colored plumage on their backs and crown and white underparts. Breeding birds develop a single black breast band, a black bar across the forehead, bright orange legs, and bill with a black tip on the bill. During the winter, the birds lose the black bands, the legs fade to pale yellow, and the bill becomes mostly black.

Piping plovers breed in three geographic regions of North America: the Atlantic Coast (which is where the Clam Bay NRPA is located), the Northern Great Plains, and the Great Lakes. Nesting in the Atlantic Coast region occurs on coastal beaches, sand flats, and bars associated with barrier islands, gently sloped and sparsely vegetated dunes, and washover areas cut into or between dunes. Plovers from all three breeding populations winter along South Atlantic, Gulf Coast, and Caribbean beaches and barrier islands, primarily on intertidal beaches with sand and/or mud flats with no or very sparse vegetation.

Piping plover populations were federally listed as threatened and endangered in 1986. The Northern Great Plains and Atlantic Coast populations are threatened, and the Great Lakes population is endangered. Piping plovers are considered threatened throughout their wintering range. The highest concentration of birds reported in winter censuses are found in Texas, Louisiana, and Florida. In recent decades, piping plover populations have drastically declined as breeding habitat has been replaced with shoreline development and recreation. (USFWS).

West Indian Manatee (*Trichechus manatus*)
Manatees have been sighted on numerous occasions within the Clam Bay NRPA boundaries. Manatees can be found in shallow, slow moving rivers, estuaries, saltwater bays, canals, and coastal areas particularly where seagrass beds or freshwater vegetation flourish. Manatees are a migratory species. Within the U.S., they are concentrated in Florida in the winter. In summer months, they can be found as far west as Texas and as far north as Massachusetts, but summer sightings in Alabama, Georgia and South Carolina are more common.

Manatees are large, gray aquatic mammals with bodies that taper to a flat, paddle-shaped tail. They have two forelimbs, called flippers, with three to four nails on each flipper. The average adult manatee is about 10 feet long and weighs between 800 and 1,200 pounds. They eat a large

variety of submerged, emergent, and floating plants and can consume 10-15% of their body weight in vegetation daily. Because they are mammals, they must surface to breathe air. They rest just below the surface of the water, coming up to breathe on an average of every three to five minutes. It is believed that one calf is born every two to five years, and twins are rare. The gestation period is about a year. Mothers nurse their young for one to two years, during which time a calf remains dependent on its mother.

Protections for Florida manatees were first enacted in 1893. Today, they are protected by the Florida Manatee Sanctuary Act and are federally protected by both the Marine Mammal Protection Act and the ESA.

Other Species

Plant Species – *List based on FLUCFCS Mapping*

Representative Plant Species found within the NRPA Boundary

FLUCFCS Code 181 – Swimming Beach

COMMON NAME	SCIENTIFIC NAME
Seagrape	*Coccoloba uvifera*
Sea Oats	*Uniola paniculata*
Railroad vine	*Ipomoea pes-caprae*

FLUCFCS Code 322 – Coastal Scrub

COMMON NAME	SCIENTIFIC NAME
Seagrape	*Coccoloba uvifera*
Cabbage Palm	*Sabal Palmetto*
Buttonwood	*Conocarpus erectus*
Spanish Bayonet	*Yucca aloifolia*
Saltbush	*Baccharis halimifolia*
Beach Naupaka	*Scaevola taccada*
Australian Pine	*Casuarina equisetifolia*

FLUCFCS Code 428 – Cabbage Palm Hammock

COMMON NAME	SCIENTIFIC NAME
Cabbage Palm	*Sabal palmetto*
Seagrape	*Coccoloba uvifera*
Strangler Fig	*Ficus aurea*
Saffron Plum	*Sideroxylon celastrinum*
Coinvine	*Dalbergia ecastaphyllum*
Brazilian Pepper	*Schinus terebinthifolia*
Beach Naupaka	*Scaevola taccada*

FLUCFCS Code 612 – Mangrove Swamps (Forest)

COMMON NAME	SCIENTIFIC NAME
Red Mangrove	*Rhizophora mangle*
White Mangrove	*Laguncularia racemosa*

Black Mangrove	*Avicennia germinans*
Buttonwood	*Conocarpus erectus*
Leather Fern	*Acrostichum danaeifolium*
Saltwort	*Batis maritima*
Glasswort	*Salicornia bigloveii*

FLUCFCS Code 642 – Salt Marsh

COMMON NAME	SCIENTIFIC NAME
Lance-leaf Arrowhead	*Sagittaria lancifolia*
Needlerush	*Juncus roemerianus*
Bulrush	*Scirpus californicus*
Carolina Willow	*Salix caroliniana*
Peruvian Primrosewillow	*Ludwigia peruviana*

Animal Species

The following list of species has been observed within the Clam Bay NRPA and the adjacent Pelican Bay development areas. These lists are not all inclusive but represent a wide array of the species found within and adjacent to the Clam Bay NRPA habitats.

Aquatic Invertebrates *From Conservancy Report*

Aquatic Invertebrate species found within the NRPA boundary

COMMON NAME	*SCIENTIFIC NAME*
American Oyster	*Crassostrea virginica*
Brittlestar	*Ophiophragmus filograneus*
Florida Crown Conch	*Melongena corona*
Grass Cerith	*Bittiolum varium*
Heart Urchin	*Moira atropos*
Pointed Venus Clam	*Anomalocardia auberiana*
Shell-encrusted tubes	*Polychaeta*
Stout Razor Clam	*Tagelus plebeius*
Trumpet worm tubes	*Pectinaria gouldi*
Worm mud tubes	*Polychaeta spp.*
Quahog	*Mercenaria mercenaria*
Atlantic Bay Scallop	*Argopecien irradians*
Atlantic Oyster Drill	*Urasalpinx cinera*
Whelk	*Melongenidae spp.*
West Indian Worm Snail	*Vermicularia fargoi*
Lace Murex	*Chicoreua florifer dilectus*
Horse Conch	*Pleuroploca gigantean*
Mangrove Periwinkle	*Littoraria scabra anguliflera*

West Indian Worm Snail	*Vermicularia spirata*
Florida Fighting Conch	*Strombus alatus*
Penaeod Shrimp	*Penaeidea spp.*
Tunicates	*Ascidiacia spp.*
Blue Crab	*Callinectes sapidus*
Fiddler Crab	*Uca spp.*
Mangrove Mud Crab	*Ocypodidae (Ucides) spp., Grapsidae spp., and Gecarcinidae spp.*
White Fingered Mud Crab	*Rhithropanopeus harrisii*
Depressed Mud Crab	*Eurypanopeus depressus*
Common Mud Crab	*Panopeus herbstii*

Fish

Fish species found within the NRPA boundary

COMMON NAME	SCIENTIFIC NAME
American Eel	*Anguilla rostrata*
Atlantic needlefish	*Strongylura marina*
Barracuda	*Sphyraena barracuda*
Bay anchovy	*Anchoa mitchilli*
Blacktip Shark	*Carcharhinus limbatus*
Cowfish	*Acanthostracion quadricornis*
Flounder	*Paratichthys albigutta*
Gray or Mangrove snapper	*Lutjanus griseus*
Great barracuda	*Sphyraena barracuda*
Gulf killifish	*Fundulus grandis*
Hammerhead Shark	*Sphyrna mokarran*
Inshore Iizardfish	*Synodus foetens*
Killifish spp.	*Fundulus spp.*
Leatherjacket	*Oligoplites saurus*
Longnose killifish	*Fundulus simitis*
Mullet	*Mugil cephalus*
Mutton snapper	*Lutjanus anatis*
Needlefish	*Strongylura marina*
Permit	*Trachinotus falcatus*
Pigfish	*Orthopristus chrysoptera*

Pinfish	*Lagodon rhomboides*
Pipefish	*Syngnathus spp.*
Puffer	*Sphoeroides parvus*
Sailfin molly	*Poecilia latipinna*
Sand perch	*Diplectrum bivittatum*
Scaled sardine	*Harengula pensacolae*
Sea robin	*Prionotus scitulus*
Sheepshead	*Archosargus probatocephalus*
Sheepshead minnow	*Cyprinodon variegatus*
Silver jenny	*Eucinostomus gula*
Smalltooth Sawfish*	*Pristis pectinata*
Snook	*Centropomus undecimalis*
Spot	*Leiostomus xanthurus*
Spotfin mojara	*Eucinostomus argenteus*
Spotted seatrout	*Cynoscion nebulosus*
Tidewater silverside	*Menidia peninsulae*
Triggerfish (Grey)	*Balistes capriscus*
White grunt	*Haemulon plumierii*
Whiting	*Menticirrhus littoratis*

Reptiles and Amphibians

Reptile and Amphibian species found within the NRPA Boundary

COMMON NAME	SCIENTIFIC NAME
SNAKES	
Banded water snake	*Nerodia faciata faciata*
Black racer	*Coluber constrictor*
Common garter snake	*Thamnophis sirtalis*
Eastern coachwhip	*Masticophis flagellum*
Mangrove salt marsh water snake	*Nerodia clarkii*
Mud snake	*Farancia abacura*
Red rat snake*	*Elaphe guttata guttata*
Ring-necked snake	*Diadophis punctatus*
Yellow rat snake	*Elaphe obsoleta*

LIZARDS AND CROCODILIANS

American alligator*	*Alligator mississippiensis*
Brown anole	*Anolis sagrei*
Brown basilisk lizard	*Basiliscus vittatus*
Cuban knight anole	*Anolis equestris*
Eastern glass lizard	*Ophisaurus ventralis*
Green anole	*Anolis carolinensis*
Southeastern five-lined skink	*Eumeces inexpectatus*

FROGS AND TOADS

Cuban treefrog	*Osteopilus septentrionalis*
Eastern narrow-mouthed toad	*Gastrophryne carolinensis*
Eastern spadefoot toad	*Scaphiopus holbrookii*
Giant marine toad	*Rhinella marina (fka Bufo marinus)*
Green treefrog	*Hyla cinerea*
Oak toad	*Anaxyrus quercicus*
Southern leopard frog	*Lithobates sphenocephalus*
Southern toad	*Bufo terrestris*
Squirrel treefrog	*Hyla squirella*

TURTLES AND TORTOISES

Chicken turtle	*Deirochelys reticularia*
Florida box turtle	*Terrapene carolina bauri*
Florida redbelly cooter	*Pseudemys nelsoni*
Florida snapping turtle	*Chelydra serpentina osceola*
Florida softshell turtle	*Apalone ferox*
Gopher tortoise*	*Gopherus polyphemus*
Green sea turtle*	*Chelonia mydas*
Loggerhead sea turtle*	*Caretta caretta*
Peninsula cooter	*Pseudemys peninsularis*
Pond (yellowbelly) slider	*Trachemys scripta scripta*
Striped mud turtle*	*Kinosternon baurii*

Birds

Bird species found within the NRPA Boundary

COMMON NAME	SCIENTIFIC NAME
American avocet	*Recurvirostra americana*
American coot	*Fulica americana*
American kestrel	*Falco sparverius*
American oystercatcher*	*Haematopus palliatus*
American Robin	*Turdus migratorius*
Anhinga	*Anhinga anhinga*
Bald eagle	*Haliaeetus leucocephalus*
Barred owl	*Strix varia*
Belted kingfisher	*Megaceryle alcyon*
Black skimmer*	*Rynchops niger*
Black vulture	*Coragyps atratus*
Black-and-white warbler	*Mniotilta varia*
Black-bellied plover	*Pluvialis squatarola*
Black-crowned night heron	*Nycticorax nycticorax*
Black-necked stilt	*Himantopus mexicanus*
Blue jay	*Cyanocitta cristata*
Blue-gray gnatcatcher	*Polioptila caerulea*
Boat-tailed grackle	*Quiscalus major*
Brown pelican*	*Pelecanus occidentalis*
Brown thrasher	*Toxostoma rufum*
Budgerigar	*Melopsittacus undulatus*
Caspian tern	*Hydroprogne caspia*
Cattle egret	*Bubulcus ibis*
Chuck-will's-widow	*Caprimulgus carolinensis*
Common grackle	*Quiscalus quiscula*
Common ground-dove	*Columbina passerina*
Common moorhen	*Gallinula chloropus*
Common nighthawk	*Chordeiles minor*
Common snipe	*Gallinago gallinago*
Common tern	*Sterna hirundo*
Common yellowthroat	*Geothlypis trichas*

Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
Dunlin	*Calidris alpina*
Eastern screech owl	*Megascops asio*
Eurasian collared dove	*Streptopelia decaocto*
European starling	*Sturnus vulgaris*
Fish crow	*Corvus ossifragus*
Forster's tern	*Sterna forsteri*
Glossy ibis	*Plegadis falcinellus*
Gray catbird	*Dumetella carolinensis*
Great blue heron	*Ardea herodias*
Great crested flycatcher	*Myiarchus crinitus*
Great egret	*Ardea alba*
Great horned owl	*Bubo virginianus*
Greater yellowlegs	*Tringa melanoleuca*
Green heron	*Butorides virescens*
Green-winged teal	*Anas crecca*
Herring gull	*Larus argentatus*
Hooded merganser	*Lophodytes cucullatus*
House sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Laughing gull	*Leucophaeus atricilla*
Least sandpiper	*Calidris minutilla*
Limpkin*	*Aramus guarauna*
Little blue heron*	*Egretta caerulea*
Loggerhead shrike	*Lanius ludovicianus*
Long-billed dowitcher	*Limnodromus scolopaceus*
Magnificent frigate bird	*Fregata magnificens*
Mangrove cuckoo	*Coccyzus minor*
Merlin	*Falco columbarius*
Mocking bird	*Mimus polyglottos*
Mottled duck	*Anas fulvigula*
Mourning dove	*Zenaida macroura*
Muscovy duck	*Cairina moschata*
Northern bobwhite	*Colinus virginianus*
Northern cardinal	*Cardinalis cardinalis*

Northern gannet	*Morus bassanus*
Northern parula	*Parula americana*
Northern waterthrush	*Seiurus noveboracensis*
Osprey*	*Pandion haliaetus*
Painted bunting	*Passerina ciris*
Palm warbler	*Dendroica palmarum*
Peregrine falcon	*Falco peregrinus*
Pied-billed grebe	*Podilymbus podiceps*
Pileated woodpecker	*Dryocopus pileatus*
Piping plover*	*Charadrius melodus*
Prairie warbler	*Dendroica discolor*
Purple gallinule	*Porphyrula martinica*
Red knot	*Calidris canutus*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-breasted merganser	*Mergus serrator*
Reddish egret*	*Egretta rufescens*
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Roseate spoonbill*	*Platalea ajaja*
Royal tern	*Sterna maxima*
Ruby-throated hummingbird	*Archilochus colubris*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Sandwich tern	*Sterna sandvicensis*
Semipalmated plover	*Charadrius semipalmatus*
Short-billed dowitcher	*Limnodromus griseus*
Snowy egret*	*Egretta thula*
Spotted sandpiper	*Actitis macularia*
Swallow-tailed kite	*Elanoides forficatus*
Tri-colored heron*	*Egretta tricolor*
Turkey	*Meleagris gallapavo*
Turkey vulture	*Cathartes aura*
Western sandpiper	*Calidris mauri*
White ibis*	*Eudocimus albus*

White pelican	*Pelecanus erythrorhynchos*
Willet	*Catoptrophorus semipalmatus*
Wood stork*	*Mycteria americana*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Yellow-crowned night heron	*Nyctanassa violacea*
Yellow-rumped warbler	*Dendroica coronata*
Yellow-throated warbler	*Dendroica dominica*

Mammals

Mammal species found within the NRPA Boundary

COMMON NAME	*SCIENTIFIC NAME*
Big brown bat	*Eptesicus fuscus*
Bobcat	*Lynx rufus*
Bottle-nosed dolphin	*Turciops truncatus*
Brazilian free-tailed bat	*Tadarida brasiliensis*
Coyote	*Canis latrans*
Eastern gray squirrel	*Sciurus carolinensis*
Eastern mole	*Scalopus aquaticus*
Feral domestic cat	*Felis catus*
Florida Black bear	*Ursus americanus floridanus*
Florida Panther	*Puma concolor coryi*
Gray fox	*Urocyon cinereoargenteus*
House mouse	*Mus musculus*
Marsh rabbit	*Sylvilagus palustris*
Nine-banded armadillo	*Dasypus novemcinctus*
Raccoon	*Procyon lotor*
River otter	*Lutra canadensis*
Roof rat	*Rattus rattus*
Virginia opossum	*Didelphis virginia*
West Indian manatee	*Trichechus manatus*

* Indicates Endangerd Species, Threatened Species, or Species of Special Concern

APPENDIX 5 - CLAM PASS MAINTENANCE DREDGING DESIGN CRITERIA

Clam Pass Maintenance Dredging Design Criteria

June 2014

Prepared by

Humiston & Moore Engineers

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Background

This report provides an overview of the governing factors to establish design criteria for future maintenance dredging for Clam Pass. These factors are based on the physical nature of Clam Pass and monitoring data of the inlet evolution.

Clam Pass is a small wave dominated inlet on the southwest coast of Florida that provides a tidal connection to 570 acres of nature preserve including 420 acres of mangroves. The relatively small tidal prism of Clam Bay provides a critical balance between tidal flow in and out of the inlet channel and littoral processes moving to the inlet. This affects the inlet hydraulic efficiency over time, especially when littoral transport rates are high due to periods of high wave energy. During the 1990's, Clam Pass was subject to channel migration as well as closure, and frequent dredging was necessary to keep the inlet open. In 1999 Collier County, in cooperation with the community of Pelican Bay, which borders Clam Bay, implemented *The Clam Bay Restoration and Management Plan*. The purpose of the plan was to provide more sustainable tidal flushing of the wetland preserve by keeping Clam Pass open longer. The plan included dredging the inlet channel and parts of the flood shoals which had accumulated sand over many years. Those interior shoals, when present, reduce the tidal prism by obstructing tidal flow to bay areas beyond the immediate vicinity of the inlet. The implementation of *The Clam Bay Restoration and Management Plan* resulted in significant increase of the tidal prism relative to conditions prior to the 1999 dredging. The plan also included monitoring and maintenance dredging which occurred at approximately 4 year intervals. As a result, the inlet remained open for 12 years, and the areas of stressed or dying mangroves recovered.

Clam Pass requires maintenance dredging to remain an open and viable inlet and bay system. Following the 1999 dredging, maintenance dredging occurred in 2002, 2007 and 2013. The most recent maintenance dredging in 2013 took place following inlet closure in late 2012. Following the passage of Tropical Storms Debbie and Isaac and high energy wind and wave conditions during 2012, the inlet shoaled rapidly, resulting in inlet closure in September of 2012. The County obtained a state permit for the continued maintenance dredging of the inlet. Subsequently, the County, through the Pelican Bay Services Division (PBSD), obtained a federal permit to reopen the inlet, following the same channel template that had been permitted since 1999. The complete closure of the inlet in late 2012 resulted in the collapse of its ebb shoal onto the beach and a relatively large volume of sand was pushed onshore by waves. The inlet reopening was completed in April 2013 and tidal exchange between the bay and the Gulf of Mexico was restored to near design levels.

Governing factors for Inlet Channel Stability

The inlet channel is one part of a larger tidal inlet system where the inlet connects the bay system to the Gulf of Mexico. The tidal flow through flood and ebb tides interacts with active beach wave and sediment transport processes that influence the stability of a tidal inlet. The morphologic features of a tidal inlet include ebb shoal, flood shoal and inlet channel. **Figure 1** illustrates these three features. The flood shoal includes the sand shoals on the bay side of the inlet channel. The flood shoal is less dynamic than the gulf side of the inlet as it is influenced mainly by tidal flow and sheltered from the varying wave conditions on the open coast side. The ebb shoal features can be explained as sand bar features forming a delta on the open coast side of the inlet. The ebb shoal delta shields the inlet channel from waves and provides pathways for sand transport along the coast to bypass the channel without shoaling the inlet closed. A stable inlet system requires an ebb shoal feature that prevents rapid shoaling at the inlet mouth. The inlet channel maintains its flow cross section through tidal flow that scours the channel to required flow area while the waves are moving large amounts of sand along coast. The stability and dynamics of a tidal inlet is based on the balance of the two forces of tidal flow versus wave induced current and sand transport. The direction of wave action plays a significant role in the shape and dynamics of the inlet features.

Clam Pass is critically stable but subject to shoaling and therefore requires regular monitoring to determine when dredging is required to prevent inlet closure. The relatively small bay area compared to other estuaries in southwest Florida provides adequate tidal flow to keep the inlet open under typical conditions. The narrow nature of the flood shoal area, surrounded by mangrove forest limits the flood shoal capacity to maintain an equilibrium volume and bypass additional sand to the gulf and bay waters. The accumulation of sand over long periods of time, especially within the flood shoal and inlet channel creates additional resistance to flow. This additional resistance causes a reduction in the tidal range within the bay system and consequently reduces the flow through the inlet. Reduced flow through the inlet may be detrimental to the inlet remaining open. Maintenance dredging to restore the flow rates to stable magnitude is needed prior to reaching such shoaling conditions. The design criteria presented in this report aim to establish guidelines for the inlet stability to assist in determining the need for maintenance dredging. Design objectives also aim to minimize dredging to essential maintenance needed to maintain an open inlet and protect the valuable environmental resources by restoring flushing and to allow natural evolution of the inlet morphological features.

The hydraulic and physical monitoring data of the Clam Bay system collected since 1998 to date were used to evaluate the governing parameters for the inlet hydraulic stability. The monitoring data for Clam Pass indicates that the dynamic nature of the inlet is consistent with that of a wave-dominant small tidal inlet where the inlet channel and ebb shoal morphologic features (sand bodies) may change shape following sustained wave and wind conditions. During the summer months, persistent winds and waves from the southwest cause the inlet channel and ebb shoal to migrate to the north. The fall and winter wave climate is predominately from the northwest direction, which pushes the inlet southward. The seasonal variation of wind/wave energy windows and the temporal cycle of the tides result in the shifting of the channel entrance and morphologic features around the inlet entrance. Recently collected monitoring data shows the inlet to be hydraulically stable, with an adequate flow cross section to maintain the inlet open. The data also show the dynamics of the inlet channel and ebb shoal features.

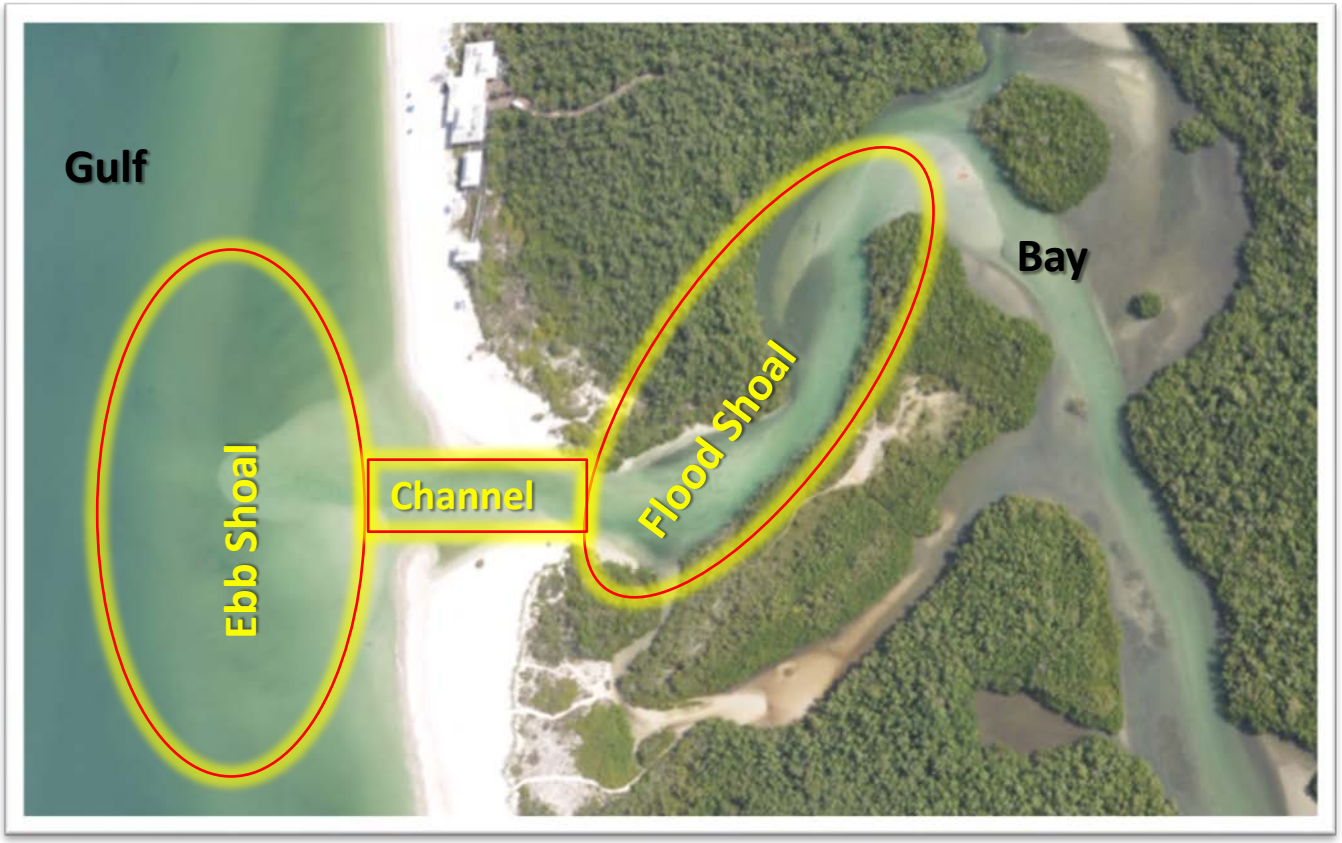


Figure 1. Clam Pass Morphologic Feature Definitions

Bay Tide Range

The existing hydraulic monitoring program provides water level measurements at several stations within the bay system. The hydraulic monitoring data provides a record of the tidal range in the bay which is an indicator to the tidal prism or volume of water flowing through the inlet at each tidal cycle. In this analysis a review of ratios of the bay tidal range to that of the gulf tide is used as the monitoring indictor to the flow through the inlet. **Figure 2** shows a definition sketch illustrating the tidal ranges for the gulf and bay. The bay tidal range is typically smaller than that of the gulf tide due to flow resistance through the inlet channel and shoal features. The figure also shows the locations of two of the bay tidal gages that are used in this analysis to represent the bay tide range.

Figure 3 shows a plot of the annual ratios of bay to gulf tide from 1998 to date. However, data collected in 2006 and 2007 were insufficient to provide an annual representation of the tidal range ratio. The figure indicates that when the inlet was hydraulically stable the ratio between the bay and gulf tide was between 0.6 and 0.7 over 90% of the time. The data also show that this ratio was below 0.5 prior to 1999 dredging when the inlet was unstable and in 2012 prior to the inlet closure. Dredging occurred in 2002 and 2007 while the tide range ratio was within the stable range. These dredging events were carried out based on physical monitoring data. In both dredge events, approximately one-third of the 1999 dredge quantity had accumulated within the dredge template at the time of dredging. In both dredge events the dredged material was placed south of the inlet.

Physical Monitoring Data Analysis

In addition to the hydraulic monitoring program, analysis of the physical monitoring data is used to characterize the flow areas and shoaling within the channel and flood shoal areas. The physical monitoring data includes bathymetric surveys of the inlet channel, flood shoal and ebb shoal features. The data analysis includes evaluation of the flow cross-section areas in three main sections of the dredging template, Sections A, B and C. **Figure 4** shows the dredge template and the three monitoring segments. Section A represents the inlet channel, Section B represents the seaward part of the flood shoal and Section C represents the bay side part of the flood shoal. The analysis included evaluation of the cross section of flow below mean high water and volume of sand within each segment. The cross section of flow was computed at each survey station spaced approximately 50 feet apart. The average and minimum cross section areas were used as indicators of the physical condition of the flow area through each of the three segments. The cross section areas were compared to the design cross section area of 2013 dredging and the inlet conditions in 2004 and 2008. The 2008 and 2004 inlet conditions were used as a background benchmark for inlet conditions near equilibrium as the 2004 and 2008 survey were completed 2 years and 16 months following the 2002 and 2007 dredging event respectively. These conditions represent the inlet at stable conditions after the post dredging adjustment phase.

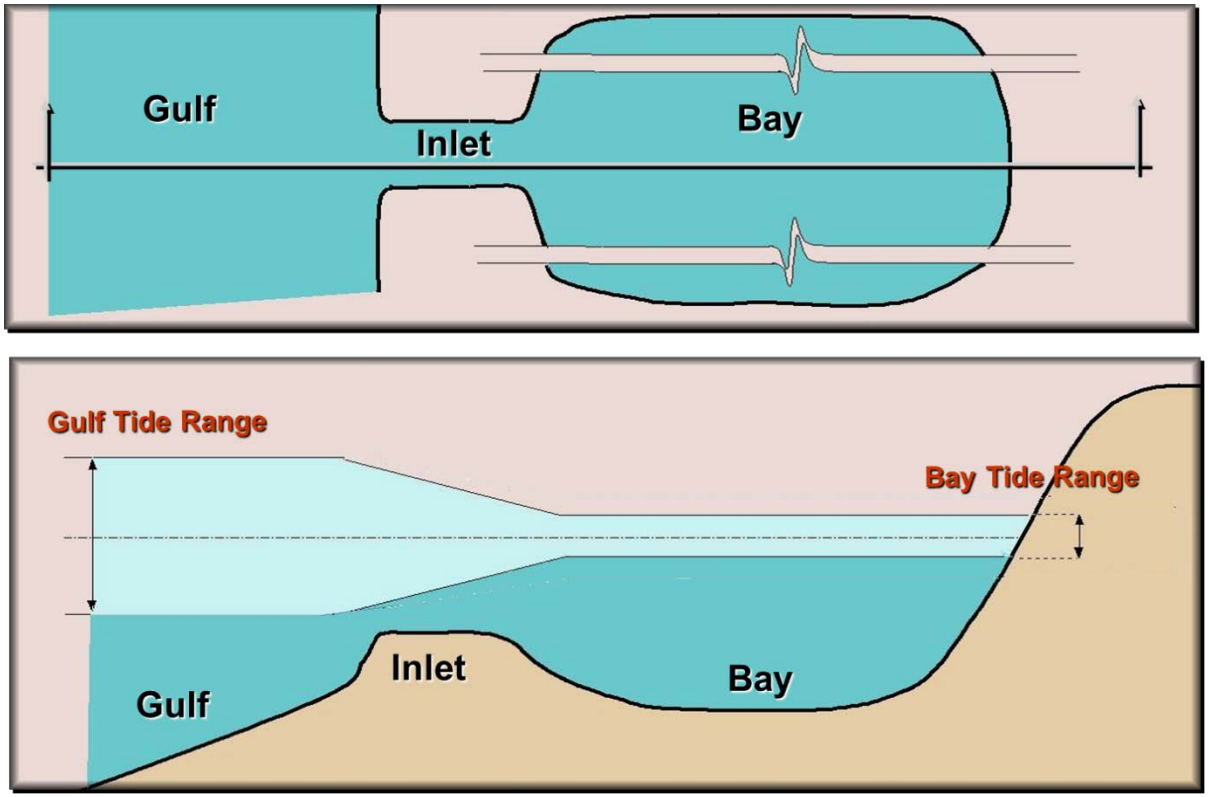




Figure A5-1. Clam Pass Tidal Range

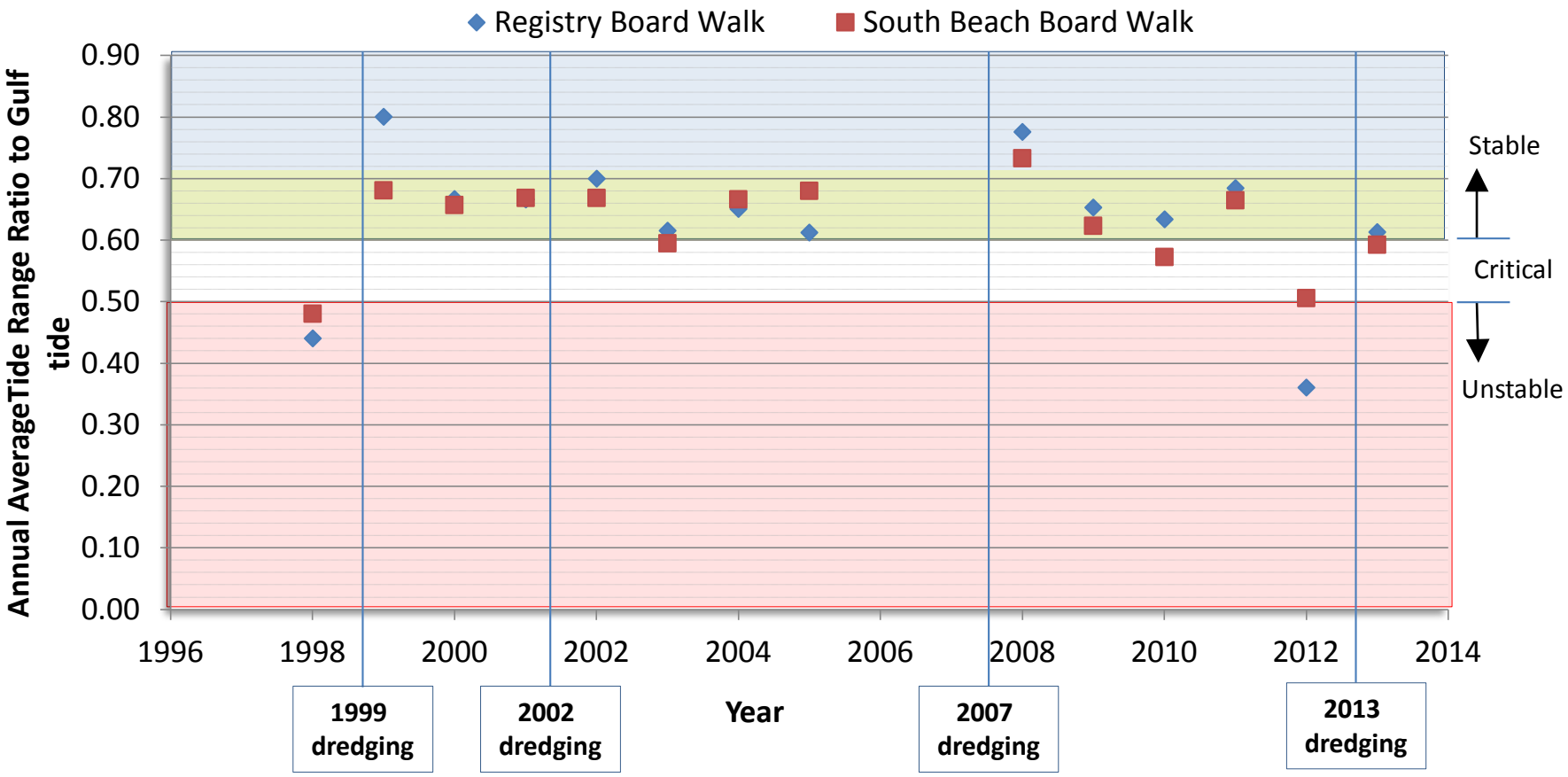


Figure A5-2. Clam Bay Tidal Range Ratios

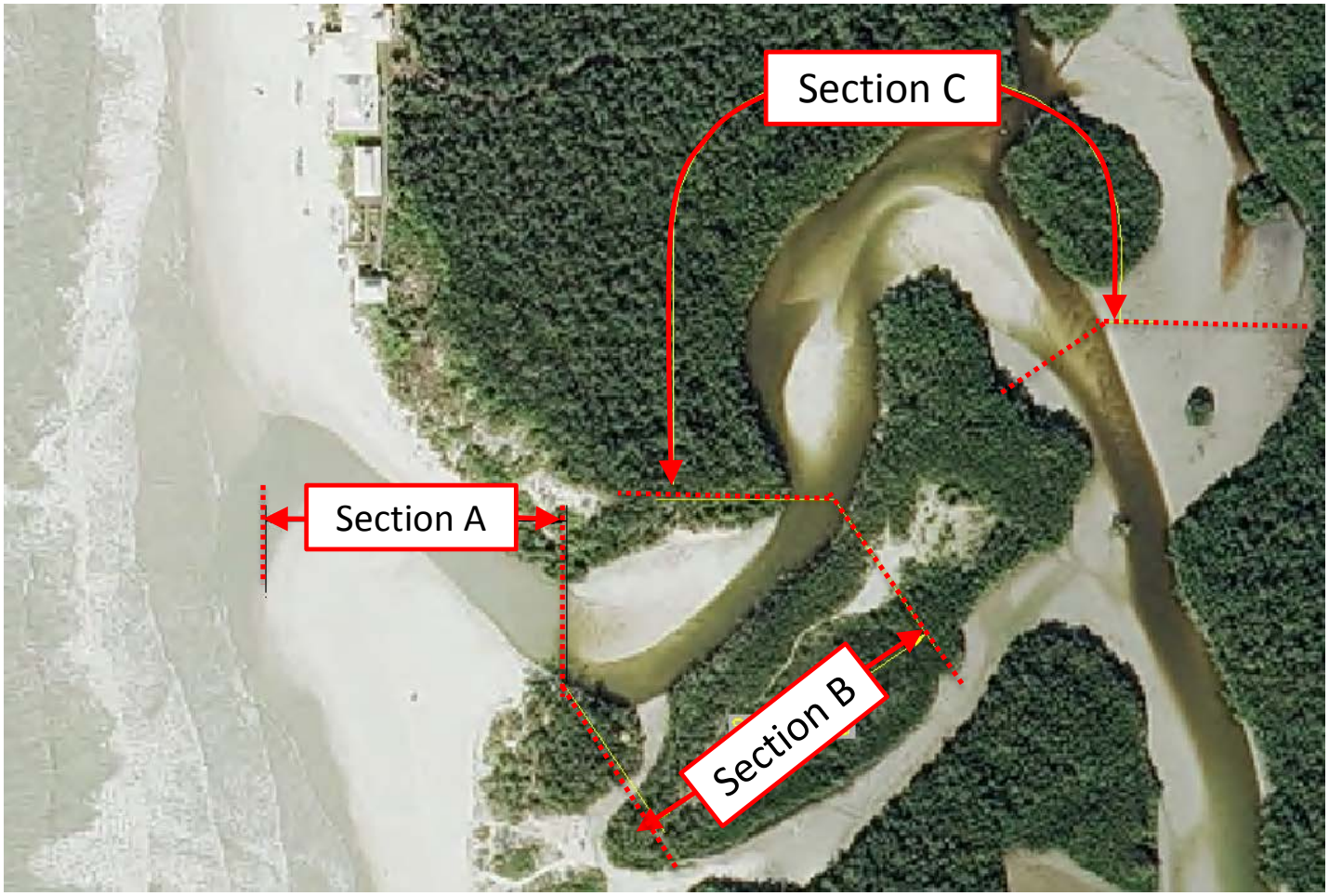


Figure A5-3. Clam Pass Monitoring Segments

Section A Inlet Channel

The indicators used in this analysis were average cross section area, minimum cross section area and total volume of sand within Section A.

Figure 5 shows the change of average flow cross- section area below mean high water for Section A. The figure covers the time period from January 2013 (pre-dredging conditions) to April 2014 (12 months post-dredging). The figure shows the change in cross-section area from pre-dredging conditions when the inlet was closed and its evolution immediately following dredging to 4 months, 7 months, and 12 months post dredging. The figure also shows the benchmark reference areas for the 2004 and 2008 average cross sections and the 2013 design cross section area. The data indicate that following the inlet opening in 2013 the average cross section shoaled below the design area while the inlet morphologic features were forming. After the initial adjustments the cross section area increased to above the design area and 2008 conditions, but remained below the 2004 conditions.

Figure 6 shows the change of the minimum flow cross section area below mean high water for Section A. The figure also shows the change in minimum cross section area from pre-dredging to 12 months post dredging with comparison to the 2004 and 2008 minimum cross sections and the 2013 design cross section area. The data indicate that following the inlet opening the minimum cross section shoaled then steadily increased. The minimum cross section area remained smaller than the design cross section area, but approaches the design cross section area after 12 months.

Figure 7 shows the change in total volume of sand accumulated in the dredge template since inlet opening. The figure shows that the Section A dredge template has accumulated sand within the dredge cut. It should be noted that the channel migrates and meanders within in the vicinity of the dredge cut. Thus, this indicator should not be used as a measure of critical conditions of the channel.

Figure 8 shows a table of the design criteria parameters for Section A with comparisons to post dredging measurements. Recommended target values for each parameter are shown in red.

Section B Flood Shoal

The cross section area of flow through the flood shoal in Section B is an important indicator of the flow exchange between the bay and inlet and the flow efficiency to maintain the tidal range within the bay.

Figure 9 shows the change of average flow cross section area below mean high water for Section B since inlet reopening. The figure covers the time period from January 2013 (pre-dredging conditions when the inlet was closed) to 12 months post dredging in April 2014. The figure shows how the average cross section evolved immediately following dredging to 4 months, 7 months and 12 months post dredging. The figure also shows the benchmark reference cross section areas for the 2004 and 2008 conditions and the average design template dredged in 2013. The data indicate that following the inlet opening the average cross section shoaled below the design area while the inlet morphologic features were forming. This process has continued throughout the 12 months post dredging. The cross section area remained larger than 2004 and 2008 conditions during the first 6 months post dredging then shoaled significantly in the following 6 months. The 12 months post dredging data indicate that the average cross section area within Section B became smaller than both historical benchmark conditions of 2004 and 2008.

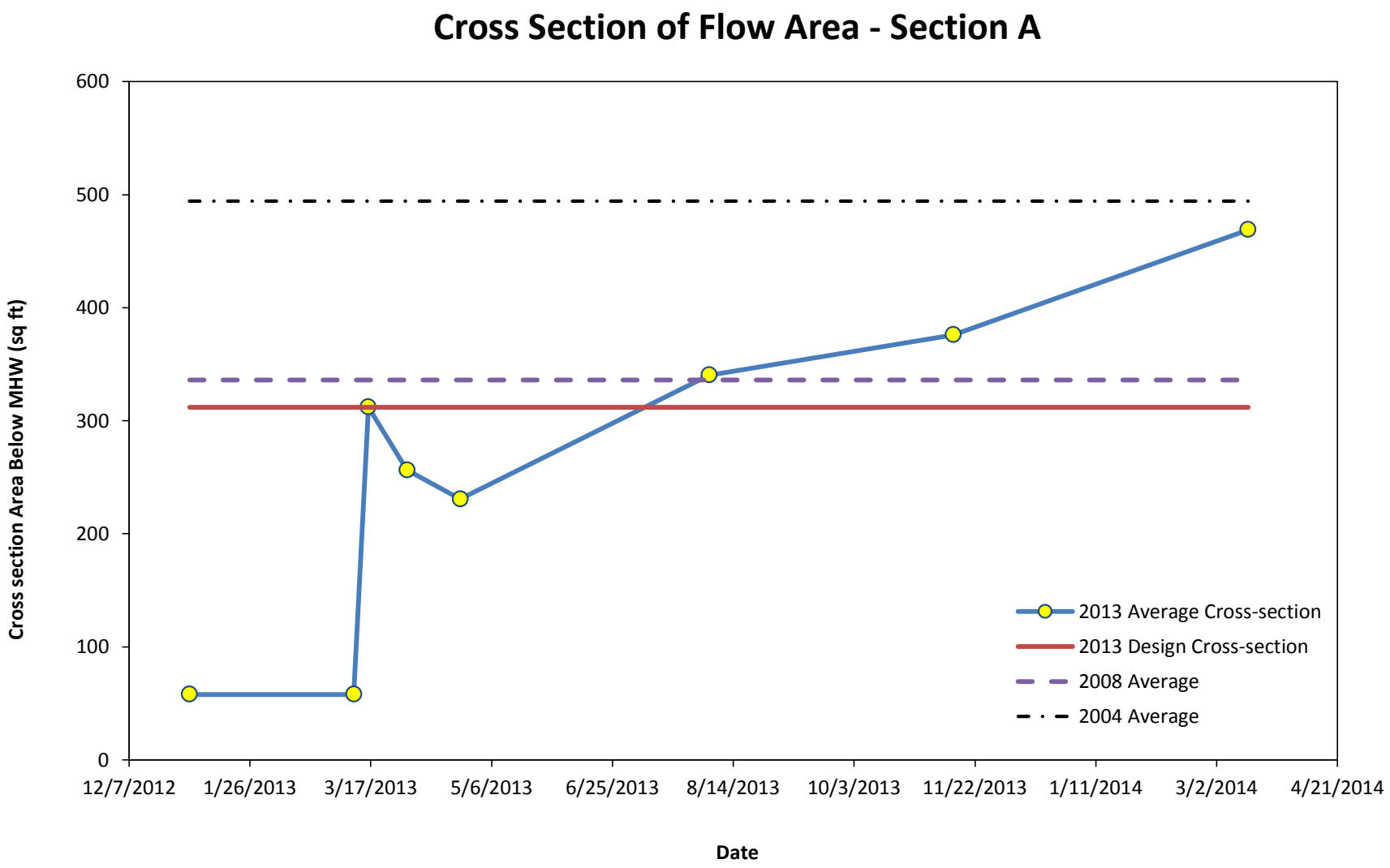


Figure A5-4. Average Cross Section of Flow Area – Section A

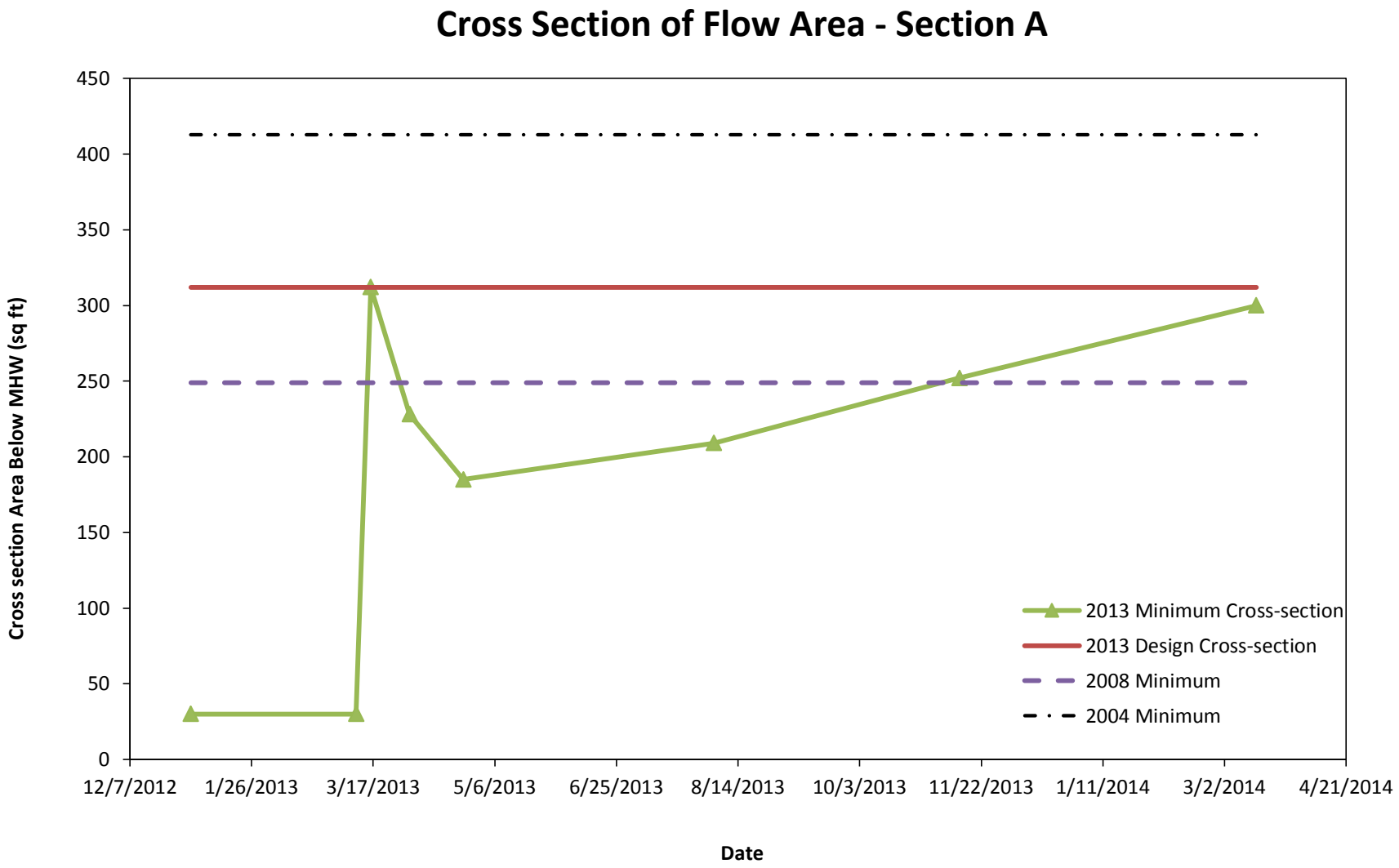
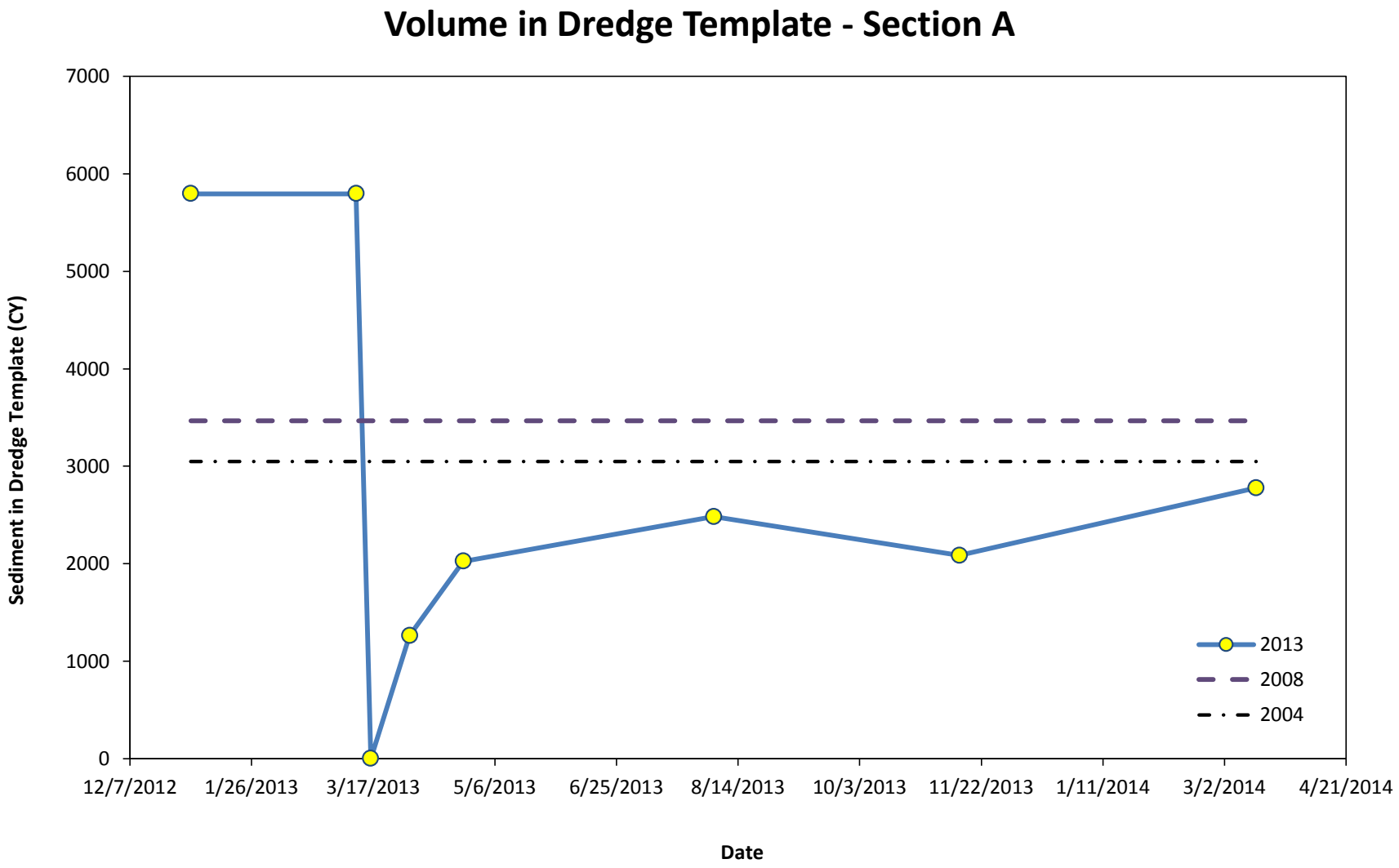


Figure A5-5. Minimum Cross Section of Flow Area – Section A



FigureA5-6. Volume of Material in Dredge Template – Section A

Section A
Design Criteria and Monitoring Data



	Cross-section Avg (ft^2)	Cross-section Min (ft^2)	Volume within Template (yd^3)
2004	*500*	*420*	*3000*
2008	*340*	*250*	*3500*
2013 Design	312	312	0
Target	>300	>250	<3000
Post Const	300	300	0
3m post	340	220	2500
6m post	375	250	2100
12m post	470	300	2800

Figure A5-7. Design Criteria for Section A with Comparisons to Post-2013 Dredging Evolution

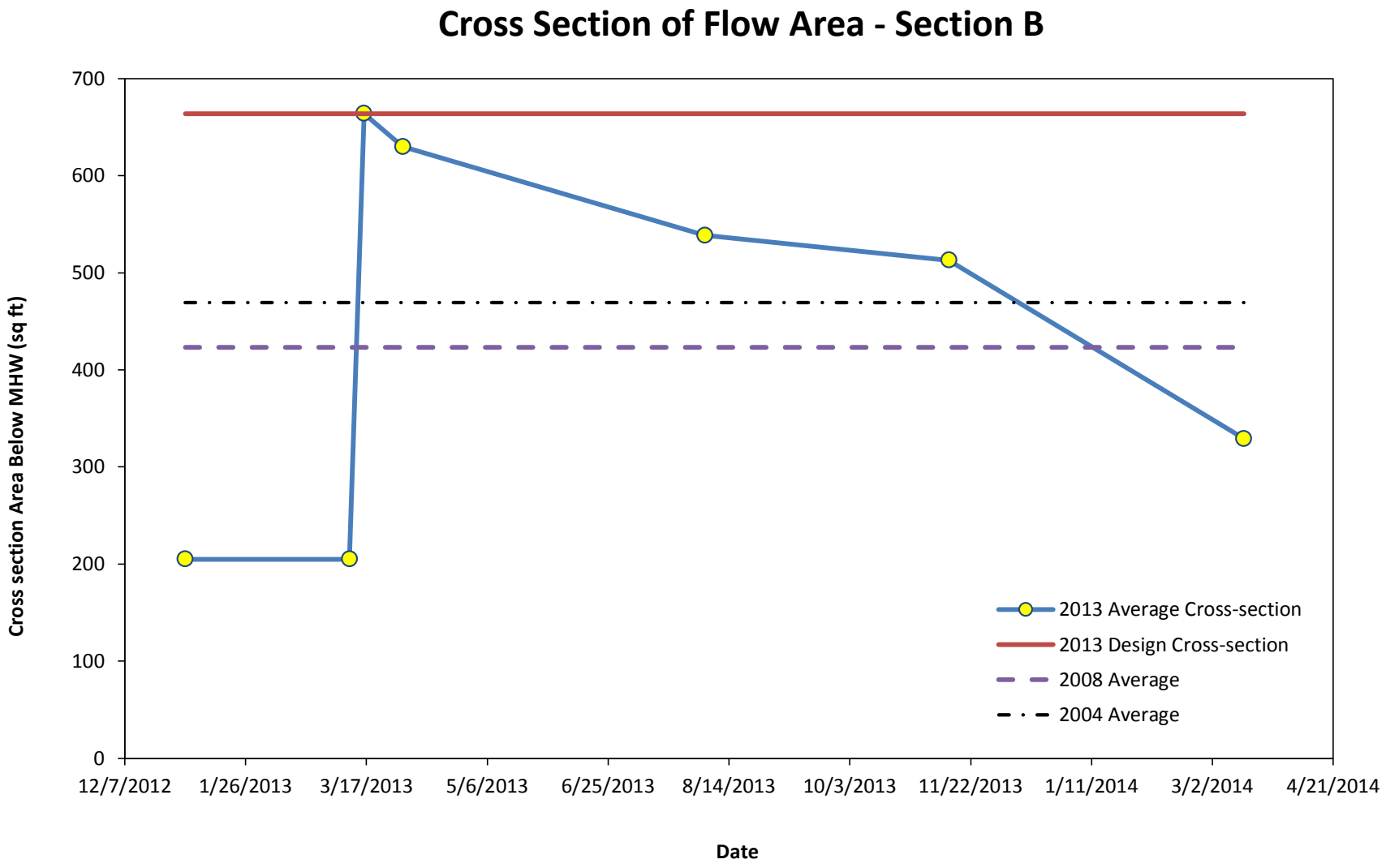


Figure A5-8. Average Cross Section of Flow Area – Section B

Figure 10 shows the change of the minimum flow cross section area below mean high water for Section B since inlet opening. The data indicate that following inlet opening the minimum cross section shoaled to a level similar to the 2008 conditions. After the initial post dredging adjustment the minimum cross section area of flow, the 4 month and 7 month post dredging conditions became larger than the conditions of 2004 and 2008. However, at 12 months post dredging the minimum cross section dropped below the 2004 and 2008 conditions.

Figure 11 shows the change in total volume of sand accumulated in the dredge template following inlet opening. The figure shows that over 5,500 cubic yards of sand were dredged from Section B. Over the 12 months since dredging nearly 5,000 cubic yards have accumulated in Section B. The amount of material accumulated in Section B after 12 months was much greater than the 2004 and 2008 conditions. **Figure 12** shows a table of the design criteria parameters for Section B with comparisons to post dredging measurements. Recommended target values for each parameter are shown in red.

Section C Outer Flood Shoal

Section C represents the outer (bay side) flood shoal area of Clam Bay which is also a junction in the Clam Bay system where flow from the north and south tributaries connects to the inlet. Restriction of this area below design levels may reduce the tidal ranges in the bay system and therefore reduce tidal flow through the inlet. Only part of Section C was dredged in the 2013 maintenance dredging. This analysis is presented in part based upon the dredged portion of Section C and in part based upon the entirety of Section C.

Figure 13 shows the change of average flow cross section area below mean high water for the dredged portion of Section C in 2013. The figure covers the time period from January 2013 to 12 months post dredging. This illustrates pre-dredging conditions when the inlet was closed, how the average cross section evolved immediately following dredging, 4 months, 7 months, and 12 months post dredging. The figure also shows the 2008 average cross section area and the design template area dredged in 2013. The data indicate that since Section C was partially dredged the average cross section remained below the 2008 conditions. The data also shows that the average cross section area in the dredged portion of Section C was similar to the 2008 conditions at 7 months post dredging and approached pre-dredging conditions at 12 months post dredging.

Figure 14 shows the change of the minimum flow cross section area below mean high water for all of Section C following inlet opening. The data indicate that since Section C was partially dredged the average cross section generally remained below the 2004 and 2008 conditions.

Figure 15 shows the change in total volume of sand accumulated in the dredged portion of Section C since inlet opening. The figure shows that over 2,000 cubic yards of sand were dredged from Section C. Over the 12 month period since dredging, approximately 1,500 cubic yards have accumulated in Section C. The accumulated material in the dredged portion of Section C is greater than the conditions of 2004 and 2008.

Figure 16 shows the change in total volume of sand in all of Section C including the part that was not dredged in 2013. This figure illustrates the relative amount of dredging to the total volume within the template. The figure also shows the volumes within the template for 2004 and 2008 conditions.

Figure 17 shows a table of the design criteria parameters for Section C with comparisons to post dredging measurements. Recommended target values for each parameter are shown in red.

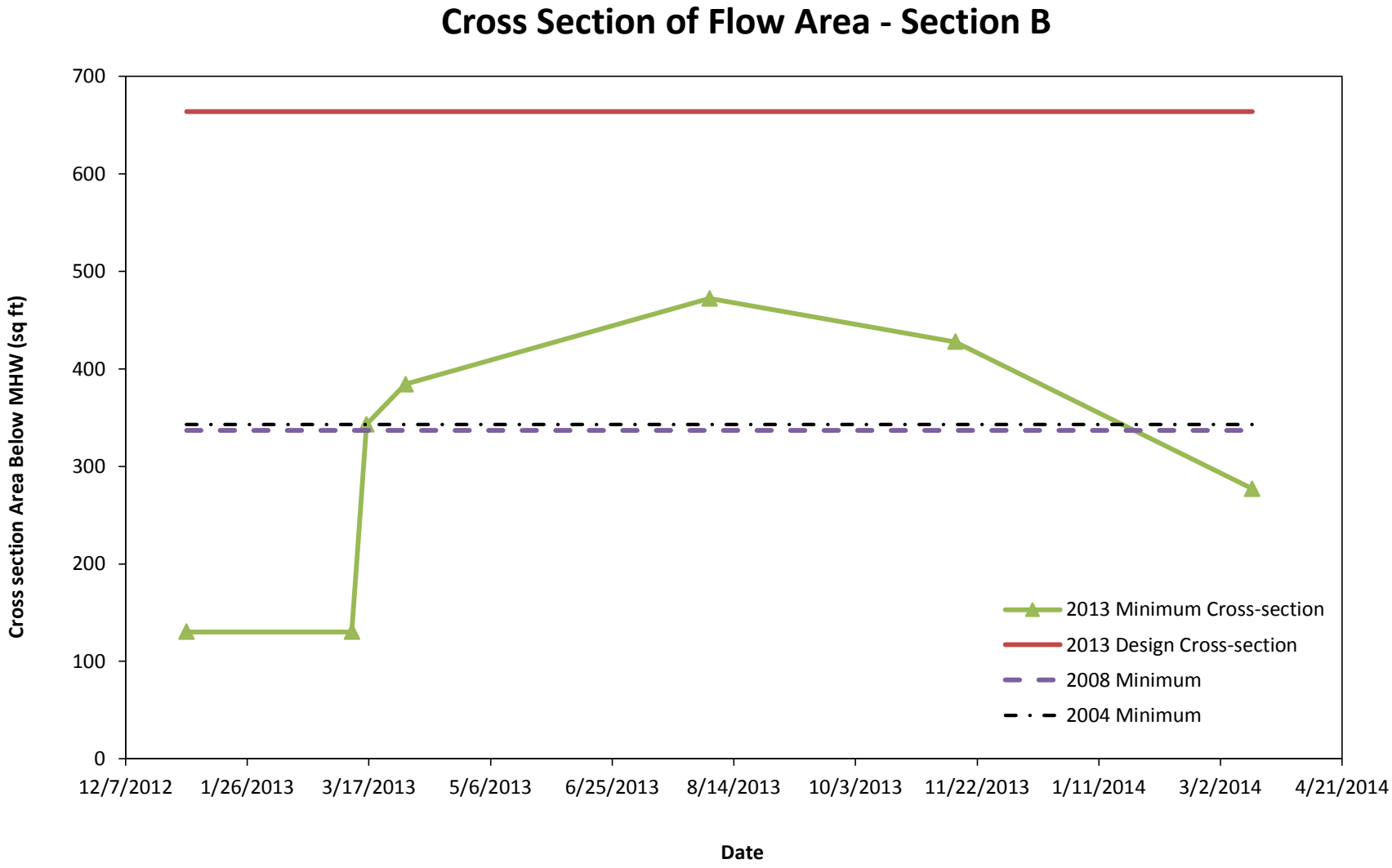


Figure A5-9. Minimum Cross Section of Flow Area – Section B

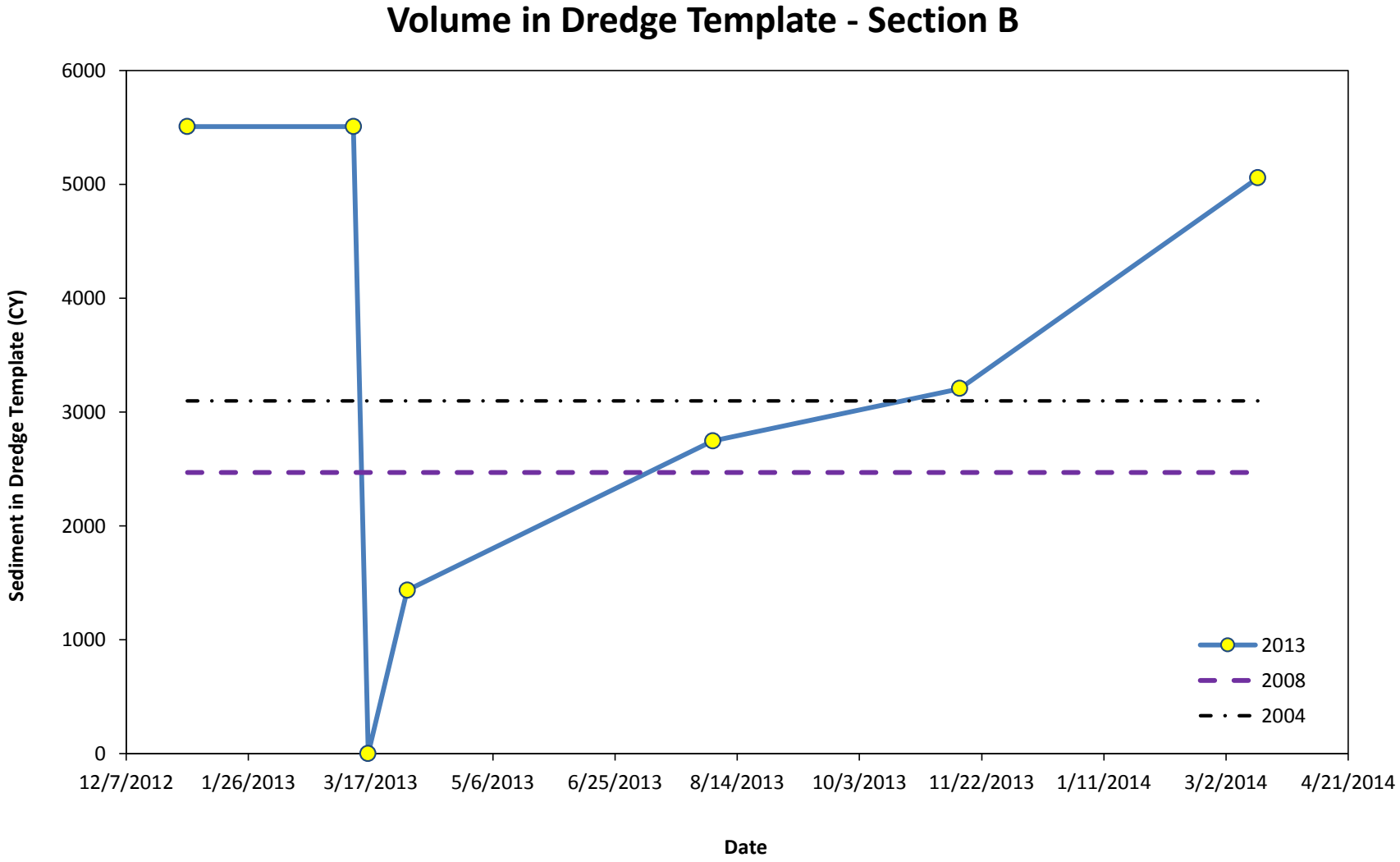


Figure A5-10. Volume of Material in Dredge Template – Section B

Section B
Design Criteria and Monitoring Data



	Cross-section Avg (ft^2)	Cross-section Min (ft^2)	Volume within Template (yd^3)
2004	*470*	*345*	*3100*
2008	*425*	*335*	*2500*
2013 Design	650	350	0
Target	>450	>350	<2500
Pre Const	200	150	5500
Post Const	650	350	0
3m post	550	450	2750
6m post	500	400	3200
12m post	325	275	5050

Figure A5-11. Design Criteria for Section B with Comparisons to Post-2013 Dredging Evolution

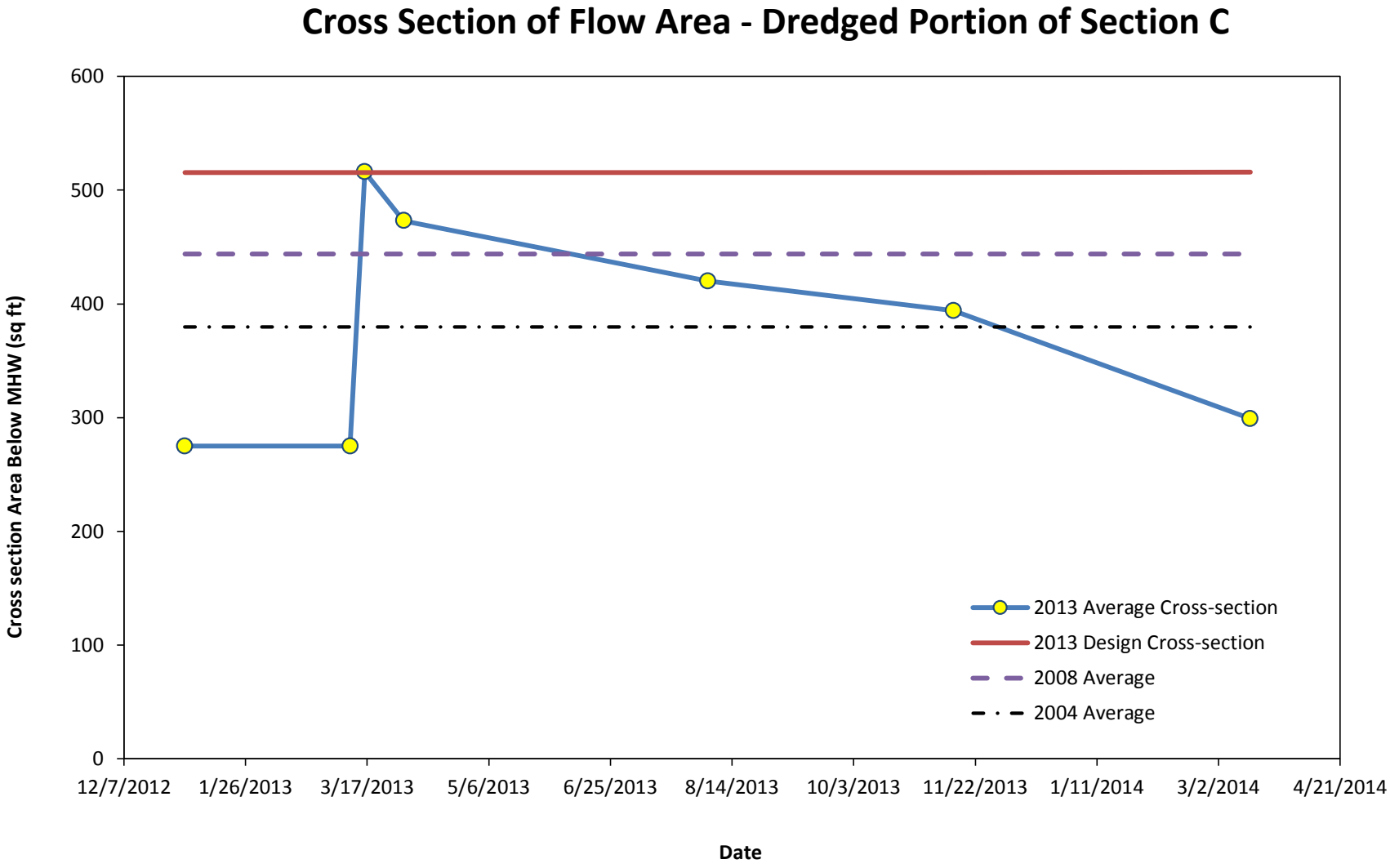


Figure A5-12. Average Cross Section of Flow Area – Section C

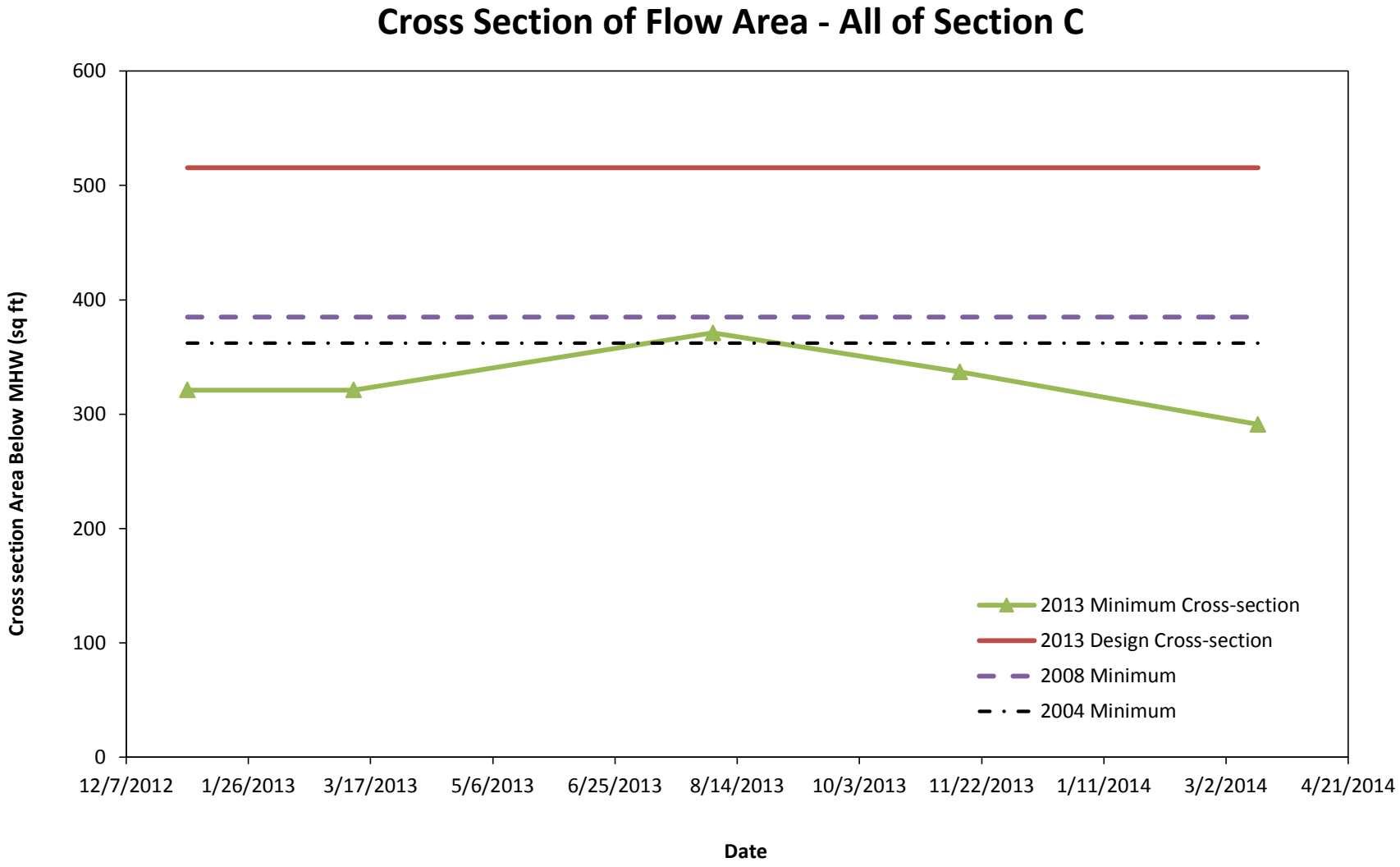


Figure A5-13. Minimum Cross Section of Flow Area – Section C

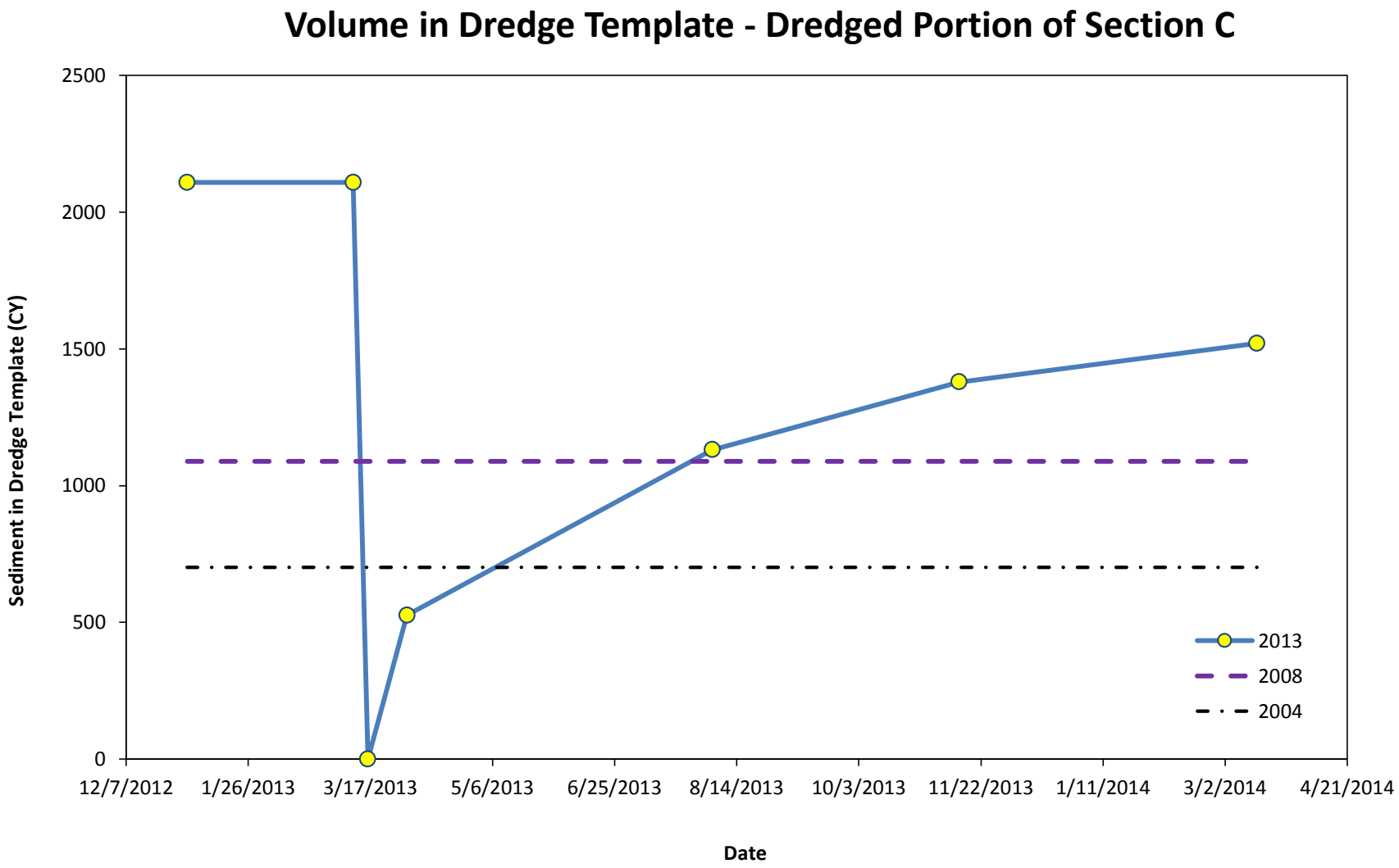


Figure A5-14. Volume of Material in 2013 Dredge Template – Section C

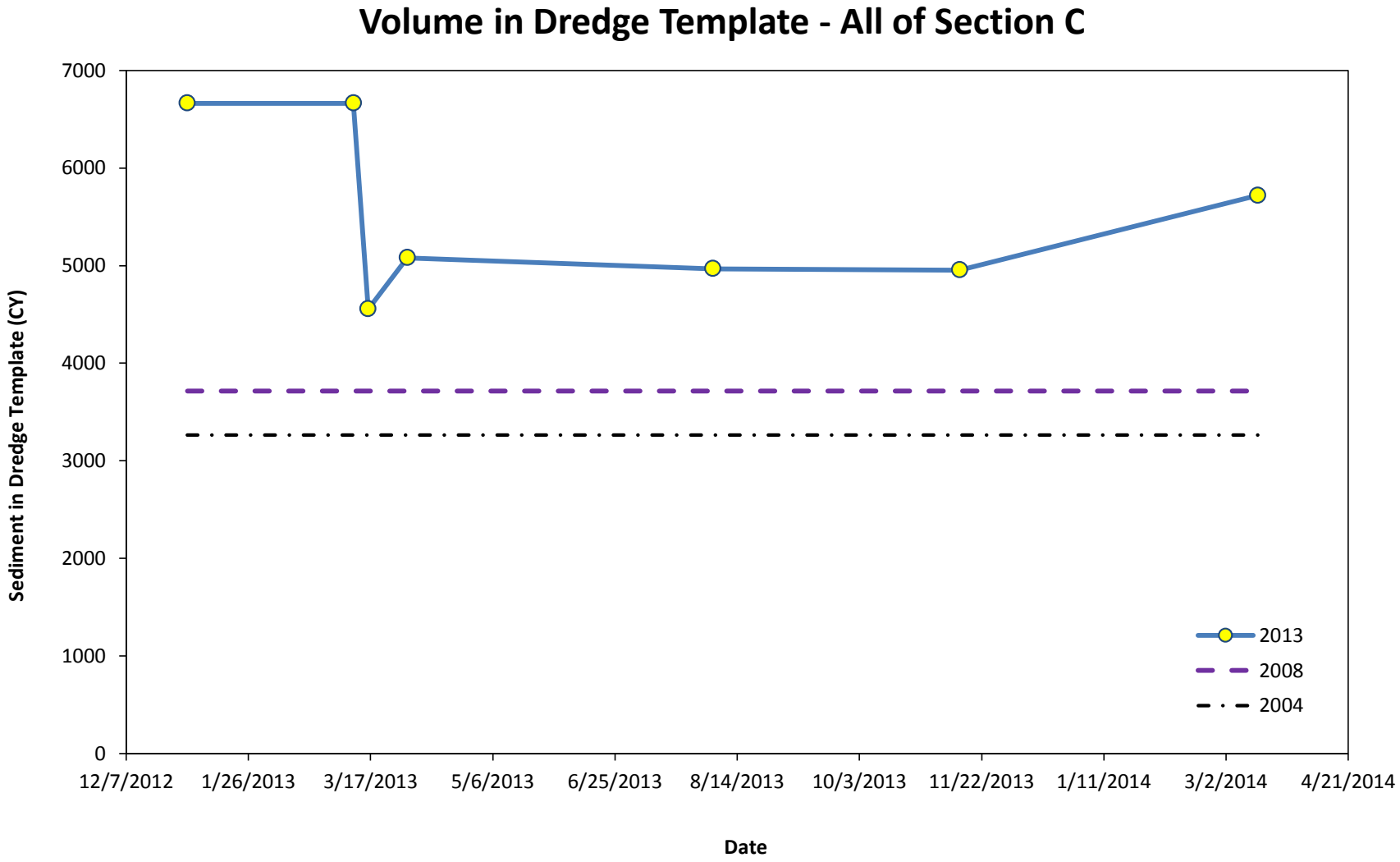


Figure A5-15. Volume of Material in Dredge Template – Section C

Section C – Dredged Portion Only
Design Criteria and Monitoring Data



	Dredged Cross-section Avg (ft^2)	Dredged Cross-section Min (ft^2)	Volume within Overall Template (yd^3)
2004	*380*	*360*	*3250*
2008	*450*	*385*	*3700*
2013 Design	500	350	0
Target	>450	>350	<4000
Pre Const	400	300	6500
Post Const	500	400	4500
3m post	425	375	5000
6m post	400	350	5000
12m post	300	300	5700

Figure A5-16. Design Criteria for Section C with Comparisons to 2013-Post Dredging Evolution

Inlet Channel Length

The channel length is an important factor in the inlet stability parameters. A longer inlet channel will provide greater resistance to flow. Higher flow resistance will reduce the tidal range and increase the phase lag with the gulf tide which reduces the tidal prism and flow through the inlet.

Figure 18 shows a selection of aerials showing Clam Pass from 2004 to 2013. The figure shows the range of channel orientation and change in channel length and beach width on both sides of the inlet during that period.

Figure 19 shows a plot of the approximate channel length measured at the center line of the channel through Section A from open coast to the beginning of Section B. The plot shows the dredged channel length of approximately 250 feet. Pre-dredging conditions show a channel length of over 500 ft. The data shows the channel in Section A meandered to over 600 feet in length before the inlet closed in 2012.

Figure 20 shows a table of the design criteria parameters for channel length with comparisons to post dredging measurements and mapping of the channel evolution since reopening in April 2013. The recommended target value for channel length is shown in red.

A similar situation also occurs in Sections B and C. After dredging, these Sections behave as bay areas where sand may accumulate. As sand accumulates these areas become channelized. This channelization increases the overall channel length and adds to the flow resistance and attenuation of the bay range. When the flood shoal areas fill to capacity, the connection between the gulf and bay become a very long meandering channel that dissipates the tidal range and diminish the flow rate beyond critical conditions needed to keep the inlet open. Such conditions existed in the late nineties and in 2012 prior to inlet closure. Maintenance dredging of Sections B and C as conducted in 1999, 2002, 2007 and partially in 2013 is necessary to keep the inlet stable.

Ebb shoal

The size and shape of the ebb shoal is a key factor to the stability of the inlet that supports the stability of the system. The ebb shoal helps to keep the inlet open when facing storms and big wave events. The ebb shoal delta provides sheltering to the channel and sand bypass pathway around the inlet without filling it closed. The shape and volume of the ebb shoal are additional indicators of the stability of the inlet. Ebb shoal critical conditions include onshore collapse of the ebb shoal that can be indicated by significant change in ebb shoal offshore distance, volume, and increase in dry beach areas adjacent to the inlet.

Figure 21 shows a table for the ebb shoal design criteria parameters and monitoring measurements since inlet opening in April 2013. Recommended target values for the ebb shoal are presented in red.

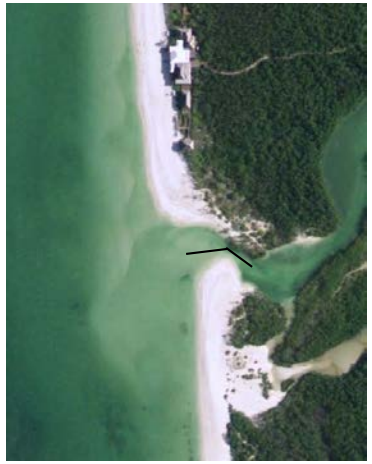


December 2004



October 2005

Dredged



May 2007



November 2008



December 2008



April 2010



April 2012

Dredged



March 2013

Figure A5-17. Clam Pass Channel Evolution 2004-2013

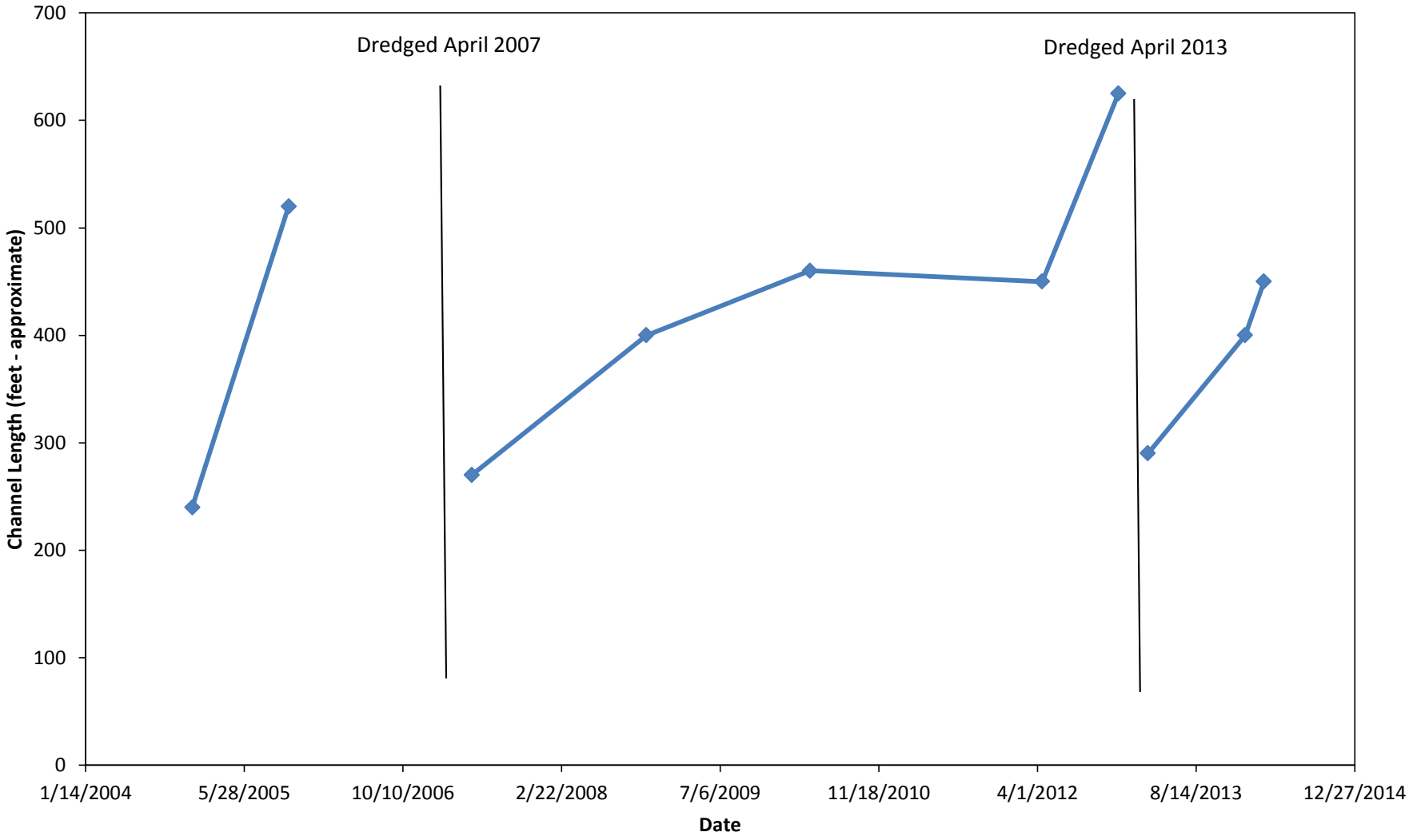


Figure A5-18. Approximate Length of Inlet Channel over Time

	L (ft)
Design	250
Target	< 400
Pre const	>600
Post Const	350
3m post	300
6m post	400
12m post	450

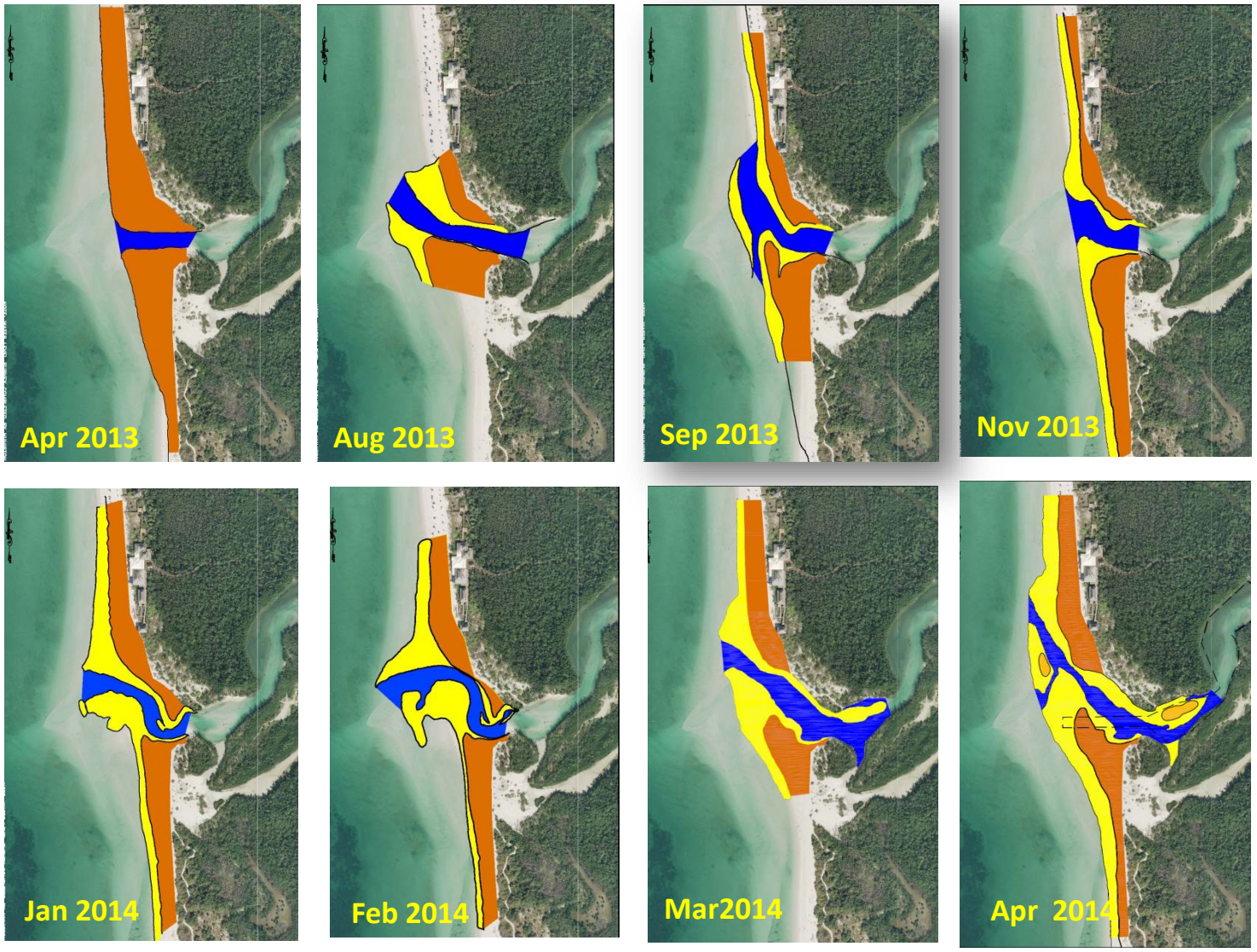


Figure A5-19. Inlet Channel Length

	Seaward Extent of Ebb Shoal (ft)	Ebb Shoal Area (ft^3)	Ebb Shoal Size (yd^3)
2008	*345*	*255,000*	*27,750*
Target	>250	200,000	25,000
Pre const	115	110,000	10,000
Post Const	80	115,000	8,300
3m post	245	110,000	13,000
6m post	290	145,000	16,800
12m post	195	175,000	20,800

NOTES:
1. Seaward Extent determined from channel inlet seaward to -4 feet NAVD.
2. Area determined from Mean High Water to -4 feet NAVD.
3. Volume determined between surveyed bathymetry and shoreline if no inlet present.

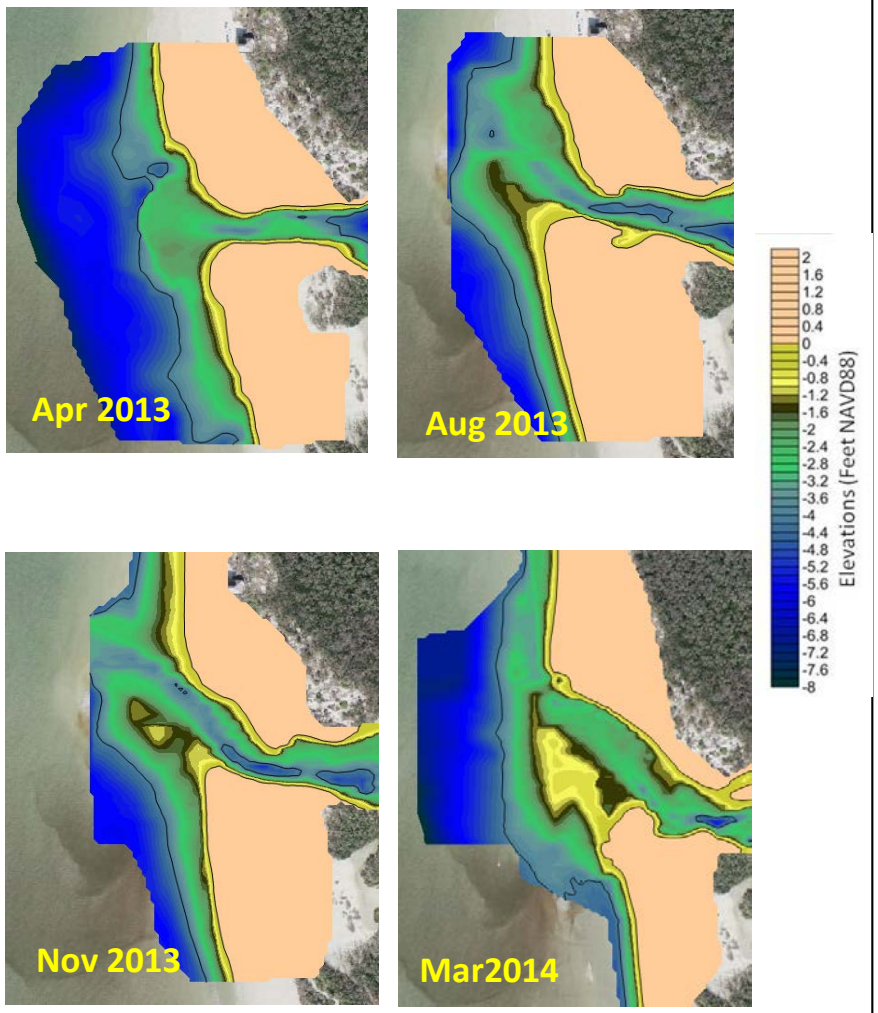


Figure A5-20. Ebb Shoal Design Criteria and Post-2013 dredging.

Summary and Recommendations:

This draft provides the main interrelated inlet stability indicators to be monitored for the management of Clam Pass. The inlet design criteria include "target" ranges to be observed for the following parameters; Bay Tidal Range, Average and Minimum Cross Section Flow Area, Volume of Shoaled Material within the template, Channel Length and Ebb Shoal Size and Area. The following monitoring measures are recommended to be included in the inlet management plan.

1. It is recommended to continue to monitor the tide range in the bay on monthly basis to understand the level of hydraulic stability of the system. Based on previous tidal data monitoring records, inlet flow stability can be indicated when the tidal range ratio remains above 0.6. If the monthly tidal range ratio drops below 0.6 but above 0.5, further monitoring is needed to observe monthly trends. If the range drops below 0.5 or displays a downward trend for three consecutive months, then physical monitoring surveys should be done promptly to evaluate potential shoaling areas that could be impeding the tidal flow.
2. The physical monitoring data is important to quantify the flow areas and shoaling throughout the dynamic parts of the system. It is necessary to continue to monitor the physical changes in the inlet annually under stable hydraulic monitoring indicators. However, It is recommended to monitor the physical changes at 6 month interval when possible. If tidal monitoring data show relative tidal ranges in the critical range, field observation while continuing to monitor the tidal range for the following months are necessary. If the hydraulic monitoring indicates a continued trend down towards the unstable range, then additional physical monitoring should be done as an emergency survey to quantify shoaling areas and examine need for maintenance dredging.
3. The design criteria identified in this report should be used as indicators to the level of stability for the inlet. When dredging is deemed necessary, it is recommended to follow the design cross section areas as stated in the design range with consideration to existing conditions at the time.

Some minor modifications to the dredging template may be needed for future permitting, These are intended to create a template that more closely mimics stable inlet conditions and to provide simplified design cut dimensions based on the NAVD survey datum.

Typical cross sections for the adjusted template are provided in **Figures 22, 23,** and **24**. Typical cross sections are shown for bay areas in Sections B and C where the bay is wider than the target cross section area. In areas where the bay is limited by mangroves, the width of the cut will be limited (smaller than typical width) in order to maintain a minimum of five foot buffer to the mangroves.

	2013 Dredged Area	Target Area	Proposed Design area
Below MHW	312	300	300

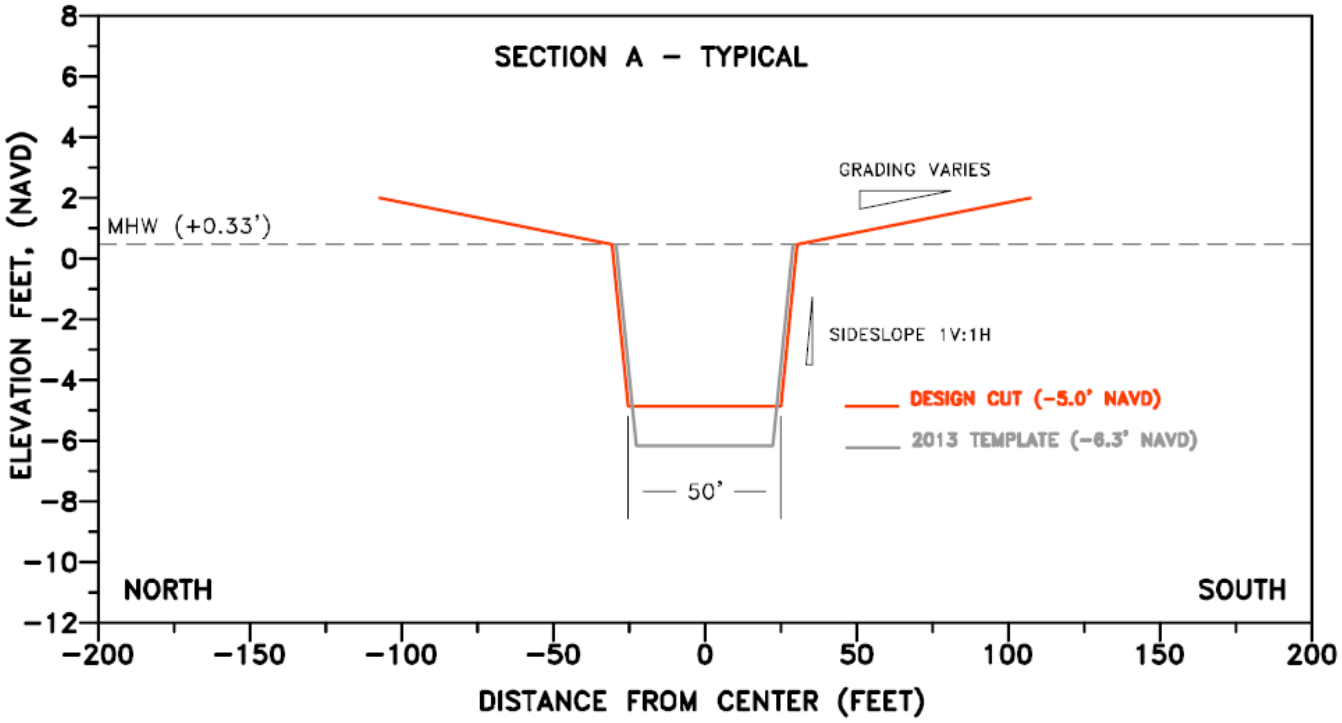




Figure 22. Typical Maintenance Dredging Cross Section - Inlet Channel - Section A

	2013 Dredged Area	Target Area	Proposed Design area
Below MHW	650	450	450



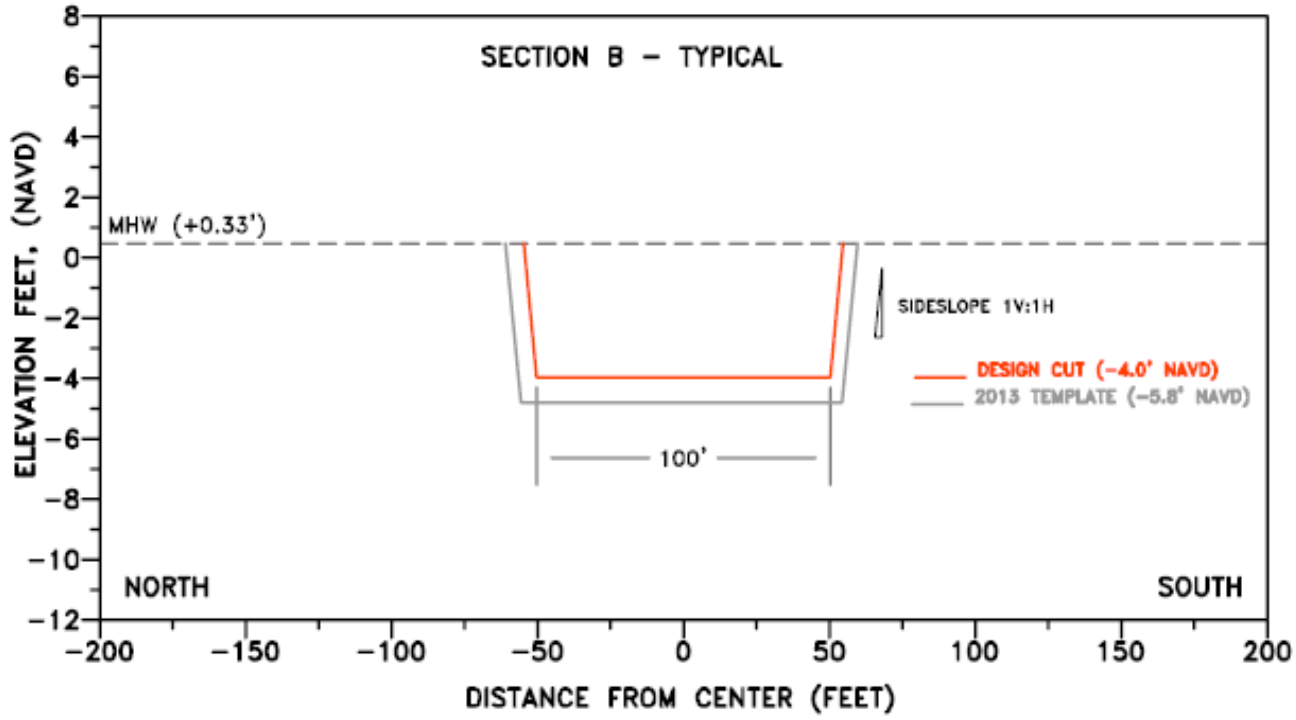
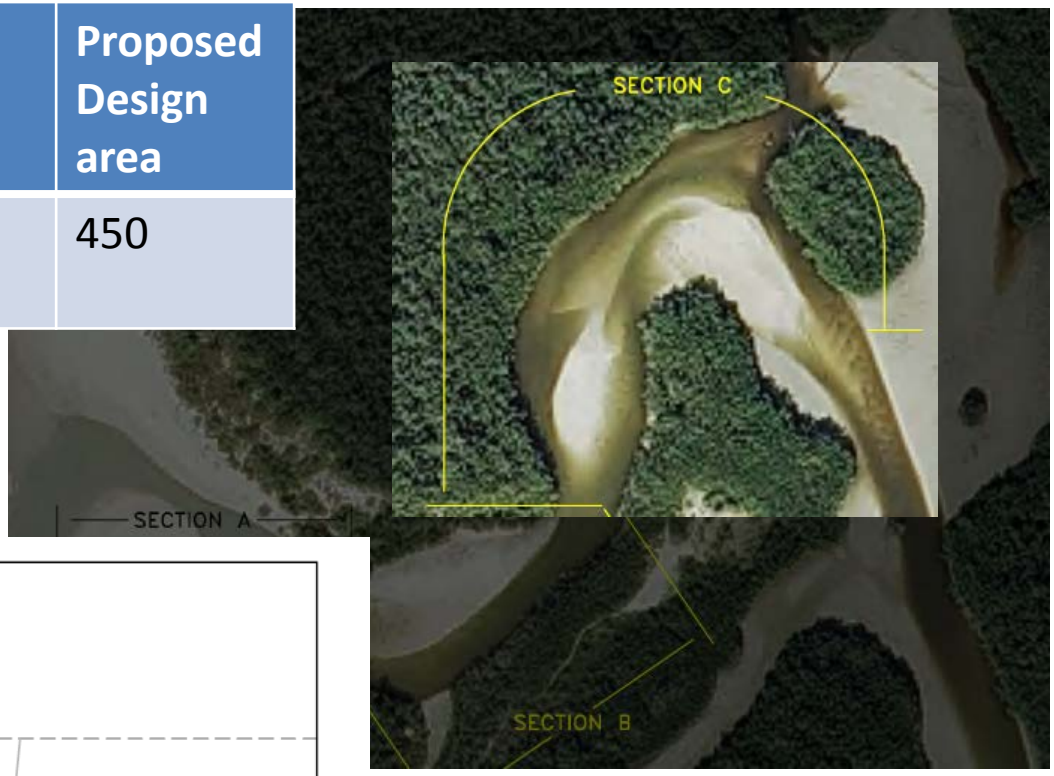


Figure 23. Typical Maintenance Dredging Cross Section – Seaward Flood Shoal – Section B

	2013 Dredged Area	Target Area	Proposed Design area
Below MHW	530	450	450



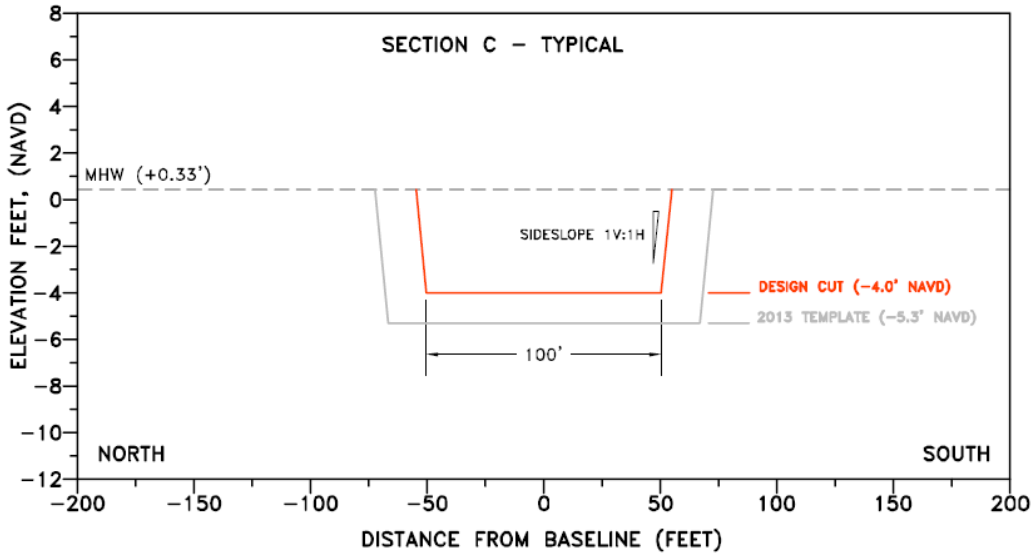
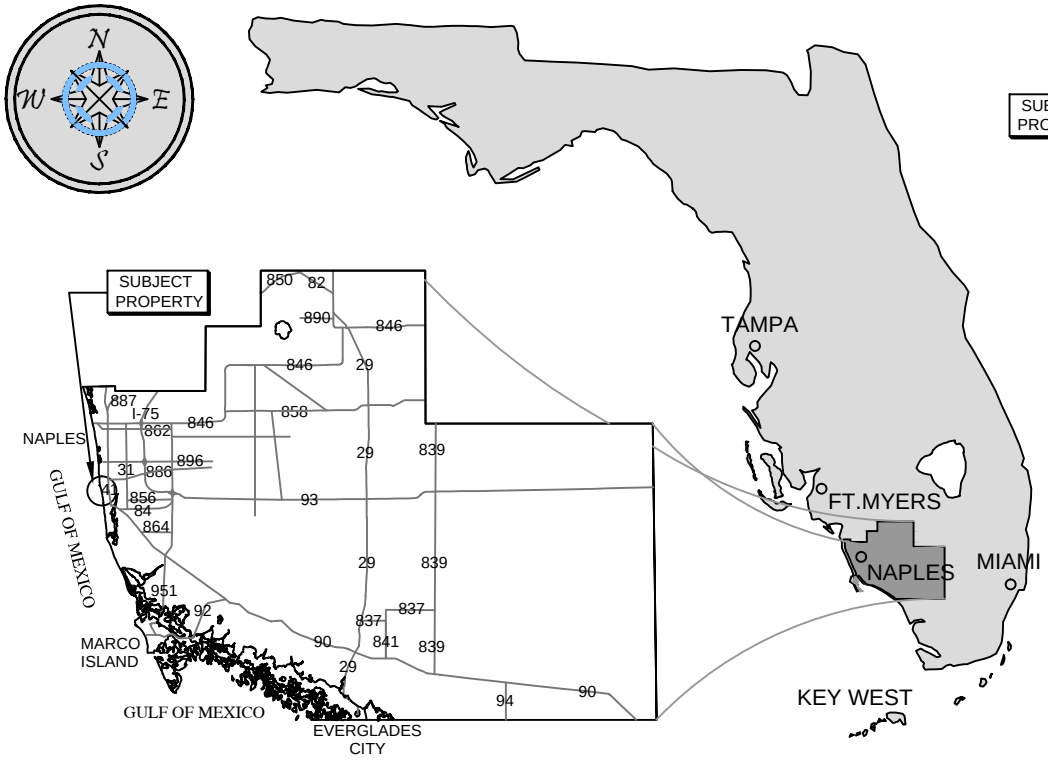


Figure 24. Typical Maintenance Dredging Cross Section – Bayside Flood Shoal – Section C

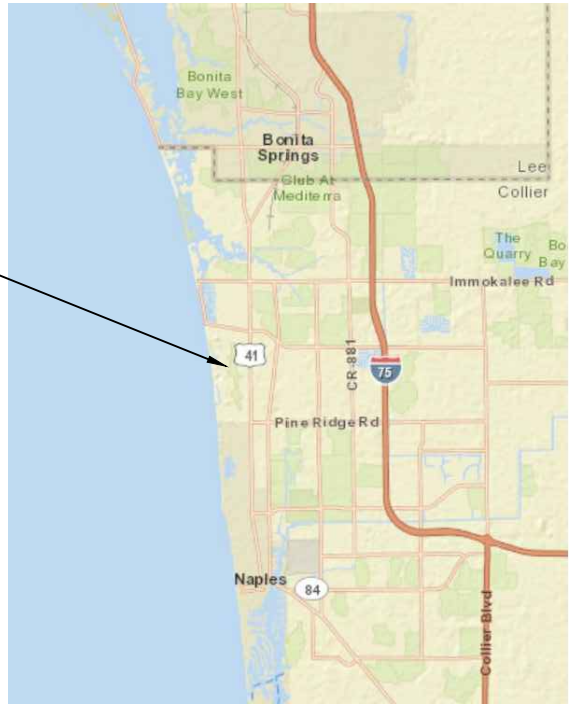
APPENDIX 6 - EXHIBITS

STATE OF FLORIDA



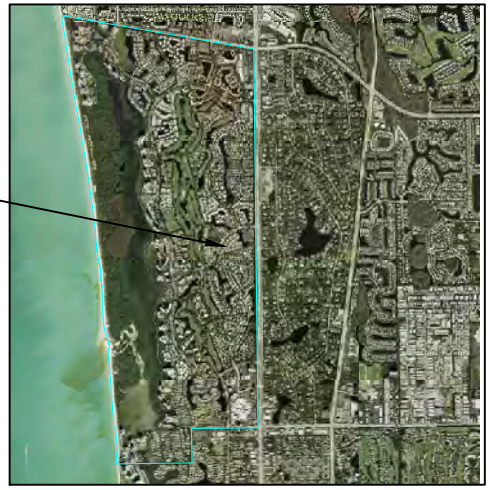
COLLIER COUNTY

SUBJECT PROPERTY



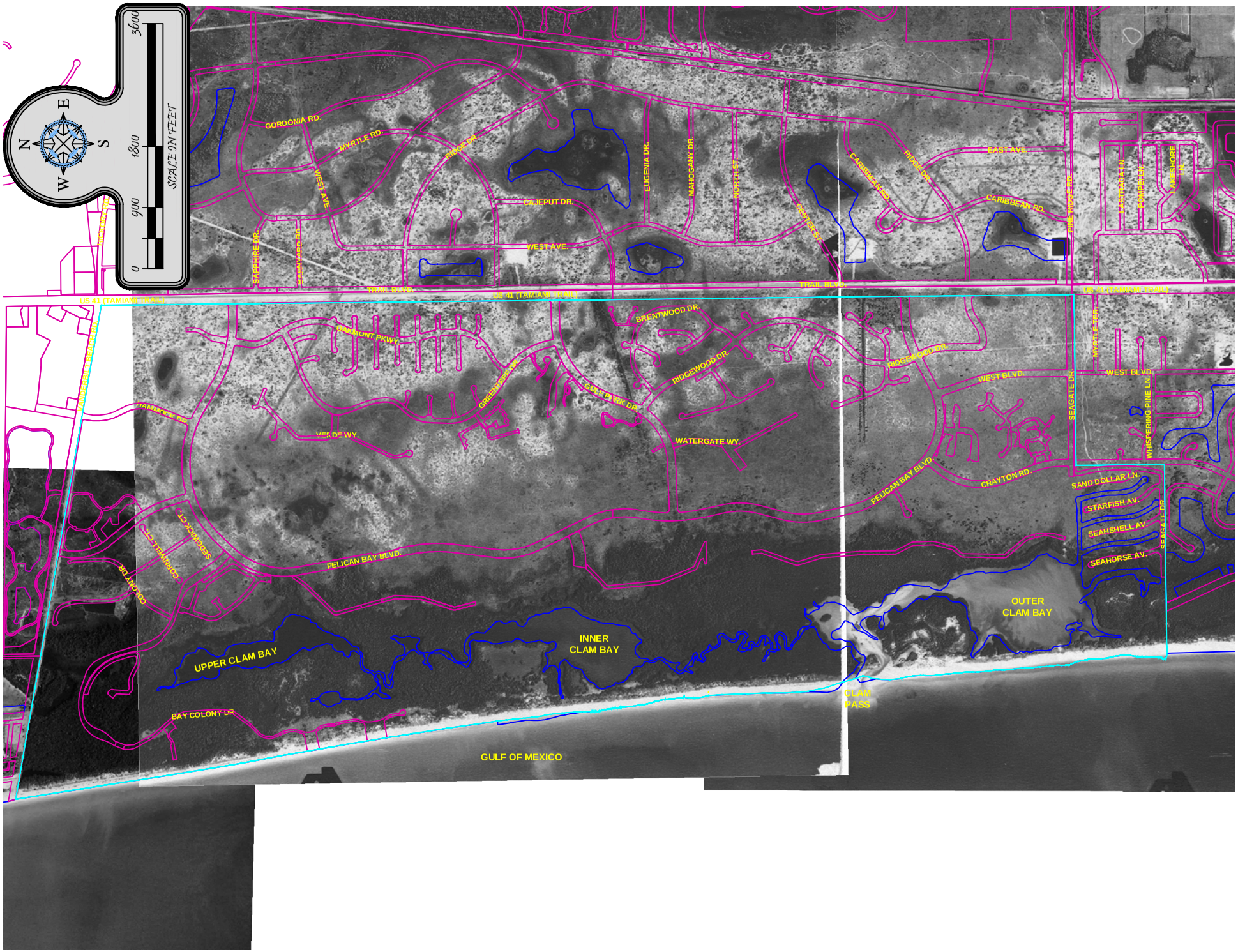
VICINITY MAP

SUBJECT PROPERTY



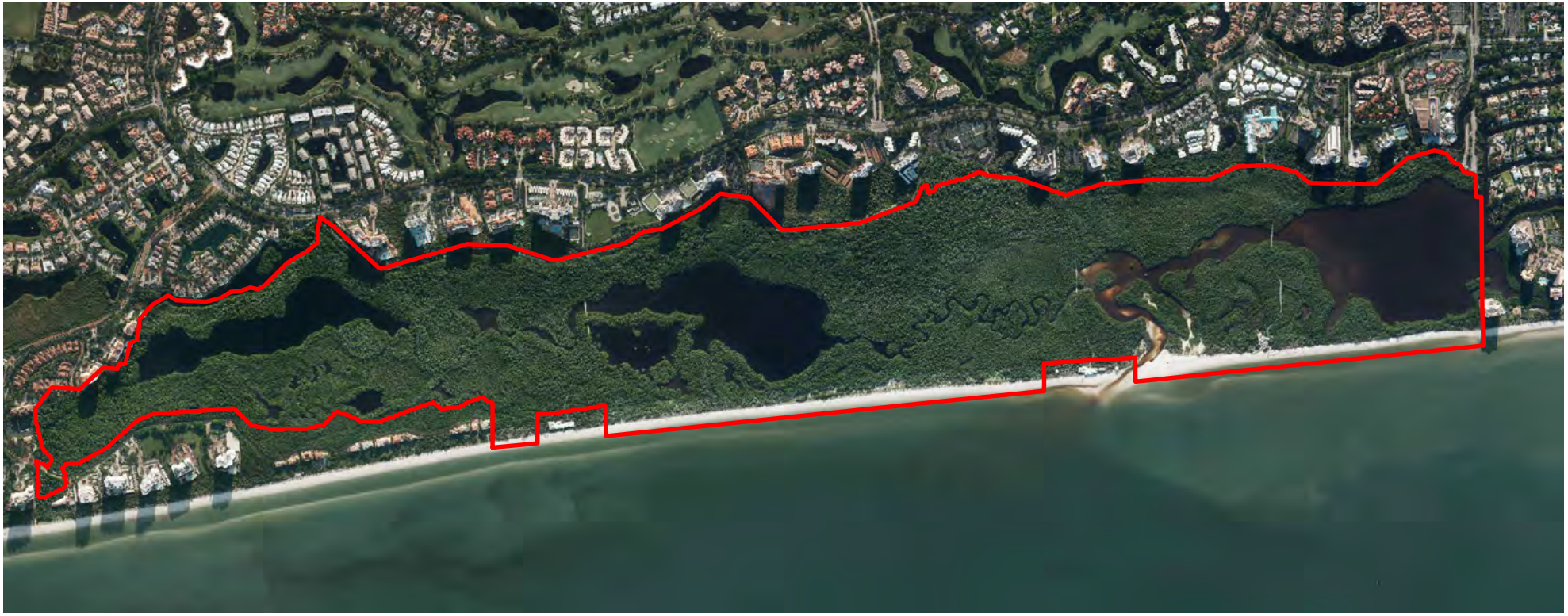
COUNTY AERIAL

LOCATION MAP

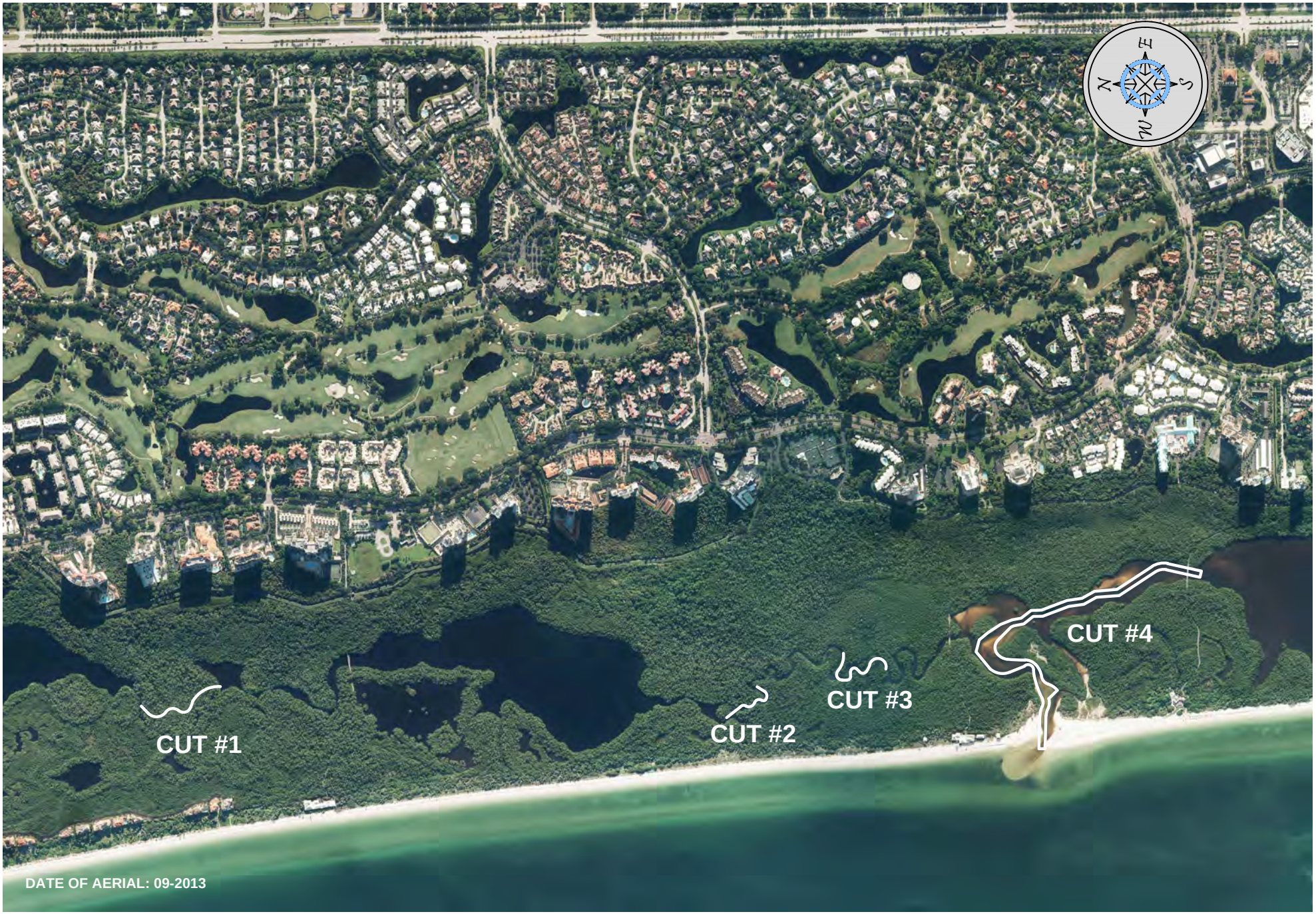


1952 AERIAL

P:\9845 Clam Bay\Drawings\SHEET\MANAGEMENT_PLAN\2013\1952-OVERLAYS.dwg 5/7/2014



CLAM BAY NRPA BOUNDARY



CLAM BAY DREDGE CUT SITE PLAN 1999

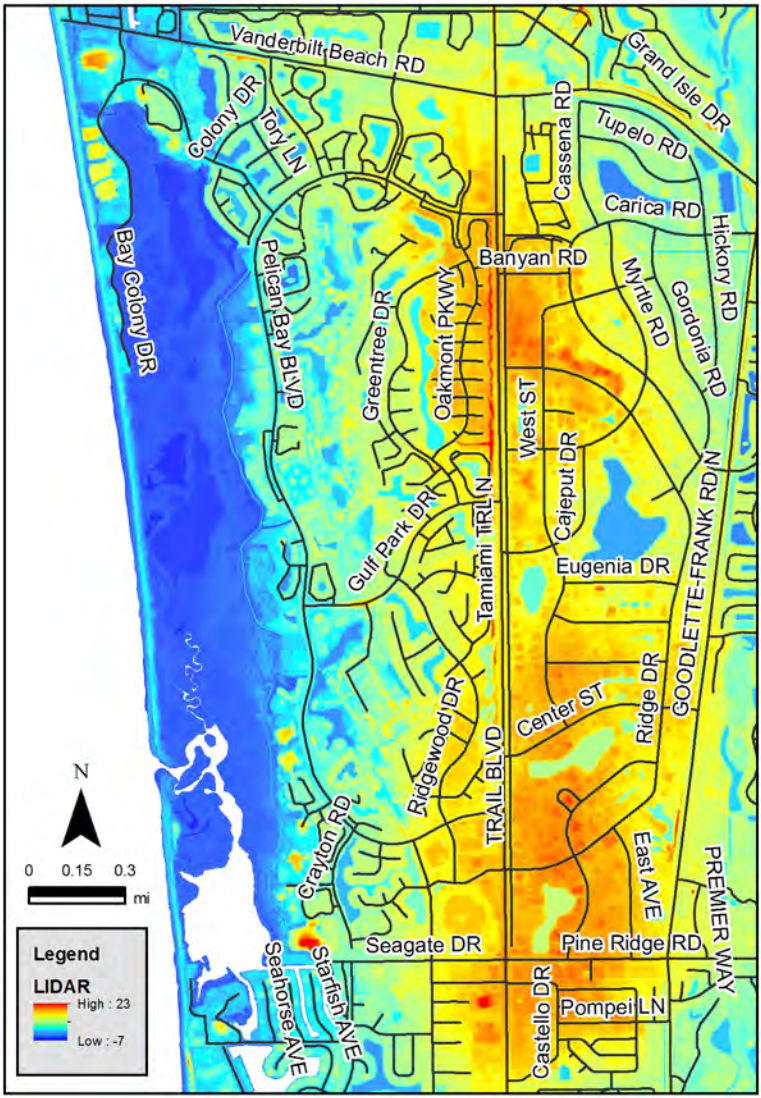


HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

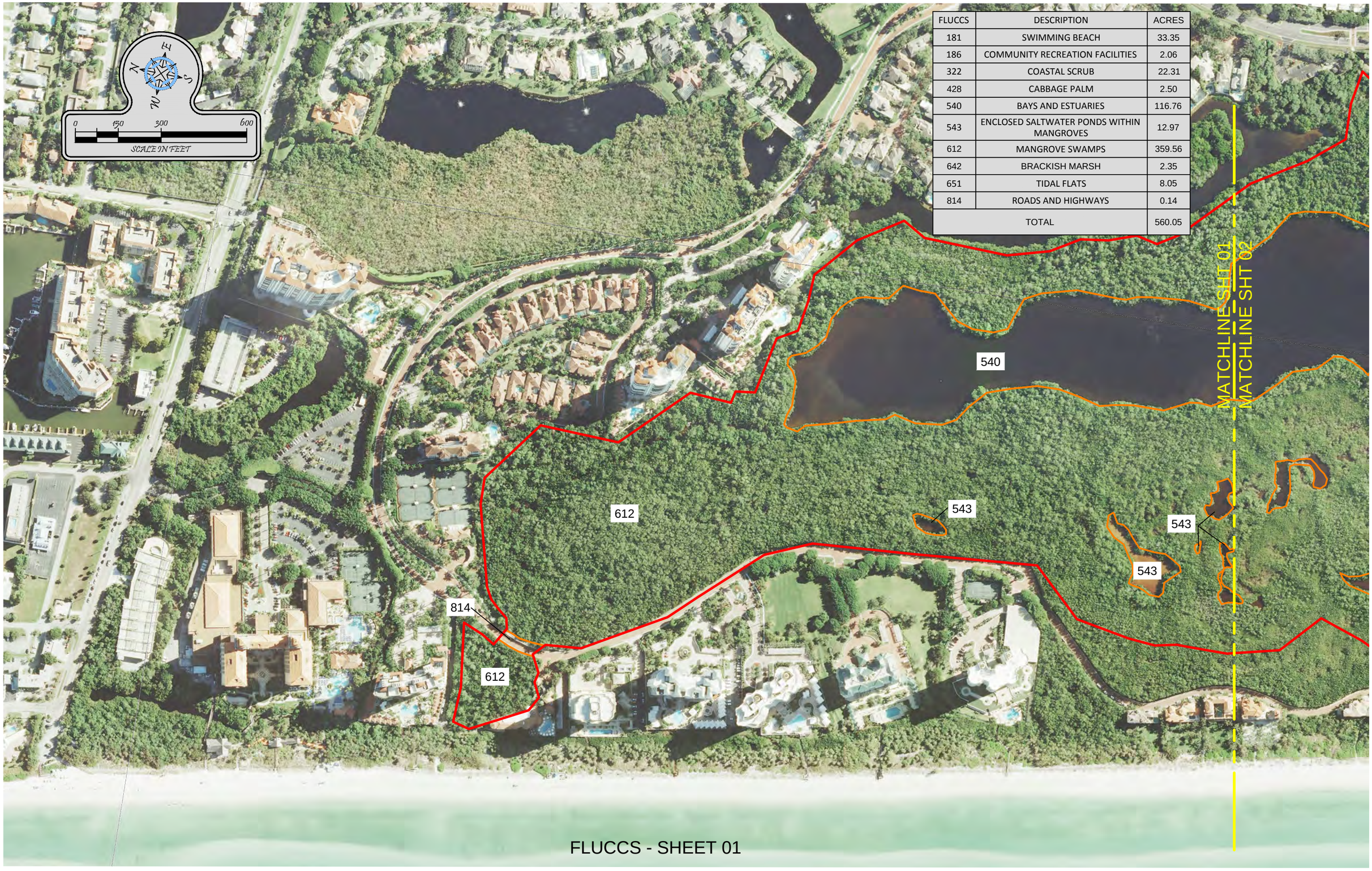
CLAM PASS MONITORING SCOPE
INLET STATIONS

FOR: PELICAN BAY SERVICES DIVISION		
DATE: 6/23/13	FILE: SCOPE	SCALE: 1"=200'
JOB: 13078	DATUM: NAD83	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com



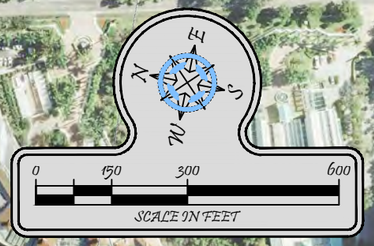
CLAM BAY LIDAR MAP



FLUCCS	DESCRIPTION	ACRES
181	SWIMMING BEACH	33.35
186	COMMUNITY RECREATION FACILITIES	2.06
322	COASTAL SCRUB	22.31
428	CABBAGE PALM	2.50
540	BAYS AND ESTUARIES	116.76
543	ENCLOSED SALTWATER PONDS WITHIN MANGROVES	12.97
612	MANGROVE SWAMPS	359.56
642	BRACKISH MARSH	2.35
651	TIDAL FLATS	8.05
814	ROADS AND HIGHWAYS	0.14
TOTAL		560.05

FLUCCS - SHEET 01

FLUCCS	DESCRIPTION	ACRES
181	SWIMMING BEACH	33.35
186	COMMUNITY RECREATION FACILITIES	2.06
322	COASTAL SCRUB	22.31
428	CABBAGE PALM	2.50
540	BAYS AND ESTUARIES	116.76
543	ENCLOSED SALTWATER PONDS WITHIN MANGROVES	12.97
612	MANGROVE SWAMPS	359.56
642	BRACKISH MARSH	2.35
651	TIDAL FLATS	8.05
814	ROADS AND HIGHWAYS	0.14
TOTAL		560.05

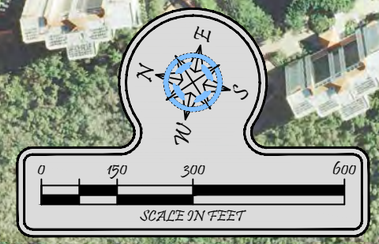


MATCHLINE SHT 01
MATCHLINE SHT 02
MATCHLINE SHT 02
MATCHLINE SHT 03

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FLUCCS - SHEET 02

FLUCCS	DESCRIPTION	ACRES
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322	COASTAL SCRUB	22.31
428	CABBAGE PALM	2.50
540	BAYS AND ESTUARIES	116.76
543	ENCLOSED SALTWATER PONDS WITHIN MANGROVES	12.97
612	MANGROVE SWAMPS	359.56
642	BRACKISH MARSH	2.35
651	TIDAL FLATS	8.05
814	ROADS AND HIGHWAYS	0.14
TOTAL		560.05



MATCHLINE SHT 02
MATCHLINE SHT 03

MATCHLINE SHT 03
MATCHLINE SHT 04

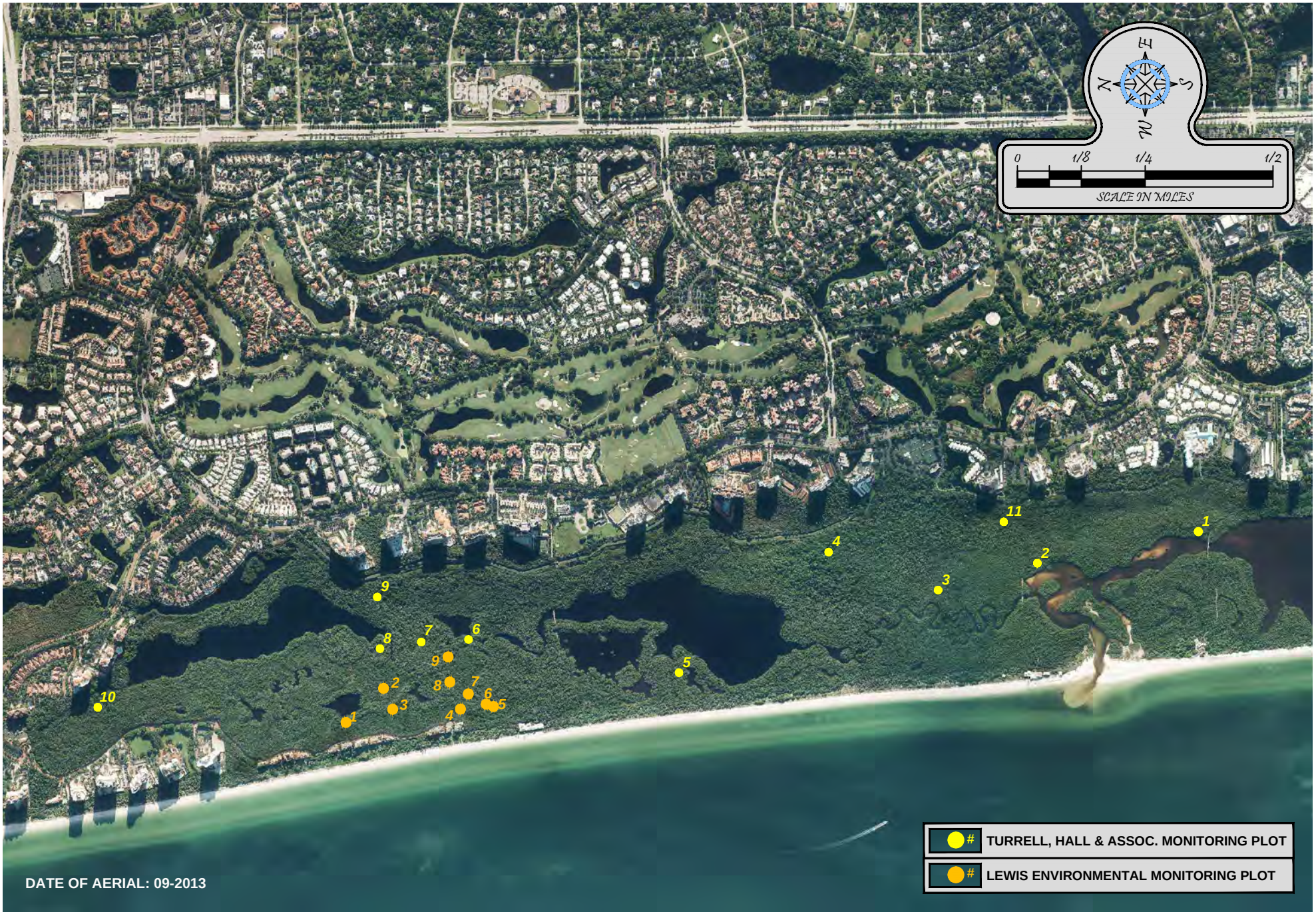
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FLUCCS - SHEET 03

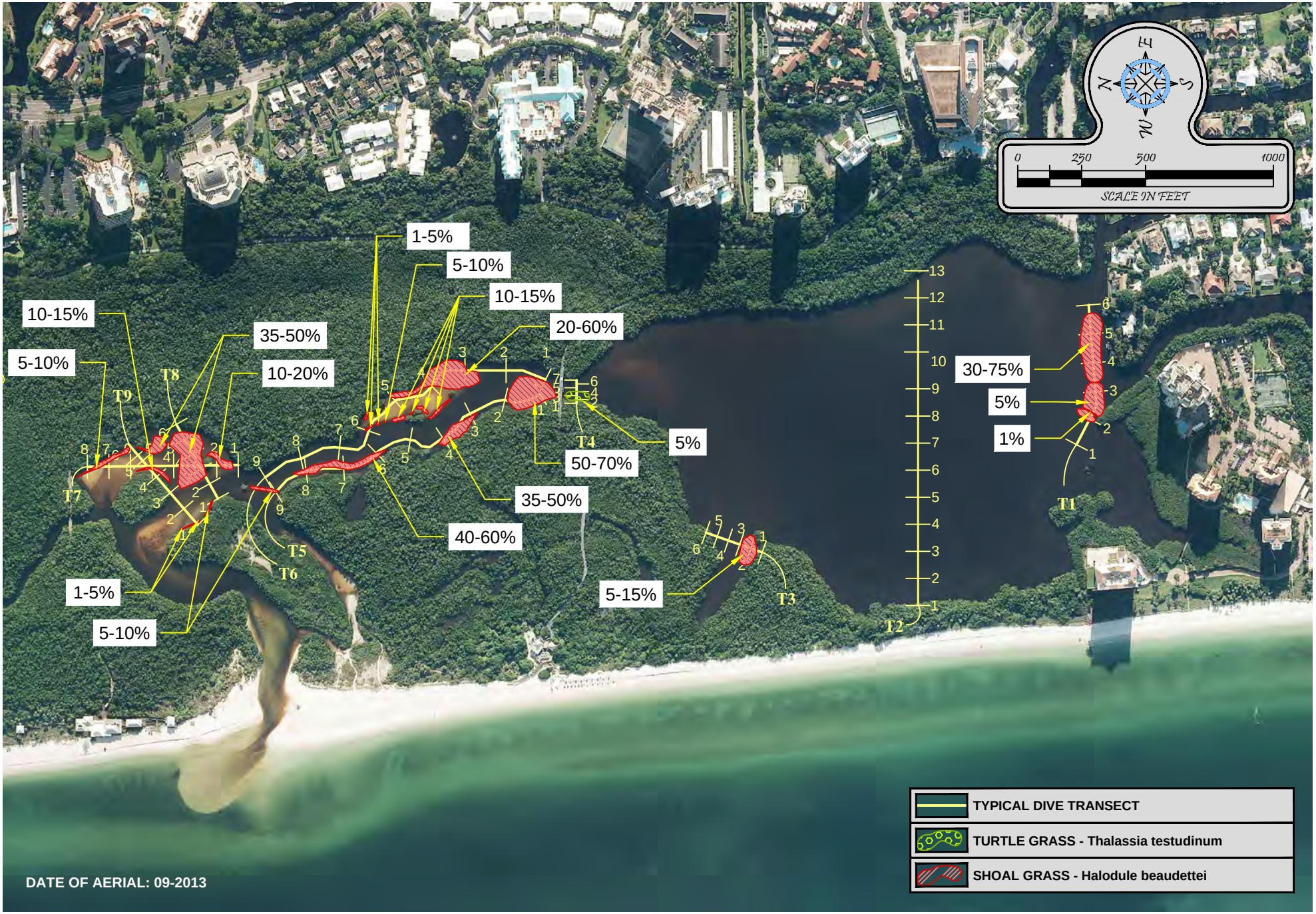


FLUCCS	DESCRIPTION	ACRES
181	SWIMMING BEACH	33.35
186	COMMUNITY RECREATION FACILITIES	2.06
322	COASTAL SCRUB	22.31
428	CABBAGE PALM	2.50
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612	MANGROVE SWAMPS	359.56
642	BRACKISH MARSH	2.35
651	TIDAL FLATS	8.05
814	ROADS AND HIGHWAYS	0.14
TOTAL		560.05

FLUCCS - SHEET 04



EXISTING VEGETATIVE MONITORING PLOTS



SEAGRASS TRANSECTS