APPENDIX C

Living Shoreline

Technical Guidance Document

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1.0 INTRODUCTION

Anticipating both environmental and economic impacts from climate change and sea level rise, proactive shoreline management is critical to protect property interests and estuarine ecosystems. Over the past century, extensive development in the coastal zone has resulted in the proliferation of traditional 'hard' shoreline stabilization measures such as bulkheads, seawalls and revetments. When designed and constructed properly, these structural measures have proven successful at stabilizing shorelines. However, they have also resulted in a number of negative impacts on adjacent shorelines and critical intertidal and nearshore habitats when not properly designed or maintained. Contrary to the traditional approach, shoreline stabilization does not need to create a hard barrier between land and water to be effective (NOAA, 2015).

In recent years, a variety of softer, more nature-based shoreline stabilization approaches have been developed to reduce erosion by creating natural features (Figure C1.1-Figure C1.2). These approaches are known under a variety of names such as "living shorelines", "green shores", "nature-based features", and "ecologically enhanced shorelines". In contrast to the traditional shoreline stabilization options, living shorelines protect ecosystem services and (when properly designed and installed) perform better over time in controlling erosion and preventing catastrophic flood and storm damage (Miller et al., 2015). Over time, as sea level rises, a living shoreline may maintain its elevation relative to local sea level. (NOAA, 2015). According to Morris et al (2015), wetlands may increase in elevation by nearly 12 mm/year, surpassing the global rate of sea level rise. Oyster reefs may increase in elevation at a rate of nearly 60 mm/year (Ridge et al 2017, Rodriguez et al 2014).

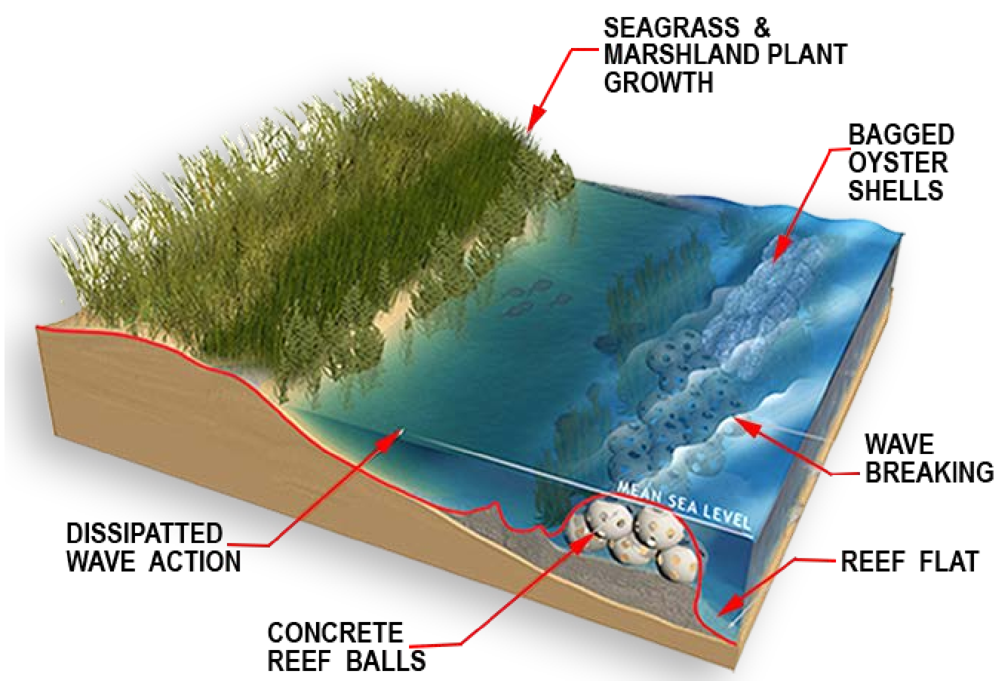


Figure C1.1 Combined Structural and Nonstructural Living Shoreline Installation, Pre-Storm Condition
(graphic by EWN/ERDC)

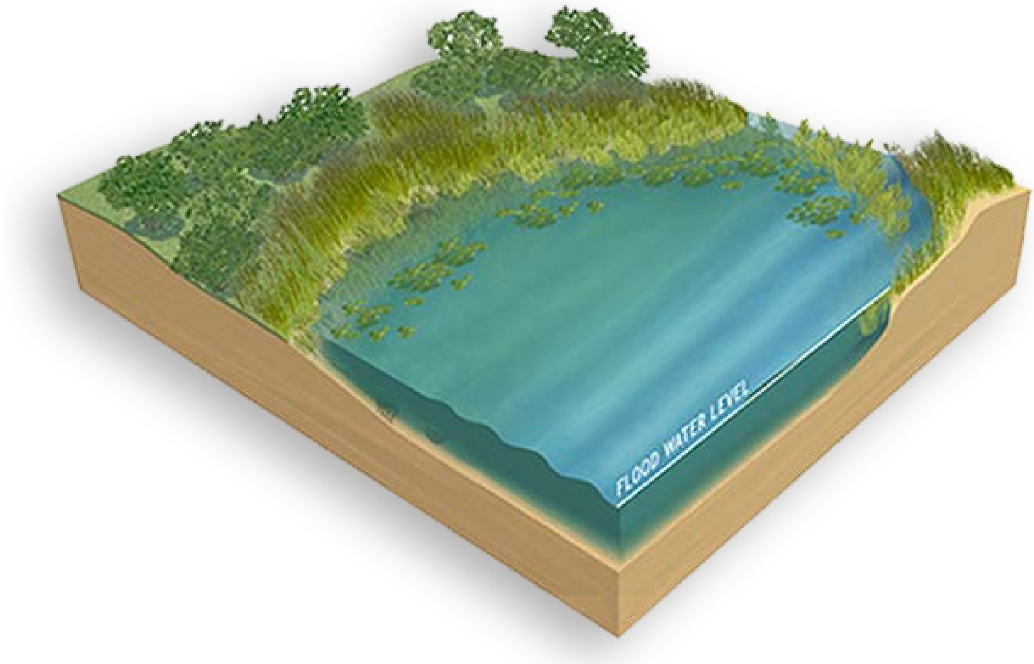


Figure C1.2 Combined Structural and Nonstructural Living Shoreline Installation – Inundated Storm Condition
(graphic by EWN/ERDC brochure)

Originally developed in the Chesapeake Bay nearly two decades ago, the living shorelines approach has gradually gained momentum. The National Research Council (2007) report "Mitigating Shore Erosion along Sheltered Coasts" advocated the development of a new management framework within which decision makers would be encouraged to consider the full spectrum of options. More recently, a U.S. Army Corps of Engineers (USACE) (2013) report on coastal risk reduction and resilience advocated an integrated approach to risk reduction that draws from a full array of available measures. Both documents encourage greater consideration of projects such as living shorelines which offer multiple benefits of providing shoreline stabilization, habitat creation, adaptive capacity, nutrient sequestration, and water quality improvements. The NOAA graphic (Figure C1.3) summarizes the ways in which various nature-based approaches can be used independently or in combination to achieve those benefits.

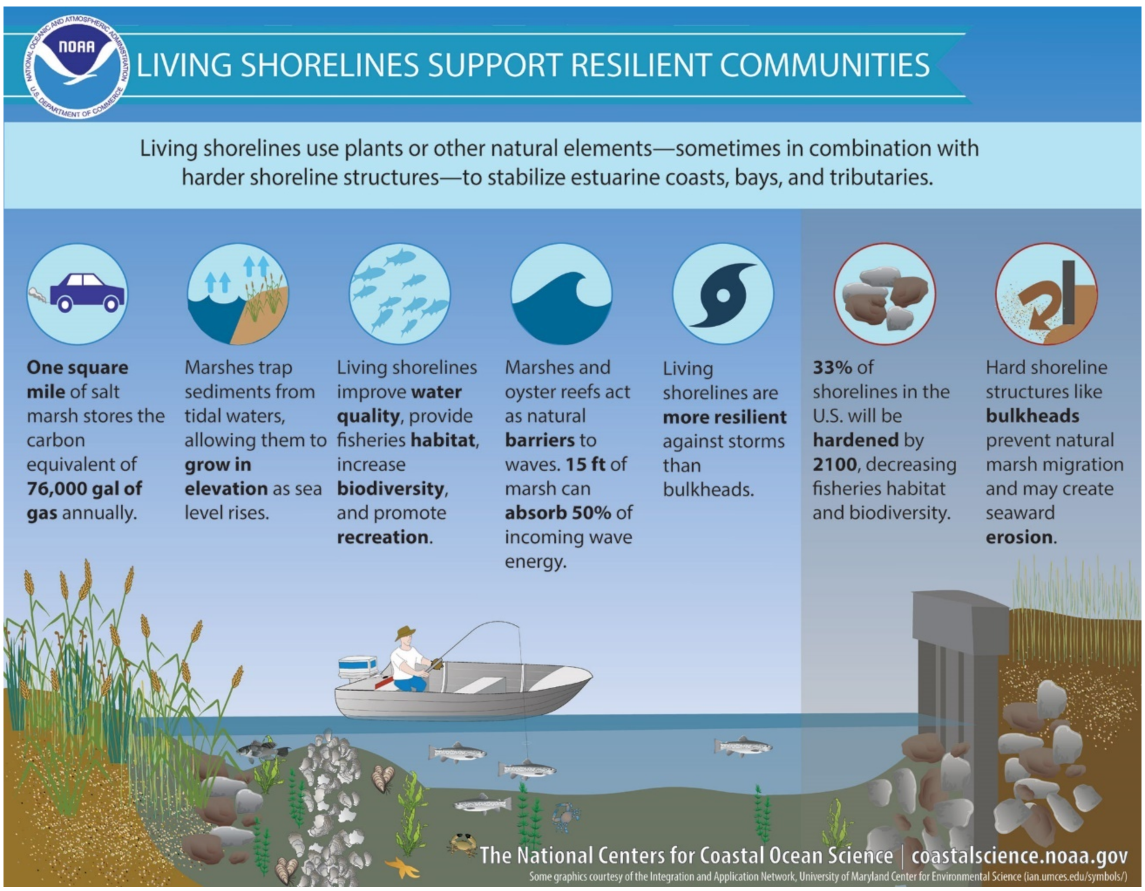


Figure C1.3 Living Shorelines Infographic *(NOAA)*

Erosion control, protection from storm and flood damage, and coastal climate change adaptation strategies are addressed differently on a regional basis due to regional differences in biogeophysical conditions (RAE, 2015). The use of living shorelines is one approach that can be implemented successfully under various conditions to address erosion, threats from flooding and inundation, ecosystem protection, and adaptation to ecosystem shifts brought about by climate change and sea level rise.

This document provides technical guidance to the City of Punta Gorda on engineering, planning, regulatory authorizations, and monitoring required for successful design and implementation of living shoreline projects.

2.0 BACKGROUND

In February 2019, the City of Punta Gorda contracted Taylor Engineering, Inc. to conduct a vulnerability analysis of the city's publicly owned infrastructure, prepare an addendum to the 2009 Climate Adaptation Plan, and develop a living shorelines technical guidance document. The City received a NOAA Resiliency grant in January 2019 to fund the work, with the grant expiring June 30, 2019.

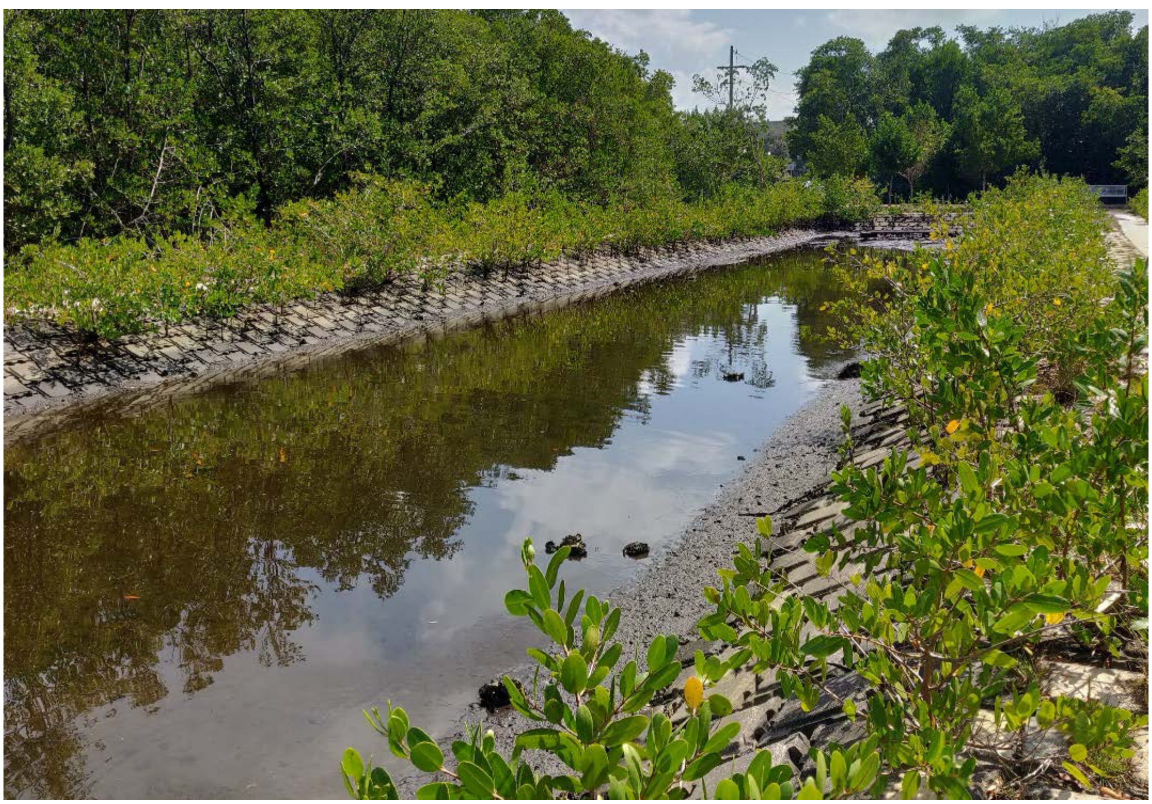
The City's 2009 Climate Adaptation Plan identified a series of adaptation strategies developed by a working group with community input through public outreach and workshops. The 2009 plan identified eight categorized vulnerabilities: 1) fish and wildlife habitat degradation, 2) inadequate water supply, 3) flooding, 4) unchecked or unmanaged growth, 5) water quality degradation, 6) education and economy and lack of funds, 7) fire, 8) availability of insurance. From this, the working group identified 104 acceptable change adaptations. The consensus top adaptations, applicable to each vulnerability, were:

- Seagrass protection and restoration
- Xeriscaping and native plant landscaping
- Explicitly indicating in the comprehensive plan which areas will retain natural shorelines
- Constraining locations for certain high-risk infrastructure
- Restrict fertilizer use
- Promote green building alternatives through education, taxing incentives, green lending
- Drought preparedness planning

Notably, the first three items (listed above) identify adaptation strategies related to implementation of living shorelines. Since the City's inception, preservation of greenspace has been a cornerstone for land use management, beginning with Colonel Isaac Trabue in 1884 who designated all waterfront blocks as City parks. This legacy serves the City to this day with a string of public waterfront parks connected by the 2.5-mile-long Trabue Harborwalk promenade. The City has taken a proactive approach to acquiring and preserving greenspace for the creation of parks and natural recreational areas.

Currently, the City of Punta Gorda has a few living shorelines in place. Naturally occurring mangrove forests thrive in many places on the water's edge. In some locations, juvenile mangroves are transforming a 'gray' shore protection strategy into a 'green' one that will eventually adapt to changes in the sea level (Photograph C2.1 & Photograph C2.2). The City has also implemented oyster restoration projects in partnership with the Nature Conservancy (TNC) and the Coastal & Heartland National Estuary Partnership (CHNEP, formerly known as Charlotte Harbor National Estuary Program) using volunteer engagement. Part of a community resilience initiative, the oyster reefs were installed to protect the shoreline while also creating habitat and recruiting estuarine wildlife to the reefs and surrounding waters.

Photograph C2.1 Mangrove Living Shoreline, February 2019



Photograph C2.2 “Volunteer” Mangrove Living Shoreline, February 2019

In 2018, the City also completed a conceptual level living shoreline pilot project study, Tiki Point at Harborwalk fronting the Four Points Sheraton Hotel in the downtown area. The Harborwalk is a waterfront promenade that connects Trabue Park, Laishley Park, the Charlotte Harbor Events Center, Gilchrist Park, and Fishermen's Village. A public-private partnership was formed between the City, CHNEP, TNC, the Florida Department of Environmental Protection (FDEP) Aquatic Preserves, Four Points Sheraton, and Jacobs Engineering. The hotel expressed interest in improving the natural aesthetics and habitat value along the hotel's seawall (Figure C2.1), within a pubic easement that exists along the City's Harborwalk.

Figure C2.1 Tiki Point at Four Points by Sheraton Living Shoreline Pilot Project Location
(from Jacobs Engineering Technical Memo dated August 2018)

As part of the 2019 Climate Adaptation Plan addendum, the City seeks to further define living shorelines as one adaptation strategy for improving the City's resilience to the effects of climate change and sea level rise. Rather than a traditional 'managed retreat / planned relocation' approach, the City's goal is to take advantage of the publicly owned greenspace and focus on advancing living shoreline stabilization features into the water for increased upland flood protection. According to the 2009 Climate Adaptation Plan, the concept of "rolling easements" was addressed to manage areas where shorelines are hardened to allow for continued lateral public access to the shoreline even as the intertidal zone (deemed as state-owned public lands) translates landward with rising water levels. However, such easements are not applicable in all areas.

3.0 LIVING SHORELINES DEFINED

There are many definitions for living shorelines. Restore America's Estuaries (RAE 2015) defines a living shoreline as "any shoreline management system that is designed to protect or restore natural shoreline ecosystems through the use of natural elements and, if appropriate, manmade elements. Any elements used must not interrupt the natural water/land continuum to the detriment of the natural shoreline ecosystems." NOAA[1] defines living shorelines as "a shoreline management practice that provides erosion control benefits; protects, restores, or enhances natural shoreline habitat; and maintains coastal processes through the strategic placement of plants, stone, sand fill, and other structural organic materials (e.g. biologs, oyster reefs, etc.)". When protecting coastal properties, a living shoreline approach represents a 'softer and greener' alternative to 'gray' approaches such as traditional armoring (e.g., seawalls, bulkheads). A living shoreline uses natural materials such as wetland plants, oyster shell, coir fiber logs, sand, wood, and native rock to stabilize the shoreline and maintain valuable fish and wildlife habitat. Every living shoreline design should result from careful consideration of the project site and strategic placement of natural components along the shoreline profile.

[1] https://shoreline.noaa.gov/glossary.html#partj, accessed June 12, 2019.

Figure C3.1 depicts a range of shoreline stabilization techniques from 'green', nature-based materials to a hybrid (combination) approach to 'gray' traditional hardened structures. NOAA encourages the use of these softer techniques for shoreline stabilization, however, after consultation with a variety of research institutes, non-governmental organizations, USACE, and FEMA, the "Systems Approach to Geomorphic Engineering (SAGE) continuum" was developed. This continuum provides a wider range of living shoreline strategies, which are outlined in the SAGE Natural and Structural Measures for Shoreline Stabilization brochure (http://sagecoast.org/docs/SAGE_LivingShorelineBrochure_Print.pdf). The stabilization techniques on the left side of the figure represent more green methods while those on the right side represent more traditional, hard stabilization techniques.

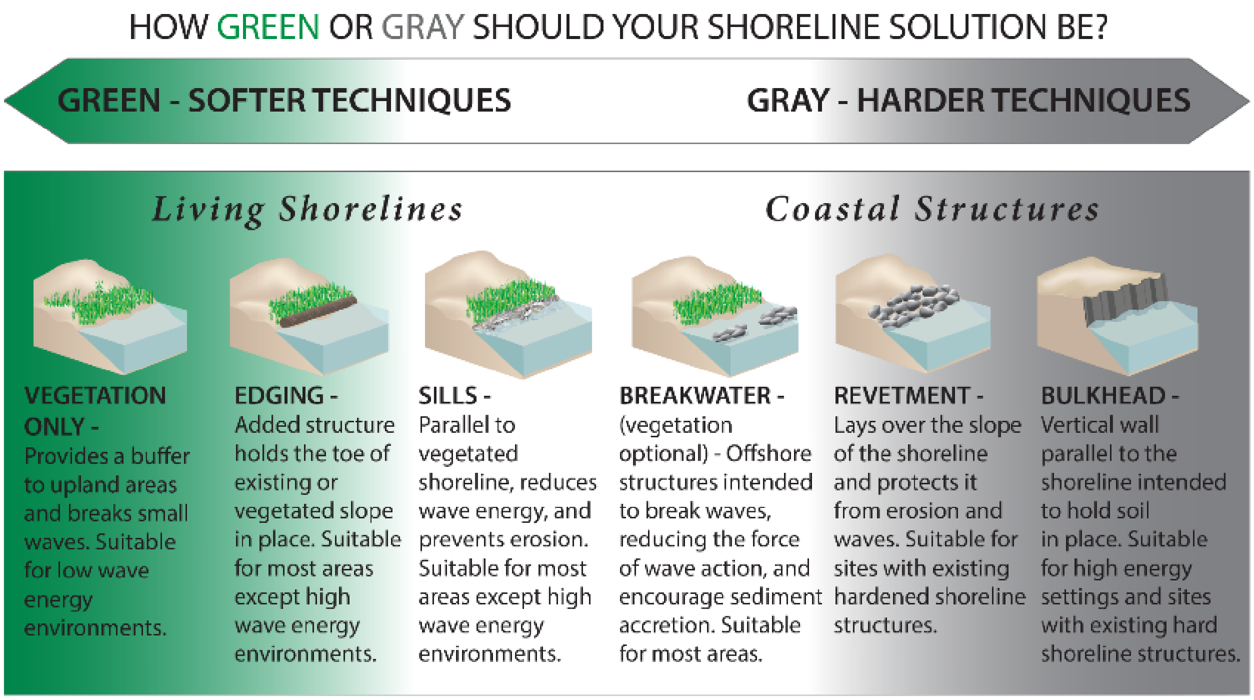


Figure C3.1 Range of Green to Gray Alternatives based on Wave Energy
(NOAA Guidance for Considering the Use of Living Shorelines,2015 adapted from SAGE,2015)

The key differentiator in selecting among the spectrum of green to gray solutions depends on the existing project site conditions and, specifically, the degree of exposure to wave energy. When engineered and constructed correctly, a living shoreline not only provides erosion control, but also maintains coastal processes. Similar in behavior to naturally vegetated coastlines, living shorelines reduce wave energy and storm impacts, reduce erosion and property loss, trap sediments, improve water clarity, filter pollutants, preserve coastal resiliency, provide recreational opportunities, and provide important fish and wildlife habitat.

4.0 SITE EVALUATION

The first step in developing a successful living shoreline project is to perform a siting analysis in order to determine the most appropriate management system. For each potential site evaluated, the following considerations must be identified: shoreline type, degree of energy (waves, currents), potential sediment transport characteristics, types and location of ecological resources present, and the nature of adjacent land uses. Selection of a shoreline management system is largely dependent on the type of shoreline. A mix of hardened and natural vegetated shorelines exist within City limits, consisting of vertical bulkheads, natural mangrove fringe and pocket beaches. According to the Estuaries Report Card, the nearshore zone along the Peace River and Charlotte Harbor includes intertidal and shallow flats with oysters, mangroves, and aquatic vegetation in some areas. The nearshore zone consists of primarily fine-grained silty sand with fractions of shell along the east and west sides of the harbor (Estuaries Report Card, 2005 and 2017).

5.0 DESIGN CRITERIA

Once the shoreline type is identified for the selected project site, a coastal conditions analysis should be performed to determine the appropriate design. Several site-specific parameters are used to characterize site conditions and determine the optimum solution. To design long-term shoreline stabilization, the designer must analyze the coastal conditions affecting the site. The following parameters used to develop such analysis are identified and defined below.

- Reach – a longshore segment of shoreline where influences and impacts, such as wind direction, wave energy, littoral transport, etc. mutually interact. Understanding the limits for which these influences are bounded beyond the selected project site allows the designer to understand the degree of exposure and shoreline orientation.
- Fetch – a cross-shore distance along open water, over which wind blows to generate waves. For any given shore, fetch distances vary depending on wind direction.
- Topographic conditions – the slope and elevation of the foreshore within a defined project area. The nearshore slope impacts the behavior of waves and currents immediately offshore of the project site. Steeper slopes tend to reflect energy while milder slopes generally absorb and dissipate energy.
- Tidal range – the vertical difference between high and low tide. Understanding the water level changes and potential water depths at all stages of the tide help to inform the range of applicable solutions.
- Storm surge – the temporary rise in sea level due to the action of wind stress on the water surface and low atmospheric pressure created during storms. Surge is the difference between the highest water level caused by a storm and the predicted astronomical tide level.
- Wave energy – the force exerted on a shoreline by waves. Different areas have lower or higher wave energy depending on the wave height, degree of exposure, shoreline orientation, proximity to navigation channels, wind, and bathymetry.
- Currents – the movement of water from one location to another. Currents are driven by wind, tides, and density differences due to water temperature and salinity variations.
- Water quality and salinity - chemical, physical, and biological characteristics of water. Water quality can affect the ability of aquatic plants and animals to thrive.
- Sediment transport – the movement of sediment, usually caused by water or wind. Sediment transport can occur over vast segments of shoreline or in localized areas. An example of localized sediment transport is scour adjacent to a vertical bulkhead and alongshore transport of the scoured material.

Waves generated by local winds tend to be one of the dominant forces impacting shorelines and are considered in nearly all engineered shoreline improvements. As the wind blows over the surface of a water body, its energy is transferred to the water (Miller et al, 2015). The wind speed, duration, and open water distance (fetch) over which it acts will determine size of the waves. For sites located inland, wave growth is limited by the available fetch, resulting in wave heights and periods that are generally much smaller than those observed on open coastlines. In a study conducted by (Shafer et al, 2003), an evaluation of wave climate statistics in relation to wetland establishment was performed for several sites in Texas and Alabama. The study found that the percent exceedance of wave height (percent of time wave heights are above any one value) varied between sites (Shafer et al, 2003). The patterns observed in this study suggest that the 20^{th} percentile wave height statistics are indicators of long-term shoreline stability and vegetation characteristics, representing a critical threshold for marsh establishment and long-term survival (Shafer et al, 2003). However, for most sheltered water bodies, minimal wave observations within vegetated shorelines exist. For inland or more sheltered water bodies, wave energy generated by boat wakes are often a critical design parameter. Evaluation of this parameter is further described below.

Miller et al. (2015) documented the industry standard for engineering design of shoreline stabilization techniques, specifically for living shorelines. The Miller et al (2015) paper classified typical living shoreline design parameter values (for projects in New Jersey) into low, medium, and high ranges of magnitude (Table C5.1) and then identified living shoreline techniques potentially suitable for each of the parameter ranges (Table C5.2). Though these criteria were developed for projects in New Jersey, (with the exception of ‘ice’) these parameter ranges are applicable for all project areas including Punta Gorda.

Table C5.1 Design Criteria Classification Ranges (Miller, et al, 2015)

	Criterion		
Parameter	Low/Mild	Moderate	High/Steep
System Parameters			
Erosion History	<2 ft/yr	2 ft/yr to 4 ft/yr	>4 ft/yr
Sea Level Rise	<0.2 in/yr	0.2 in/yr to 0.4 in/yr	>0.4 in/yr
Tidal Range	< 1.5 ft	1.5 ft to 4 ft	> 4 ft
Hydrodynamic Parameters			
Waves	< 1 ft	1 ft to 3 ft	> 3 ft
Wakes	< 1 ft	1 ft to 3 ft	> 3 ft
Currents	< 1.25 kts	1.25 kts to 4.75 kts	>4.75 kts
Ice	< 2 in	2 in to 6 in	> 6 in
Storm Surge	<1 ft	1 ft to 3 ft	>3 ft
Terrestrial Parameters			
Upland Slope	<1 on 30	1 on 30 to 1 on 10	>1 on 10
Shoreline Slope	<1 on 15	1 on 15 to 1 on 5	> 1 on 5
Width	<30 ft	30 ft to 60 ft	>60 ft
Nearshore Slope	<1 on 30	1 on 30 to 1 on 10	>1 on 10

Note: with the exception of ‘ice’, all parameters outlined above are applicable to shorelines within the City of Punta Gorda.

Table C5.2 Appropriate Conditions for Various Living Shoreline Approaches (Miller, et al, 2015)

	Marsh Sill	Breakwater	Revetment	Living Reef	Reef Balls
System Parameters					
Erosion History	***Low-Med***	***Med-High***	***Med-High***	***Low-Med***	***Low-Med***
Relative Sea Level	Low-Mod	Low-High	***Low-High***	Low-Mod	Low-Mod
Tidal Range	***Low-Mod***	Low-High	Low-High	***Low-Mod***	Low-Mod
Hydrodynamic Parameters					
Wind Waves	***Low-Mod***	***High***	***Mod-High***	***Low-Mod***	***Low-Mod***
Wakes	***Low-Mod***	***High***	***Mod-High***	***Low-Mod***	***Low-Mod***
Currents	Low-Mod	Low-Mod	Low-High	Low-Mod	Low-Mod
Ice	***Low***	***Low-Mod***	***Low-High***	***Low***	Low-Mod
Storm Surge	Low-High	***Low-High***	***Low-High***	Low-High	Low-High
Terrestrial Parameters					
Upland Slope	Mild-Steep	Mild-Steep	***Mild-Steep***	Mild-Steep	Mild-Steep
Shoreline Slope	***Mild-Mod***	***Mild-Steep***	**Mild-Steep**	***Mild-Mod***	Mild-Steep
Width	***Mod-High***	***Mod-High***	Low-High	***Mod-High***	***Mod-High***
Nearshore Slope	***Mild-Mod***	***Mild-Mod***	Mild-Steep	***Mild-Mod***	***Mild-Mod***
Offshore Depth	Shallow-Mod	Mod-Deep	Shallow-Deep	Shallow-Mod	Shallow-Mod
Soil Bearing	Mod-High	***High***	***Mod-High***	Mod-High	***Mod-High***
Ecological Parameters					
Water Quality	Poor-Good	Poor-Good	Poor-Good	***Good***	***Poor-Good***
Soil Type	***Any***	Any	Any	Any	Any
Sunlight Exposure	***Mod-High***	Low-High	Low-High	Mod-High	Low-High

Note: with the exception of 'ice', all parameters outlined above are applicable to shorelines within the City of Punta Gorda.

Comparatively, the parameter limitations identified by Miller et al are considered more conservative that those outlined by the USACE Systems Approach to Geomorphic Engineering (SAGE) brochure entitled “Natural and Structural Measures for Shoreline Stabilization” (2015). Table C5.3 summarizes wave energy by classifying wave heights into low, medium, and high energy categories, as defined by SAGE (2015). Notably the wave heights cataloged within each low, medium and high category is nearly double that of the wave height thresholds identified for similar exposure categories.

Table C5.3 Summary of Wave Energy

Wave Heights	Description	Typical Range
Low	Limited fetch in sheltered, shallow or small water body (such as estuary, river, bay)	< 2 foot
Medium	A range that combines elements of low and high energy (e.g. shallow water with a large fetch or partially sheltered)	2 to 5 feet
High	Large fetch, deep water, open ocean	> 5 feet

With much of the waterfront in Punta Gorda located along the Charlotte Harbor, the City is exposed to a relatively large fetch up to nearly 6 miles to the west. The waterfront is also located in close proximity to a navigation channel where boat traffic is prevalent. Vessel-generated waves (boat wakes) are a significant source of wave energy within sheltered water bodies. As vessels pass, waves are generated by the bow and stern as it moves through the water. Once wake waves are generated, they propagate through the water and are modified by the local site conditions. In the Punta Gorda area, multiple marinas and an abundance of private docks support extensive boat traffic as people traverse Charlotte Harbor and the Peace River. The waves caused by wind and boat wakes, in combination with the presence of existing vertical bulkheads and hardened shorelines, leads to a complex design challenge for shoreline protection. Taylor Engineering recommends applying more conservative wave height thresholds as identified in Tables C5.1 and C5.2 in future living shoreline design projects.

Given the location and physical orientation of the City’s urban downtown waterfront to the harbor, the site conditions are similar across the City’s various shoreline reaches. Average daily tidal datums are estimated by NOAA using observed water level data at long-term tide stations. In review of living shoreline design reports developed for the City by others, the tidal range utilized for those analyses references a historic tide station in Punta Gorda (Station ID No: 8725744) located near Fishermen’s Village. This is a subordinate station that actively recorded water levels for eight months from 1977-1978 and was removed in 1981, reporting only monthly tidal data for a 9-month period. This outdated tidal information does not account for water level changes over the past 40 years such as sea level rise, making this data obsolete and inconsistent with the recommendations outlined in the Climate Adaptation Plan addendum to consider future planning horizons.

Alternatively, Taylor Engineering recommends the NOAA tidal gauge located in Fort Myers at the City’s Yacht Basin, along the Caloosahatchee River, 0.25 miles east of the US 41 bridge. This tidal gauge is a close approximation for Punta Gorda’s water level trends due to its riverine location within a similar proximity to the Gulf of Mexico as downtown Punta Gorda. The Fort Myers gauge (Station ID NO: 8725520) has measured monthly mean water levels since 1965 and hourly water levels since 1969. Stations with datasets longer than 40 years are preferred for calculating sea level trends, as seasonal variability and multi-decadal variability is reduced with a longer duration dataset. While the latter tidal gauge provides more comprehensive data, it is recommended that both stations be evaluated when selecting living shoreline designs within the tidal zone.

In addition to tidal range, consideration of potential storm surge water elevations is necessary in order to achieve specific design goals. For traditional engineered structures, determination of storm surge is critical; however, for living shorelines, this parameter is less significant as most of these approaches are low lying and likely to be overtopped during extreme conditions. The key when considering storm surge is to design living shorelines to withstand and maintain stability when exposed to storm related receding waters. Upon review of storm surge data from FEMA, Table C5.4 summarizes the storm surge elevations for 10, 25, 50, 100, and 500-year storms within Charlotte County. Storm surge events can better be described as the potential frequency of occurrence within any given year.

Table C5.4 FEMA Storm Surge Range for Charlotte County

Surge Event (yr)	Annual Chance of Occurrence (%)	Min (ft)	Max (ft)
10	10%	2.2	4.9
25	4%	4.6	6.9
50	2%	5.6	8.5
100	1%	5.3	10.2
500	0.2%	8.9	14.3

Though Punta Gorda is a peninsular point, the City-owned shoreline is located primarily along the interior portion of the Charlotte Harbor. The southwestern shoreline surrounding Punta Gorda is a state-owned conservation land buffer, called Charlotte Harbor Preserve State Park. The City’s shoreline is oriented facing primarily northeast to southwest and spans approximately 18,000 linear feet along the waterfront.

According to windspeed data recorded at the Punta Gorda Airport on WindHistory.com, the dominant winds are from the northeast (11.6%) with an average windspeed of 7 knots. However, the greatest prevailing windspeeds are from the west-southwest and south-southwest at 10 knots. As Florida’s second largest open water estuary (Estuaries Report Card, 2005), the fetch distances must be carefully considered for successful project performance. Maximum fetch distances were estimated using Google Earth from both the northeastern-most and southwestern-most locations within the City. In both cases, the maximum fetch distance measured approximately 5 to 6 miles from the west-southwest. According to NOAA Navigational Chart number 11426, the water depths along that azimuth range between 6 to 15 feet MLLW, with the deeper areas extending to the far west in the open water portion of the bay. All these factors have an impact on both regional and local sediment transport trends.

A review of previous documentation indicates that sediments along the downtown waterfront consist of primarily poorly consolidated fine sand with varying degrees of organic content (Jacobs, 2018). In some shoreline segments, black organic muck pockets with small factions of fine sand and shell fragments were found, including the presence of oyster shells.

6.0 LIVING SHORELINE ALTERNATIVES

Coastal systems typically include both natural and manmade elements. The interactions among these features determine coastal vulnerability, reliability, risk, and resiliency (USACE SAGE, 2015). An array of shoreline management strategies exists for coastal and estuarine systems which have been succinctly described in the SAGE brochure and outlined below. These strategies, which may be used independently or in combination are listed below (USACE SAGE, 2015).

- Natural features, created through the action of physical, biological, geologic, and chemical processes operating in nature, and include mangroves, dunes and oyster reefs. Such features are designed, engineered, and constructed to mimic a natural system.
- Structural features, created to reduce coastal risk by decreasing shoreline erosion, wave damage, and flooding. These features include seawalls, bulkheads, groins and breakwaters – each requiring engineered design and construction.
- Non-structural features, such as modifications in public policy, management practices, and regulatory policies. These measures could be implemented through established land use regulations, emergency response planning, flood preparedness planning, and structural acquisition/relocation).

As recognized by the USACE and NOAA, an integrated ‘hybrid’ approach to risk reduction through the incorporation of natural, nature-based features in addition to non-structural and structural measures is the key to improving social, economic, and ecosystem resilience. The table below, from USACE SAGE (2015) summarizes a range of acceptable green, gray and hybrid approaches to resilient shoreline management.

To summarize the overall benefits as outlined in the table, such green to gray living shoreline measures each provide erosion control and shoreline stabilization. However, incorporation of green to hybrid type approaches improve biological, social and economic elements. Restoration and enhancement of habitats provide support for fish and wildlife populations, result in increased property values, and improved recreational use/public access. Other physical benefits include increased resilience and absorption of wave energy, storm surge and floodwaters, improved water quality from settling and trapping of suspended sediment, and carbon sequestration (USACE SAGE, 2015).

Typical challenges in development and design of living shoreline projects, specifically in urban environments, include limited land space, high velocity waters, lack of performance monitoring, lengthy permitting processes, land ownership constraints, and available funding. Though funding availability is often an issue, materials selection greatly influences the overall project cost. As outlined in Table C6.1, green shoreline approaches are often cheaper than traditional gray shoreline stabilization techniques, however, careful consideration must be given to the operation and maintenance of such installations over the project lifecycle. Note that the estimated costs identified for initial construction, operations and maintenance (Table C6.1) represent average order of magnitude costs for similar projects implemented in recent years based on data available at the time of the publication. Project costs may vary based on site conditions, accessibility, material selection, and design.

Table C6.1 Green to Gray Living Shoreline Management Alternatives

Option	Description	Suitable Site Characteristics	Material Options	Benefits	Disadvantages	Estimated Cost	Comment
Vegetation Only	Roots hold soil in place to reduce erosion. Provides a buffer to upland areas and breaks small waves.	Low wave energy environments.	• Native plants	• Dissipates wave energy • Slows inland water transfer • Increases natural storm water infiltration • Provides habitat and ecosystem services • Minimal impact to natural community and ecosystem processes • Maintains aquatic/terrestrial interface and connectivity • Flood water storage	• No storm surge reduction ability • No high water protection • Appropriate in limited situations • Uncertainty of successful vegetation growth and competition with invasive	Initial Construction: Up to $1,000/linear foot Operations & Maintenance: Up to $100/linear foot	Native plants and materials must be appropriate for current salinity and site conditions.
Edging	Structure to hold the toe of existing or vegetated slope in place. Protects against shoreline erosion	Most areas except high wave energy environments.	Vegetation base with the following options: • "Snow" fencing • Erosion control blankets • Geotextile tubes • Living reef (oyster/mussel) • Rock gabion baskets	• Dissipates wave energy • Slows inland water transfer • Provides habitat and ecosystem services • Increases natural storm water infiltration • Toe protection helps prevent wetland edge loss	• No high water protection • Uncertainty of successful vegetation growth and competition with invasive	Initial Construction: $1,000 up to $2,000/linear foot Operations & Maintenance: Up to $100/linear foot	Native plants and materials must be appropriate for current salinity and site conditions.
Sills	Parallel to existing or vegetated shoreline, reduces wave energy and prevents erosion. A gapped approach would allow habitat connectivity, greater tidal exchange, and better waterfront access.	Most areas except high wave energy environments.	Vegetation base with the following options: • Stone • Sand breakwaters • Living reef (oyster/mussel) • Rock gabion baskets	• Provides habitat and ecosystem services • Dissipates wave energy • Slows inland water transfer • Provides habitat and ecosystem services • Increases natural storm water infiltration • Toe protection helps prevent wetland edge loss	• Require more land area • No high water protection • Uncertainty of successful vegetation growth and competition with invasive	Initial Construction: $1,000 up to $2,000/linear foot Operations & Maintenance: Up to $100/linear foot	Native plants and materials must be appropriate for current salinity and site conditions.
Beach Nourishment Only	Large volume of sand added from outside source to an eroding beach. Widens the beach and moves the shoreline seaward.	Low-lying oceanfront areas with existing sources of sand and sediment.	• Sand	• Expands usable beach area • Lower environmental impact than hard structures • Flexible strategy • Redesigned with relative ease • Provides habitat and ecosystem services	• Requires continual sand resources for renourishment • No high water protection • Appropriate in limited situations • Possible impacts to regional sediment transport	Initial Construction: $2,000 up to $5,000/linear foot Operations & Maintenance: $100 up to $500/linear foot	Sediment size and characteristics must match.
Beach Nourishment & Vegetation on Dune	Helps anchor sand and provide a buffer to protect inland area from waves, flooding and erosion.	Low-lying oceanfront areas with existing sources of sand and sediment.	Sand with vegetation can also strengthen dunes with: • Geotextile tubes • Rocky core	• Expands usable beach area • Lower environmental impact • Flexible strategy • Redesigned with relative ease • Vegetation strengthens dunes and increases their resilience to storm events • Provides habitat and ecosystem services	• Requires continual sand resources for renourishment • No high water protection • Appropriate in limited situations • Possible impacts to regional sediment transport	Initial Construction: $2,000 up to $5,000/linear foot Operations & Maintenance: $100 up to $500/linear foot	Sediment size and characteristics must match. Native plants and materials must be appropriate for current salinity and site conditions.
Breakwater	Offshore structures intended to break waves, reducing the force of wave action and encourages sediment accretion. Can be floating or fixed to the ocean floor, attached to shore or not, and continuous or segmented. A gapped approach would allow habitat connectivity, greater tidal exchange, and better waterfront access.	Most areas except high wave energy environments often in conjunction with marinas.	• Grout-filled fabric bags • Armorstone • Pre-cast concrete blocks • Living reef (oyster/mussel) if low wave environment • Wood • Rock	• Reduces wave force and height • Stabilizes wetland • Can function like reef • Economical in shallow areas • Limited storm surge flood level reduction	• Expensive in deep water • Can reduce water circulation (minimized if floating breakwater is applied) • Can create navigational hazard • Require more land area • Uncertainty of successful vegetation growth and competition with invasive • No high water protection • Can reduce water circulation • Can create navigation hazard	Initial Construction: $5,000 up to $10,000/linear foot Operations & Maintenance: Over $500/linear foot	Rock/stone needs to be appropriately sized for site specific wave energy. Could be green by using oysters to colonize rocks or alternative forms and materials.
Groin	Perpendicular, projecting from shoreline. Intercept water flow and sand moving parallel to the shoreline to prevent beach erosion and break waves. Retain sand placed on beach.	Coordination with beach nourishment.	• Concrete/stone rubbleł • Timber • Metal sheet piles	• Protection from wave forces • Methods and materials are adaptable • Can be combined with beach nourishment projects to extend their life	• Erosion of adjacent sites • Can be detrimental to shoreline ecosystem (e.g. replaces native substrate with rock and reduces natural habitat availability) • No high water protection	Initial Construction: $2,000 up to $5,000/linear foot Operations & Maintenance: $100 up to $500/linear foot	Rock/stone needs to be appropriately sized for site specific wave energy. Could be green by using oysters to colonize rocks or alternative forms and materials.

	Revetment	Lays over the slope of a shoreline. Protects slope from erosion and waves.	Sites with pre-existing hardened shoreline structures.	• Stone rubble • Concrete blocks • Cast concrete slabs • Sand/concrete filled bags • Rock-filled gabion basket	• Mitigates wave action • Little maintenance • Indefinite lifespan • Minimizes adjacent site impact	• No major flood protection • Require more land area • Loss of intertidal habitat • Erosion of adjacent unreinforced sites • Require more land area • No high water protection • Prevents upland from being a sediment source to the system	Initial Construction: $5,000 up to $10,000/linear foot Operations & Maintenance: $100 up to $500/linear foot	Rock/stone needs to be appropriately sized for site specific wave energy. Could be green by using oysters to colonize rocks, using vegetation or alternative forms and materials.
	Bulkhead	Parallel to the shoreline, vertical retaining wall. Intended to hold soil in place and allow for a stable shoreline.	High energy settings and sites with pre-existing hardened shoreline structures. Accommodates working water fronts (eg: docking for ships and ferries).	• Steel sheet piles • Timber • Concrete • Composite carbon fibers • Gabions	• Moderates wave action • Manages tide level fluctuation • Long lifespan • Simple repair	• No major flood protection • Erosion of seaward seabed • Erosion of adjacent unreinforced sites • Loss of intertidal habitat • May be damaged from overtopping oceanfront storm waves • Prevents upland from being a sediment source to the system • Induces wave reflection	Initial Construction: $2,000 up to $5,000/linear foot Operations & Maintenance: $100 up to $500/linear foot	Could be green by using green wall or biowall or alternative forms and materials.
	Seawall	Parallel to shoreline, vertical or sloped wall. Soil on one side of wall is the same elevation as water on the other. Absorbs and limits impacts of large waves and directs flow away from land.	Areas highly vulnerable to storm surge and wave forces.	• Stone • Rock • Concrete • Steel/vinyl sheets • Steel sheet piles	• Prevents storm surge flooding • Resists strong wave forces • Shoreline stabilization behind structure • Low maintenance costs • Less space intensive horizontally than other techniques (e.g. vegetation only)	• Erosion of seaward seabed • Disrupt sediment transport leading to beach erosion • Higher up-front costs • Visually obstructive • Loss of intertidal zone • Prevents upland from being a sediment source to the system • May be damaged from overtopping oceanfront storm waves	Initial Construction: $5,000 up to $10,000/linear foot Operations & Maintenance: Over $500/linear foot	Could be green by using green wall or biowall or alternative forms and materials.

Green, softer approaches require site conditions that include low wave energy, small fetch, gentle slopes, and a sheltered coastal orientation, as shown in Photograph C6.1. Harder, gray shoreline stabilization approaches are suitable in areas with high wave energy, lengthy fetch, steep slopes, and exposure to open coast conditions. Photograph C6.1 demonstrates an example of an edging approach to shoreline stabilization (as outlined in Table C6.1), using native vegetation supported by oyster reefs to hold the toe of the slope in place. Other edging approach examples successfully used in southwest Florida include the use of planter boxes, geosynthetic cellular systems such as “Geoweb” or other similar products.

Photograph C6.1 Oyster Breakwater, Cat Point in the Florida Panhandle

6.1 Shoreline Vegetation Options for Southwest Florida

When properly designed for site conditions, living shorelines generally become more stable over time as plants grow. Naturally vegetated shorelines absorb wave energy (Anderson and Smith, 2014) while maintaining the ability to bounce back to their pre-stressed condition. Mangroves and marsh vegetation trap sediment and may increase in elevation to keep pace with sea level rise. According to Morris, et al (2002), wetlands can increase upward nearly 12mm per year. Similarly, mangroves can migrate landward faster than sea level rise (Das and Vincent, 2009, Gilman et al, 2007). Selection of proper vegetation depends on whether the site is located in low, mid, or high marsh tidal zones. Florida Living Shorelines[2] provides the following information on salt tolerant plants suitable for tidal zones in southwest Florida (Photograph C6.2).

The low tidal zone generally extends from the seaward edge of wetland vegetation shoreward to about the mean high water line. This zone floods daily and is generally exposed at low tide. Plants suitable for this zone include:

- Red mangrove (*Rhizophora mangle*) – generally the dominant species
- Black mangrove (Avicennia germinans)
- White mangrove (Laguncularia racemosa)

Photograph C6.2 Marsh Restoration in St. Johns County, FL

[2] http://floridalivingshorelines.com/marshplants/#South, accessed June 13, 2019.

Mid-tidal zone vegetation generally occurs near the mean high water line and experiences regular to occasional flooding. Plants suitable for this zone include:

- Red mangrove (*Rhizophora mangle*)
- Black mangrove (*Avicennia germinans*)
- White mangrove (*Laguncularia racemosa*)
- Saltwort (*Batis maritima*)
- Glasswort (*Sarcocornia ambigua*)

High-tidal zone vegetation experiences flooding under extreme high tides and storm surge. Plants suitable for the high-tidal zone include:

- Black mangrove (*Avicennia germinans*)
- White mangrove (*Laguncularia racemosa*)
- Saltmeadow cordgrass (*Spartina patens*)
- Saltgrass (*Distichils spicata*)
- Sea purslane (*Sesuvium portulacastrum* or *S. maritimum*)
- Seashore dropseed (*Sporobolous virginicus*)
- Seashore paspalum (*Paspalum vaginatum*)
- Black needlerush (*Juncus roemerianus*)
- Sand cordgrass (*Spartina bakeri*)
- Marsh elder (*Iva frutescens*)
- Sea ox-eye daisy (*Borrichia frutescens*)

6.2 Oyster Restoration

Oyster reefs are a key habitat in southwest Florida estuaries, providing numerous species of fish and invertebrate with territory for foraging, refuge, nursery, and other critical life cycle functions. However, the oyster reefs in Charlotte Harbor and elsewhere in the region have been largely lost; destroyed by dredging, oyster shell mining, and watershed urbanization effects such as sedimentation, water quality changes, and greatly increased human activity. This has resulted in an estimated 90% loss of historic oyster habitat in Charlotte harbor and the other estuaries within the CHNEP region. TNC Florida Chapter identified Charlotte Harbor as a Florida marine priority area in TNC's larger strategy to restore the Gulf of Mexico (TNC, 2017).

While oyster reef installations have been occurring in Charlotte Harbor (e.g. Photograph C6.3), for many years the efforts did not take place within a well-defined restoration plan. In 2012, CHNEP and its partners developed the CHNEP Oyster Habitat Restoration Plan (Plan; Boswell et al 2012). The Southwest Florida Oyster Working Group (SWF OWG) guided plan development, which was produced through a CHNEP Nature Conservancy (TNC) partnership. The Plan uses the TNC four-step "conservation by design" approach to define oyster restoration needs and strategies. The Restoration Suitability Model (RSM), developed as part of the Plan, identifies over 40,000 acres highly suitable for oyster restoration within the Charlotte Harbor System (Figure C6.1 Charlotte Harbor Habitation Restoration Suitability Model Results).

Photograph C6.3 Oyster Reef Installation in Charlotte Harbor near downtown Punta Gorda, 2015 (Mosaic 2019)

The Plan has a long-term goal of restoring 1,000 - 6,000 acres of oyster reef. That long-term goal is supported by a series of short term objectives:

- Map oyster habitats by type within the CHNEP by 2020.

- Design, implement and monitor the success of pilot oyster restoration projects in a variety of habitats in 50% of the CHNEP estuary segments by 2020 (Photograph C6.4).
- Increase public awareness of the ecosystem value of native oyster habitats by including
- Integrate community stewardship components in each oyster restoration project.
- Assist partners in seeking state, federal and organizational funding opportunities to support oyster habitat restoration projects.

Photograph C6.4 Artificial Oyster Reefs Implemented by CHNEP, February 2019

As part of the efforts to meet those objectives, Punta Gorda recently partnered with CHNEP, TNC, FDEP, and community volunteers to test three types of materials often used in oyster restoration projects to see which method produces the best larval oyster recruitment. Bagged shells were most attractive, with over twice the recruitment of loose shell (about 600 larvae/square meter) which was twice as attractive as shell mats, which recruited over 300 larvae/square meter). However, the shell mats produced larger individuals. This project also supports the development of community stewardship and public awareness critical for the long-term program to succeed.

In addition to the critical ecosystem functions oyster reefs provide, they can also survive and help combat consequences of sea level rise. Oyster reefs stabilize sediments, shorelines, and adjacent habitats, buffering wave energy and aiding water quality. Sediment deposition and stabilization within and around oyster reefs can result in net sediment elevation in oyster reef areas (Bahr and Lanier 1981) Oyster reefs can grow vertically up to 60 mm/year (Ridge et al, 2017 and Rodriquez et al, 2014). Based on the City's 2019 vulnerability analysis, the local rate of sea level rise is 3.1 mm/year. Predicted oyster growth rates are capable of outpacing local sea level rise at this time. Oyster reef creation has been identified as a means of reducing shoreline erosion and loss of saltmarsh habitat due to sea level rise in Charlotte Harbor (Geselbracht et al. forthcoming; from Boswell et al 2012).

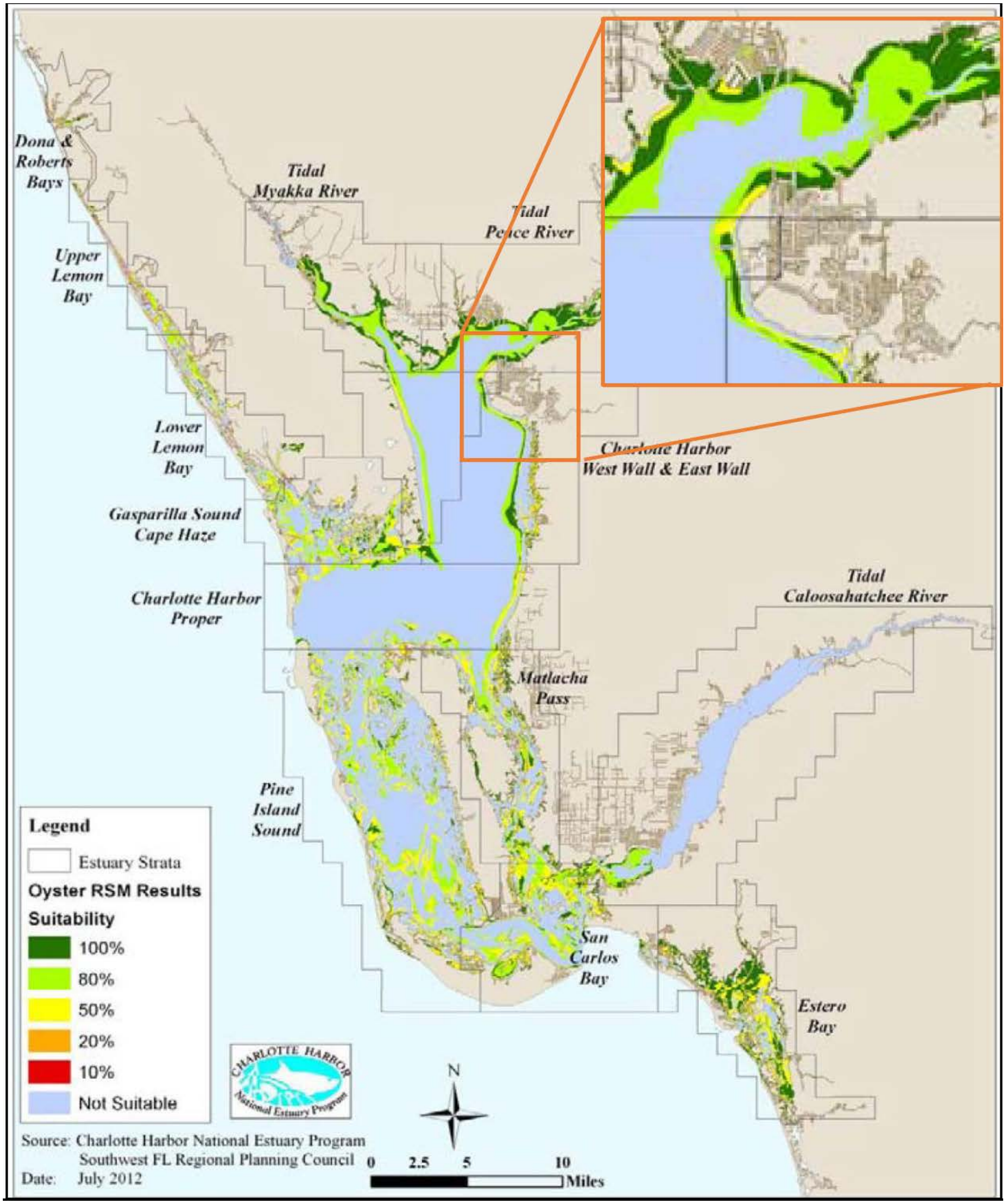


Figure C6.1 Charlotte Harbor Habitation Restoration Suitability Model Results
(Boswell, 2012)

6.3 Hybrid Approaches

For site conditions where wave energy exceeds 1 foot or more, a hybrid living shoreline approach is most viable. The City's waterfront is located within relatively shallow water. Due to the open 6-mile fetch to the west, greatest prevailing winds from the west southwest, and moderate to heavy vessel traffic (boat wakes) within the vicinity, a hybrid approach is recommended for most shoreline segments. As outlined in Table C6.1, a range of solutions such as a rock planted sills, planter boxes, limestone riprap, concrete oyster domes, marine mattresses or breakwater type solution can be used. The City, in partnership with other entities, has developed conceptual level alternatives analysis for an 800 linear foot segment of shoreline fronting the Sheraton Four Points Hotel along the downtown waterfront (Photograph C6.5).

Photograph C6.5 Existing Shoreline Conditions along the Four Points Sheraton Waterfront (*Jacobs Engineering Technical Memo, 2018*)

One example of this approach can be found in plan view (Figure C6.2). The project is located in Okaloosa County, exposed to a 10-mile fetch along the Choctawhatchee Bay. Though specific vegetation types may vary by region, the technical design approach remains the same. The design accounted for wind-driven waves, boat wakes from the adjacent navigation channel, sediment transport and existing ecological concerns; similar to conditions within the City of Punta Gorda. Notably, the green, red, and yellow zones represent low, medium, and high shoreline zone species as well as open areas to allow for natural recruitment.

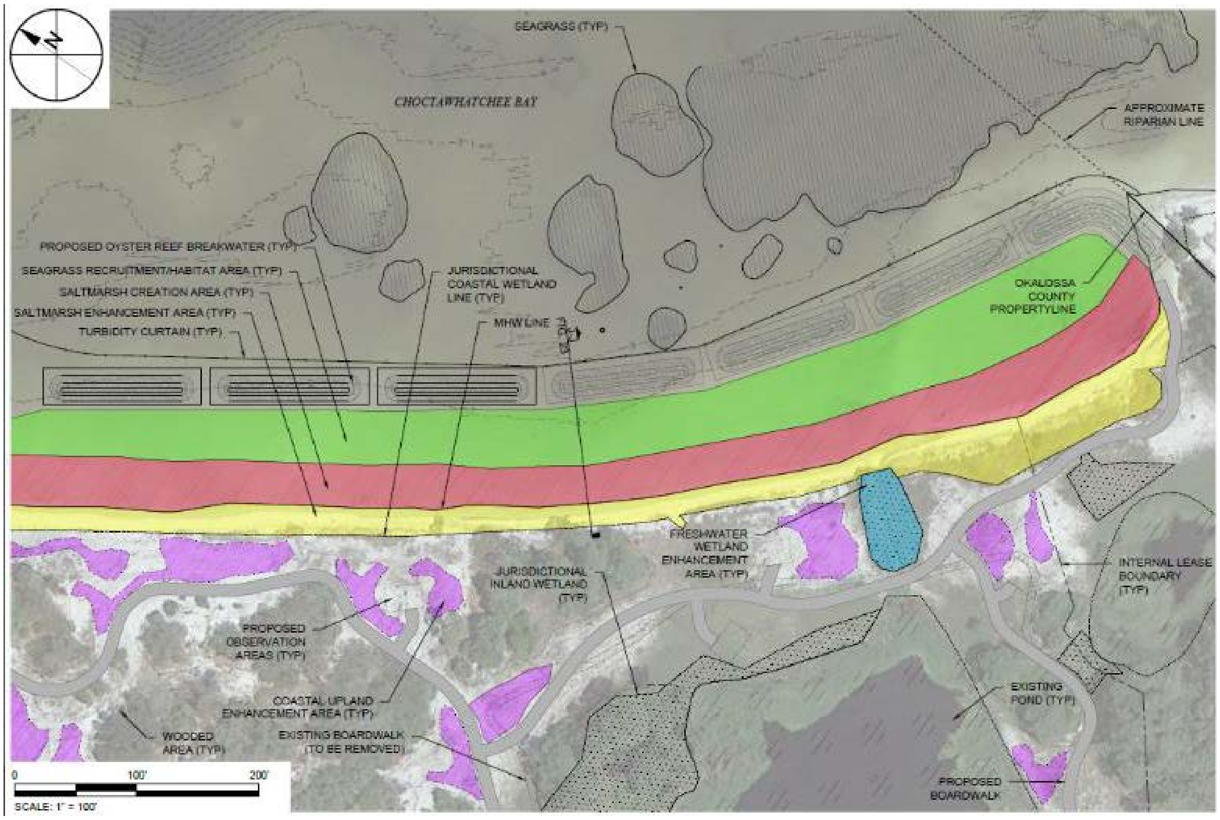
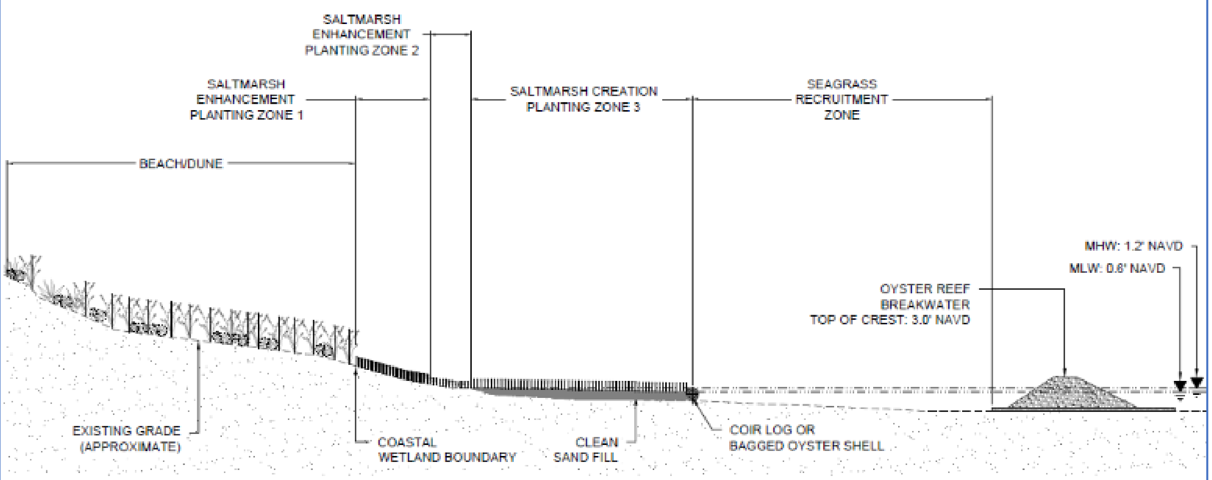


Figure C6.2 Okaloosa Baywalk Living Shoreline Design Plan View (*Taylor Engineering*)

The material elements consist of oyster reef breakwaters composed of limestone to allow for oyster recruitment. In this case, rock is required to accomplish the required stability necessary to withstand the moderate wave climate. Figure C6.3 depicts a representative cross-section of this design.



PLANTING SCHEDULE

ZONE	COMMON NAME	SCIENTIFIC NAME	SIZE	DENSITY
1	MARSH-HAY CORDGRASS	*Spartina patens*	2" LINER	12" ON CENTER
2	BLACK NEEDLERUSH	*Juncus roemerianus*	2" LINER	12" ON CENTER
3	SMOOTH CORDGRASS	*Spartina alterniflora*	2" LINER	12" ON CENTER

FIG. 9 J-J LIVING SHORELINE TYPICAL CROSS SECTION
NOT TO SCALE

Figure C6.3 Okaloosa Baywalk Living Shoreline Design Cross-section View (*Taylor Engineering)*

Another hybrid living shoreline example is shown in Figure C6.4 and Figure C6.5. Located at Cat Point in Franklin County, Florida; this project site adjoins the Apalachicola National Estuarine Research Reserve. The design consists of an oyster reef breakwater constructed of suitable substrate for marine mattress filling, such as limestone, oyster cultch, or a composite of the two. The marine mattresses, a cellular geogrid basket, provide ease in constructability, acting as a semi-emergent, low-crested natural segmented breakwater for wave attenuation.

Along the shoreline, suitable plantings are specified within each intertidal zone with clean open sandy bottom to accommodate natural vegetation recruitment. For such designs, a planting schedule with site specific vegetation types, spacings, and sizes are paramount for implantation of successful projects. Incorporation of a natural/native-material wave attenuation structure waterward of the planting area allows vegetation to take root and stabilize.

Much of the City’s downtown waterfront is already hardened with vertical walls. Therefore, mid and high intertidal planting zones may be limited in some areas. Due to the presence of vertical walls, localized scour along the toe is typical when exposed to moderate wave energy. Under the influence of tides, waves and currents, sediments suspended in the water column resulting from toe scour can be transported to other reaches or segments of shoreline This phenomenon is important when planning for installation of living shorelines as nearshore living shorelines may require periodic maintenance to maintain adequate fill necessary to stabilize living shoreline elements.

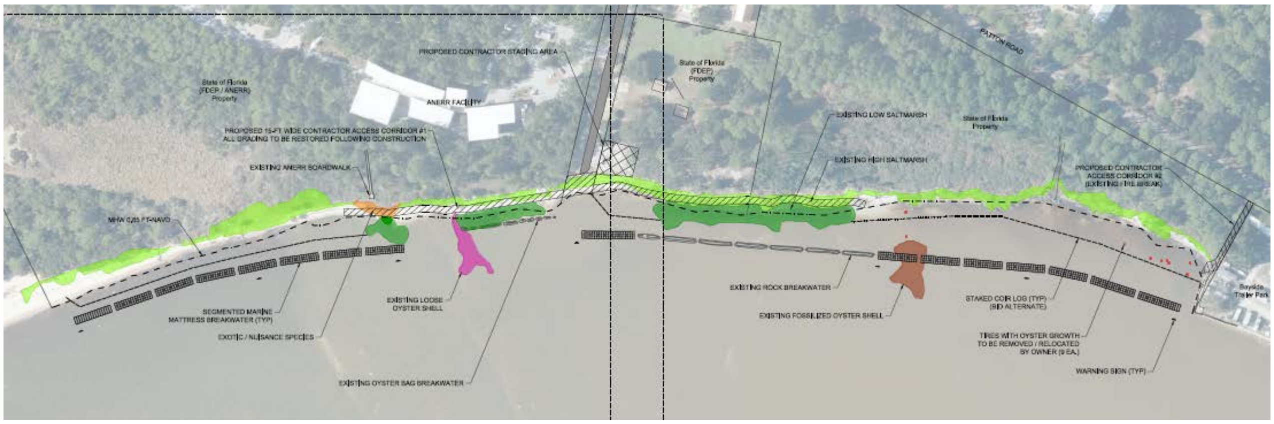


Figure C6.4 Cat Point Living Shoreline Plan View (*Taylor Engineering*)

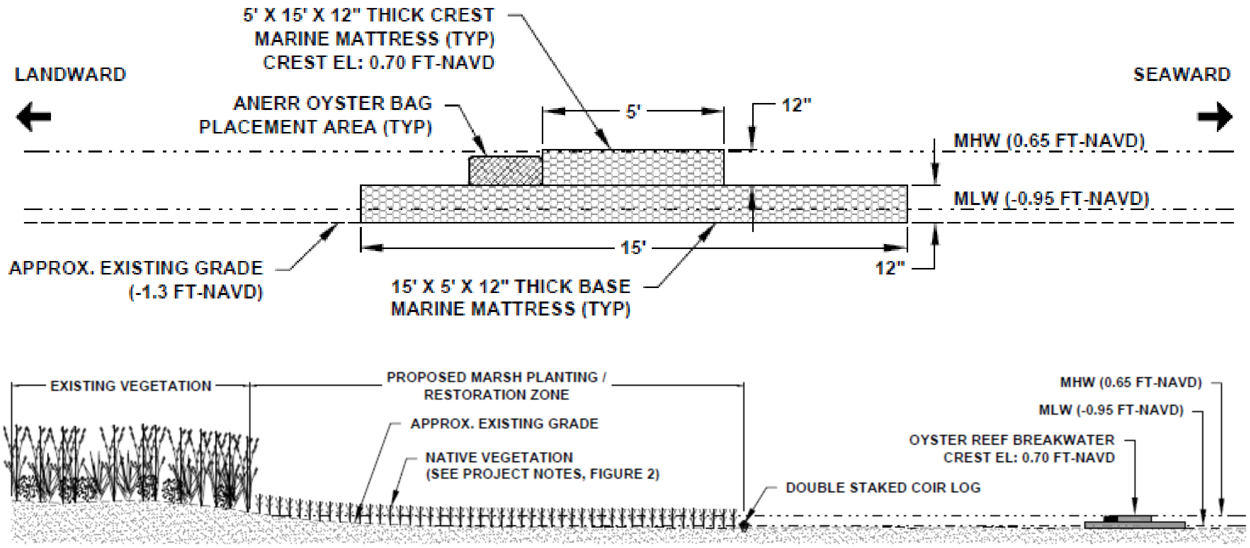


Figure C6.5 Cat Point Living Shoreline Cross-section (*Taylor Engineering*)

It is important to evaluate the level of risk for continued erosion with the level of protection that is acceptable at a particular site. Decision-makers should keep in mind that no shoreline stabilization technique (hardened or living shoreline) is guaranteed to prevent the loss of infrastructure during the most severe storms (NOAA, 2015). However, living shorelines can be more resilient than hardened vertical structures in storms with high storm surge. Storm surge can roll over the living shoreline and inundate the land, leaving the shoreline minimally impacted. In contrast, wave energy from the waterward side and retreating water can undermine bulkheads and seawalls that are not high enough to prevent overtopping and inundation of the land behind the structures.

7.0 MAINTENANCE AND MONITORING

Maintenance is critical for continued growth and minimizing storm damage sustained by living shoreline sites. Maintenance includes replanting vegetation as needed, maintaining fill, periodic debris removal, and removal of interfering invasive species. Traditional hard stabilization structures also require maintenance and repair to deal with deterioration and damage.

Living shoreline projects are planned and designed to meet specific goals and design criteria, but it is important to monitor installed projects to gauge their performance and perform adaptive management. Although many studies have demonstrated the benefits of natural, nature-based living shorelines, data gaps exist (Yepsen et al., 2016). For example, while salt mangroves and salt marshes provide coastal resilience benefits to communities during storms, little is known about how those benefits vary with storm size, speed, and duration (Sutton-Grier et al., 2015). Monitoring the effectiveness of living shorelines in preventing erosion and sustaining information to evaluate whether living shorelines should be considered for other similar environments. In most, if not all cases, regulatory or grant funding agencies require monitoring of projects. Ideally, monitoring should be initiated before project installation in order to gauge project performance through a series of monitoring stages: a) baseline monitoring, b) as-built survey, and c) performance monitoring.

Baseline monitoring includes data collection (e.g., topography, sediment characteristics, vegetation) prior to design and installation of a project to document the condition against which future monitoring will be compared. As-built surveys are monitoring surveys conducted immediately after project construction to demonstrate that the project meets the engineering specifications and regulatory requirements. Performance monitoring following installation allows for comparison of the baseline site condition and as-built conditions. This process provides documentation on progress and project performance compared to the project goals. Performance monitoring can inform the need for potential adaptive management or maintenance if a project is not performing as intended (Yepsen et al., 2016).

Kreeger and Moody (2014) and Yepsen et al. (2016) discuss the framework of monitoring plan development and provide tables to guide the user in selecting monitoring metrics and methods based on project design type, goals, and other considerations (Figure C7.1).

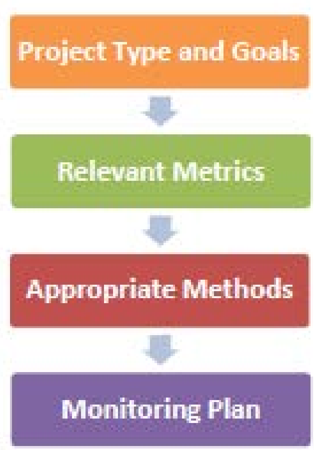


Figure C7.1 Stepwise Progression for Monitoring Plan Development (*Yepsen et al, 2016*)

Generally, the project objective will help to define the core set of metrics used to evaluate project success. Recent studies indicate that living shoreline projects typically don't begin to thrive until several years post-construction. Ongoing annual monitoring for a period of six years or more may be necessary to fully document project development and performance.

8.0 REGULATORY CONSIDERATIONS

As with all construction projects in Florida that involve surface waters or wetlands, living shoreline projects must consider regulatory requirements and obtain authorizations from state and federal governments. In addition, Punta Gorda's waterfront is within the Gasparilla Sound – Charlotte Harbor Aquatic Preserve. This designation by the State of Florida provides for additional protection and management by the state to preserve these areas in their natural or existing conditions. Chapter 18-20 Florida Administrative Code (FAC) sets management policies and criteria for activities within aquatic preserves. Activities within Aquatic Preserves must have a positive public benefit; dredging and filling activities are typically prohibited, with few exceptions. In order to receive authorization, a restoration project proposed within an aquatic preserve must demonstrate that the project will have an overall benefit to the aquatic preserve and demonstrate consistency with existing aquatic preserve management plans.

The waters within City limits are also within the National Marine Fisheries Service (NMFS) designated smalltooth sawfish critical habitat boundary (as of September 2009 per 50 CFR Part 226). The designation area contains nursery areas featuring "red mangroves and shallow euryhaline habitats characterized by water depths between the Mean High Water line and 3 ft (0.9 m) measured at Mean Lower Low Water (MLLW).

8.1 State and Federal Permitting:

State permits are issued by either the FDEP or the Southwest Florida Water Management District (SWFWMD). Federal permits for restoration of projects within waters of the United States (e.g., within wetlands or submerged areas) are issued by the USACE. Instructions and additional information for state applications can be found at on the FDEP (2019a) regulatory website. Information on the USACE permitting process, forms and guidance for the Jacksonville District may be found within the USACE Jacksonville District Source Book (USACE 2019).

Engineers and practitioners planning to implement submerged habitat restoration projects are encouraged to seek pre-application meetings with federal and state regulatory staff prior to permit application submittal. Specific permitting guidance can be obtained from such meetings on an individual project basis.

In relatively recent regulatory developments, state and federal agencies now provide expedited permitting for living shorelines and other similar projects to encourage landowners, municipalities, and planners to consider softer design solutions for shoreline stabilization.

8.2 State Permitting:

Projects affecting wetlands generally require a state environmental resource permit (ERP) issued by the FDEP or SWFWMD. Most submerged lands on which Punta Gorda living shoreline projects would be located are state owned and would, therefore, also require a state submerged lands use authorization. The ERP process follows Chapter 62-330, Florida Statutes, and the rules thereunder. Chapter 18-21 FAC governs sovereignty submerged lands management and uses, providing a guide for permitting decisions. The rule defines several types of authorization for various activities. FDEP's Submerged Lands and Environmental Resources Coordination program (FDEP 2019b) reviews applications for proposed works in wetlands and other surface waters as well as works in uplands that can affect water quality and quantity, to ensure compliance with the Florida Administrative Code and Florida Statutes

The FDEP may exempt a project from permitting or require one of several possible authorizations for living shoreline projects. The least complicated processes include review for a Verification of Exemption from Permitting or a General Permit, combined with a Statewide Programmatic General Permit (SPGP). The exemption and general permit authorizations, for projects with minimal or no impacts, include expedited review. The SPGP, which also requires only a short review period usually concurrent with the rest of the review process, allows the state to conclude that the impacts of a proposed project are so minimal that no federal review is required. An agreement between the State of Florida and the USACE Jacksonville District defines the conditions under which an SPGP can be issued. The process greatly expedites the review time if a proposed living shoreline project meets the State's design limitations. Those limitations, similar to the USACE requirements, include a project length less than 500 feet extending no more than 35 feet offshore.

8.3 Federal Permitting:

Most proposed construction that occurs in the waters of the US require a permit from USACE. That agency is responsible for issuing permits pursuant to the Rivers and Harbors Act of 1899 Section 10 and the Federal Water Pollution Control Act of 1972 (Clean Water Act or CWA) Section 404. Although the USACE and the US Environmental Protection Agency (EPA) share certain administrative responsibilities under the CWA, the USACE is the lead permitting entity for activities taking place in wetlands (Section 404 permits) while the EPA oversees water quality permitting under other provisions of the CWA (RAE, 2015). Water quality permitting authority in Florida has been delegated by the EPA to the FDEP. The USACE accepts the state permit for a project as the required water quality certification EPA would otherwise issue. The EPA does hold veto authority over USACE issued Section 404 permits but this authority is rarely used.

In general, the USACE regulates "dredge and fill" activities (excavation or placement of material) in navigable waters of the United States under 33 CFR Part 329 by requiring a permit. There are several types of permits, but those most germane to the discussion of living shorelines include General Permits and Individual permits. General Permits, primarily Nationwide Permits (NWPs) and Regional General Permits (RGPs), allow a project which meets specific design criteria and operate under specific permit conditions to proceed without an individualized (more detailed) assessment of the project. In an effort to streamline the permitting process for living shoreline projects, the USACE authorized Nationwide Permit 54 (NWP 54) in March 2017 for "Living Shoreline" projects. In order to qualify for this permit, the following design criteria must be met:

- The living shoreline must have a substantial biological component that maintains the natural continuity of the land-water interface and retain or enhance shoreline ecological processes,
- The structure and/or fill area cannot extend more than 30 feet from mean low water in tidal waters,
- The activity must be no more than 500 feet in length along a bank/shoreline,
- Structural materials (coir logs, oyster shell, etc.) must be anchored or be sufficiently weighted to prevent relocation from wave action or water flow,
- Native vegetation should be utilized,
- The discharges of dredged or fill material must be the minimum necessary for the establishment and maintenance of the living shoreline,
- The activity must be designed, constructed, and maintained so that it has no more than minimal adverse effects on water movement between the waterbody and the shore. The activity must also have minimal adverse effects on the movement of aquatic organisms,
- The living shoreline must be properly maintained.

In 2017 the USACE also reauthorized the Nationwide Permit 27 (NWP 27) for “Aquatic Habitat Restoration, Establishment, and Enhancement Activities” and Nationwide Permit 13 (NWP 13) for “Bank Stabilization” with a clarification that this includes authorization of a variety of erosion control techniques using native plants for bioengineering or vegetative stabilization.

Typically (although not always) compensatory mitigation is not required under this type of permit – but the NWP permits severely limit the amount of allowable impact. Further, federal regulations state that the NWP program will not authorize projects that are likely to jeopardize the continued existence of a threatened or endangered species as listed or proposed for listing under the Federal Endangered Species Act, or to destroy or adversely modify the critical habitat of such species. As Punta Gorda shoreline wetlands include smalltooth sawfish critical habitat and may include other listed species habitats, the USACE may determine that a proposed action could impact this or another listed species. Under requirements of the National Environmental Policy Act and Endangered Species Act they may decide to consult with the National Marine Fisheries Service (NMFS) or another federal agency to determine the potential for adverse impacts. Upon completion of consultations, they may authorize the activity under the NWP by adding activity-specific conditions or assert discretionary authority and require an individual permit.

9.0 CITY LIVING SHORELINE SITES

As outlined in the Center for Climate Strategies Adaptation Guidebook, mapping vulnerable areas and developing buyouts for these lands is a crucial adaptation strategy. The City of Punta Gorda, in essence, followed this strategy at its founding when Colonel Isaac Trabue designated much of the coastline and many low-lying, flood prone areas as natural park lands. The Punta Gorda Nature Park is a great example of publicly own space that is vulnerable to flooding but allowed to stay primarily in its natural state. Ponce De Leon Park, Trabue Park, Laishley Park, Alice Park, Shreve Park, and Gilchrist Park are other parks that act as a buffer for the city from the waters of the Peace River (Figure C9.1).

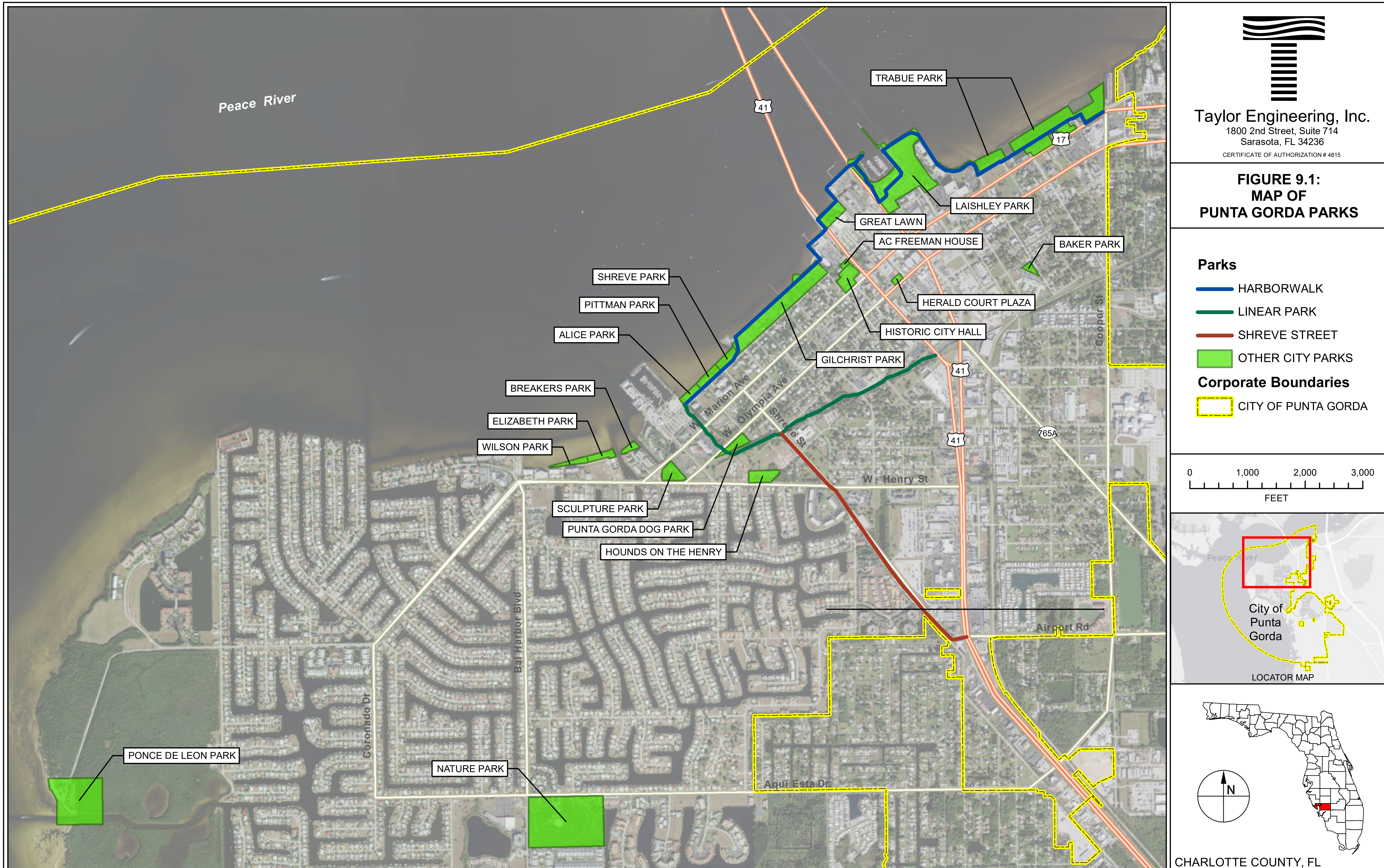


FIGURE 9.1: MAP OF PUNTA GORDA PARKS

During development of this report, Taylor Engineering staff visited several sites with City staff to observe potential living shoreline locations identified below:

- Gilchrist Park
- Breakers Park (south of Fisherman's Village)
- Ponce de Leon Park
- Old fire station in Burnt Store Isles subdivision, near Alligator Creek
- Harborwalk Boardwalk
- Linear Park, 1 mile of tidal creek

Based on feedback received during this site visit, one of the City's adaptation goals include the concept of 'retreat by advancing' into the water to reduce vulnerability, applying living shoreline elements as part of adaptation strategy. The 6 small parks (Figure C9.2Figure C9.1) located along the southwest region of the City adjacent to Punta Gorda Isles - identified as Shreve, Pittman, Alice, Breakers, Elizabeth, and Wilson Parks – consist primarily of a limestone rock revetment with mangroves along the shoreline.

Figure C9.2 Park Directory Sign, Harborwalk Park Punta Gorda

Much of the shoreline fronting Trabue Park remains relatively natural, vegetated with lush mangroves and oyster reefs within the shallow nearshore zone. The shoreline along Gilchrist Park appears to be largely hardened with a vertical concrete bulkhead. The park spans between two points for a length of approximately 2000 linear feet, with the Punta Gorda Waterfront Hotel & Suites to the east and the Punta Gorda Boat Club to the west. A small pocket beach is located adjacent to the hotel, suggesting sediment transport is occurring within the area. A thorough site analysis should be performed to determine the viability of each site for a range of living shoreline techniques.

10.0 RECOMMENDATIONS

There are a multitude of opportunities for developing successful living shoreline projects with the City. In order to advance the City's initiative to implement living shoreline techniques to reduce vulnerability to upland flooding, the following recommendations and next steps are outlined below for City consideration:

- Evaluate all projects currently in the planning and design phase to verify proper site conditions, identify and evaluate design criteria used, and refine the design and selected living shoreline techniques as necessary.
- Obtain bathymetric data within the nearshore zone for all potentially considered living shoreline project areas to identify water depths for consideration when conducting siting analyses.
- Develop living shoreline projects in concert with the goals and objectives outlined in the City's Comprehensive Plan.
- Maintain consistent data collection protocol, including the use of published, publicly available data such as tides. For example, consider the use of the Ft. Myers tide station for the best available tidal data.
- Develop a monitoring and maintenance plan for all projects currently installed and for future planned installations to evaluate performance. Performance monitoring should be implemented in all existing and future projects annually over a minimum 5 year period.
- In preparation for future subsequent design efforts, consider deployment of an acoustic doppler current profiler (ADCP) to measure water current velocities and wave heights, representative of multiple potential sites. This instrumentation can be deployed on a piling or mounted to the bottom in order to capture real-time, site-specific data. A pre-design monitoring period of 1 to 2 months is sufficient for use in developing appropriate site-specific living shoreline design.
- Continue to carefully plan for and implement sound engineered, shoreline stabilization projects – both for replacement of existing shoreline treatments and new projects.

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