DEP AGREEMENT NO. R1815

Dixie County Community Adaptation Plan

Dixie County Board of County Commissioners

Final Project Report

This report funded in part, through a grant agreement from the Florida Department of Environmental Protection, Florida Coastal Management Program, by a grant provided by the Office of Coastal Management under the Coastal Zone Management Act of 1972, as amended, National Oceanic and Atmospheric Administration Award No. *R1815.* The views, statements, findings, conclusions and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the State of Florida, NOAA or any of their subagencies.

June 2019

Final Project Report for R1815

Dixie County Community Adaptation Plan

Contents

Figures

Executive Summary

Coastal counties are currently experiencing climate change. More severe tropical storms and hurricanes with increased wind speeds and storm surges have already severely damaged both coastal and interior communities of Dixie County. Longer, more severe dry season droughts coupled with shorter duration wet seasons consisting of higher volume precipitation have generated a pattern of drought and flood impacting both natural and man-made ecosystems. The Florida Department of Economic Opportunity's Coastal Resiliency Initiative helps communities assess vulnerabilities to projected increases in coastal flooding and develop strategies to increase resiliency. Even in the most probable, lowest impact future climate change scenario predictions, the future for northwest Florida and Dixie County can be expected to include increased climate instability; wetter wet seasons; drier dry seasons; more extreme hot and cold events; increased coastal erosion; continuous sea level rise; and costs in infrastructure; and increased uncertainty concerning variable risk assessment.

This report is intended to expand upon the 2018 Vulnerability Assessment Report and to provide Dixie County with a policy framework for pursuing higher coastal resiliency. The Vulnerability Assessment draws on data from federal agencies and on inputs from Dixie County officials and community members in order to characterize the nature, implications, and certainty of the most important ways in which Dixie County is vulnerable to the impacts of sea level rise (SLR) and changing weather patterns.

This adaptation plan provides alternative adaptation strategies that can address the potential effects of climate change within the coastal communities and the identified specific vulnerabilities relating to the shoreline with regards to sea level rise and other coastal storm risks and how these risks may be negatively impactful.

Particular Conditions for Dixie County

Discussions at the community outreach workshops held throughout March of 2019 highlighted certain areas deemed to Dixie County's adaptation planning process:

- Primarily a long-term goal for SLR planning;
- Stormwater management system capacity is minimal and would require continual maintenance;
- Access to waterways may become a maintenance issue with increasing storm intensity
- Retreat and/or relocation to be warranted as a last resort

Adaptation Considerations for Dixie County

This report identifies several actions that could be undertaken to address the identified climate change vulnerabilities for Dixie County. These adaptations are presented without a prioritized order since the County will decide which adaptations it will choose to implement. Only the practical and positively received adaptations in each vulnerability area will be fully developed for potential implementation. One of the utilities of this approach is that it provides selective adaptation options based on the specific infrastructure and culture of each community. Proposals are as follows:

- **Highlight SLR impacts and policy responses to expect in the foreseeable future**

Conveying to community leaders and business the impacts of how rising seas and changing weather are expected to affect the county will serve to better promote private and government investment decisions. In many instances, this notice may occur by requiring private parties to give or take notice of known risks, for instance by requiring disclosure in real estate transactions of the frequency and height of all types of flooding that affect the property.

- **Distribution of supporting data to increase public acceptance**

Workshop participants expressed concerns regarding the span of time the data projections were based on. Providing and explaining the origin and limitations of the data used in projections to the local residents may address those concerns. This can be done through a website and distribution or mailers.

- **Engage in pre-disaster planning for post-disaster policy changes**

Disasters highlight areas of vulnerability and provide an opportunity to further develop and strengthen resiliency. Such an event, for instance, provide the basis for restricting post-disaster permitting in highly vulnerable areas on coastlines—or near coastlines where communities and infrastructure are likely to become vulnerable to flooding risks in the foreseeable future.

- **Make levels of service or capital spending allocations contingent**

Although Dixie County is not experiencing routine nuisance flooding of infrastructure such situations could occur in higher SLR scenarios. Recognizing what is coming and acting now, when doing so would not be likely to have widespread or significant immediate effects on levels of service, could prepare the county well. Specifically, the county should consider adopting policies that limit spending in instances where retreat or redesign would be more cost-effective than reconstruction or hard armoring. The same can be said for planned capital investments.

- **Create Adaptation Action Areas (AAAs)**

An AAA is an overlay zone or district applied over one or more established land uses or zoning districts to establish additional, stricter standards, or criteria for development in addition to those of the underlying land use or zoning district. Dedicating an AAA boundary, Dixie County could employ distinct policies to further govern other parts of the county.

- **Target systematic stormwater solutions**

The county should regularly consider evaluating stormwater management system capacities as SLR and weather make circumstances increasingly difficult. Repair, replacement, or redesign; and a more systematic approach to enforcement of run-off maintenance by private property owners.

Introduction

Florida communities are experiencing adverse effects of sea level rise (SLR), stronger coastal storms, and more intense precipitation events, and these effects are expected to become increasingly severe in the coming years and decades. Seeing what is happening now and recognizing what lies ahead, a number of Florida communities have begun working to adapt to present and projected impacts.

The Florida Department of Economic Opportunity (DEO) is leading the Community Resiliency Initiative in partnership with the Florida Department of Environmental Protection and with support from the Division of Emergency Management and the National Oceanic and Atmospheric Administration. The Initiative provides technical assistance to coastal communities in Florida that want to integrate effective adaptation and improved resiliency into their plans for development in the midst of SLR. By inviting localities to take the lead, the Initiative ensures that the efforts it supports are consistent with local circumstances and priorities regarding public safety, the economy, natural resources, and others.

Dixie County is particularly vulnerable to the effects of climate change. Topography is flat, naturally poorly drained and not very high above existing sea level. The majority of conservation lands and the regional economy have major investments within close proximity of the coast and rivers.

Dixie County has five major towns within its borders. These five towns consist of Jena, Horseshoe Beach, Suwannee, Cross City and Old Town. Of the five communities, Jena, Horseshoe Beach and Suwannee are situated along the 32-mile coastline and are hereafter referred to as the coastal communities. These communities are particularly vulnerable to the effects of SLR, hurricanes and tropical storms due to their proximity to the Gulf of Mexico. Climate projections indicate increases in the strength and intensity of these storms as well as sea-level rise which will increase the likelihood of future flooding events. As such, these communities will be the focal point of this plan.

The purpose of this plan is to provide a course of action and design concepts that address vulnerabilities and provide available methods to reduce potential damage to the environment, buildings, grounds and infrastructure due to impact from these events.

An adaptation plan can be a stand-alone document or be incorporated as an additional or new element in an existing management plan. Regardless of where the adaptation plan is housed, some of the key considerations include:

• How the plan affects existing management goals;

• Additional climate change-induced goals and objectives beyond the existing management goals;

• Management actions associated with achieving those goals and objectives; and

• Steps required for implementation (including the associated tools and resources that can be deployed).

Finally, an adaptation plan needs to be seen as a living document. One that allows for relatively easy revisiting and updating in response to changing conditions and lessons learned from monitoring and evaluation of results. The plan can be updated and enhanced as information changes regarding vulnerability, uncertainty, management priorities, technology, adaptation methods and costs.

SLR adaptation involves protecting current land uses and activities in vulnerable areas; modifying current uses and activities to reduce vulnerabilities; retreating from places vulnerable to SLR; or avoiding development in vulnerable locations.

> Accommodation means changing how land in the path of SLR is used so that the assets and people engaged in or reliant on those uses are made less vulnerable. Examples of physical accommodation include elevating buildings, moving mechanicals from basements to upper floors or rooftops, up-rating machinery and infrastructure to endure inundation by saltwater, and retrofitting stormwater management systems with one-way valves that allow stormwater to drain into the ocean but prevent seawater from flowing to low-lying streets. Accommodation also encompasses changes not just to physical structures but to systems and information—such as revised emergency planning protocols or mandatory notices in real estate transactions for vulnerable properties—and patterns of use—such as shifting commuter car traffic away from a coastal route to a more landward one. Accommodations aim to achieve improving infrastructure and the built environment robust to expected changes; make systems—physical or organizational—that are vulnerable to SLR more flexible by altering and/or moving their components.

Community Capacity Assessment

Evaluating a community's capacity to address the impacts of sea level rise needs to be inclusive of the types of goals and objective that can be reached by said community. Smaller communities may be limited in available resources whereas a larger community may have greater access. Furthermore, a community's size and culture play into account regarding statutory regulations, planning capabilities, administrative and technical capabilities, financial support, and infrastructure scaling.

Potential Funding Sources

The County will require outside funding sources for many of the possible implementation of adaptation strategies. The primary sources of potential funding are listed below:

- FEMA
- Hazard Mitigation Grant Program
- Pre-disaster Mitigation Grant Program
- Flood Mitigation Assistance Program
- Repetitive Flood Claims Program
- Severe Repetitive Loss Program
- Florida Communities Trust
- Florida Small Cities Community Development Block Grant Program
- Emergency Management Preparedness and Assistance Trust Fund
- Suwannee River Economic Council Programs
- State Housing Initiative Partnership Program
- Low-Income Home Energy Assistance
- Weatherization Assistance Program
- Low-Income Emergency Home Repair Program
- Energy Neighbor Fund

Brief explanations of key FEMA-funded programs are provided below.

Hazard Mitigation Grant Program - is authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (the Stafford Act), Title 42, United States Code (U.S.C.) 5170c. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster. HMGP is available, when authorized under a Presidential major disaster declaration, in the areas of the State requested by the Governor. The amount of HMGP funding available to the Applicant is based upon the estimated total Federal assistance to be provided by FEMA for disaster recovery under the Presidential major disaster declaration.

Pre-Disaster Mitigation Program - is authorized by Section 203 of the Stafford Act, 42 U.S.C. 5133. The PDM program is designed to assist States, Territories, Indian Tribal governments, and local communities to implement a sustained pre-disaster natural hazard mitigation program to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding from future disasters.

Flood Mitigation Assistance Program - is authorized by Section 1366 of the National Flood Insurance Act of 1968, as amended (NFIA), 42 U.S.C. 4104c, with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP).

Repetitive Flood Claims Program - is authorized by Section 1323 of the NFIA, 42 U.S.C. 4030 with the goal of reducing flood damages to individual properties for which one or more claim payments for losses have been made under flood insurance coverage and that will result in the greatest savings to the National Flood Insurance Fund (NFIF) in the shortest period of time.

Severe Repetitive Loss Program - is authorized by Section 1361A of the NFIA, 42 U.S.C. 4102a, with the goal of reducing flood damages to residential properties that have experienced severe repetitive losses under flood insurance coverage and that will result in the greatest savings to the NFIF in the shortest period of time.

Adaptation Action Areas

AAAs are a flexible means of designating the physical area(s) where adaptation would apply. AAAs make it possible to change important policies without rewriting zoning decisions and other plan language. They also serve important educational, social, and political function because their basic logic is transparent to stakeholders: because SLR, which is expected to increase in predictable increments, causes flooding in a given area, that area is exceptional and will receive different policy treatment. This is not to say that AAAs simply make political challenges go away. However, they can help to inoculate adaptation measures against objections that the resulting costs and services would be allocated unfairly, and they can provide a stable foundation for any number or combination of adaptation policies.

In addition, because AAAs can be designated using objective *and dynamic* criteria, such as the frequency of flooding to a particular height, they can remove controversy from questions about the boundaries within which particular policies should apply and when to change those boundaries. Should the county decide on designating AAAs in this way, it should schedule a periodic update of AAA boundaries using a standard methodology.

The county might consider adopting an AAA as part of a redefinition of the Coastal High Hazard Area (CHHA) that incorporates expectations about SLR. That is, the criteria for the boundary of the CHHA could expressly include periodic updates based on new data and the AAA could serve as a sort of vanguard of the CHHA—a boundary based on where the CHHA is expected to fall in 15 or 30 years. Importantly, SB 1094 has provided Dixie with a valid legal reason to undertake precisely this sort of change: it requires localities to include a redevelopment component in their coastal management planning element that addresses flood risk arising from SLR, and encourages localities to "eliminate" development that foreseeable flooding impacts makes "inappropriate and unsafe." The County should work with each community to identify potential AAAs and update this adaptation plan accordingly.

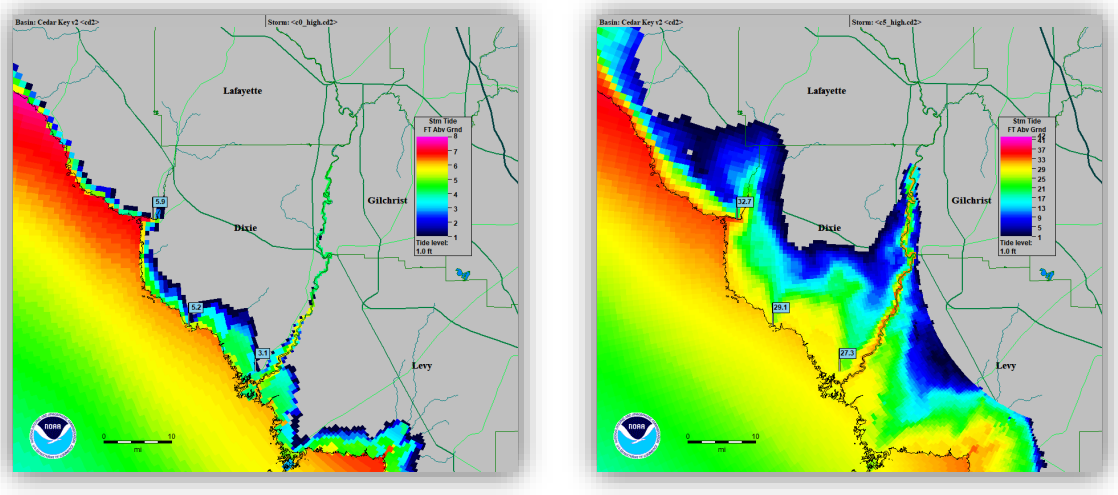


Figure 1 & 2 - Dixie county coastline due to direct storm surge impacts (Tropical Storm (Left) Category 5 (Right) [Attachment 1]

Adaptation Approaches or Elements for Consideration

After examination of the identified climate change vulnerabilities in the assigned areas of sea level rise, storm surge, local flooding, coordination with the residents', committees, and staff of Dixie County, four general categories were identified as areas for further adaptation consideration. These are listed below:

Shoreline Improvement
Living shorelines Sediment supplementation Rip-rap revetment Redesign (elevating rigid docks, etc) Floating docks 

Storm Surge Impingement
Increased finish floor elevations for structures Sediment dredging Barrier islands Dune/Berm construction Filter feeders - oyster bars 

Drainage & Erosion
Pretreatment screening for drains Improved swales and increased quantity Utilize native trees with high wind resistance Stabilize exposed and eroding shoreline 

Retreat
Improved evacuation access and coordination Relocation development efforts 

The four key elements are: shoreline improvement, storm surge impingement, drainage and erosion, and retreat.

Shoreline Improvement: Dixie County's shoreline is vulnerable to the effects of climate change including not only sea level rise, but also such factors as elevated temperatures, and overland erosion and flooding from runoff from heavier rainfall events. In addition, our natural

environment and property values are vital to a community. This report identifies specific vulnerabilities of the shoreline to potential sea level rise and other coastal storm risks and how these risks may be negatively impactful and corrected.

Storm Surge Impingement: Storm surge impingement are counter actions to rising sea levels due to large intensity storm systems that increases flooding vulnerabilities. Atmospheric pressure changes and strong winds increase sea levels temporarily. This report identifies specific vulnerabilities from storm surge including how these risks may be negatively impactful.

Drainage and Erosion: A majority of Dixie County is situated at a lower elevation than much of the surrounding counties and is vulnerable to overland erosion and flooding related to runoff from heavier rainfall events. Additionally, storm sewer systems were designed to utilize sheet flow directly into the surrounding waterways. The potential sea level rise and storm surge associated with hurricanes, tropical storms and extra tropical storms increases vulnerabilities to flooding. This report identifies specific vulnerabilities from erosion and runoff caused by potential sea level rise and increased rain fall and storm activities including how these risks may be negatively impactful.

Retreat: Partial or full retreat involves abandoning land made vulnerable by rising seas and is appropriate in situations where SLR makes continued use and maintenance of existing structures—even in modified form—prohibitively costly. Retreat is conceptually simple, but establishing criteria and implementing decisions to retreat is nearly always complex and politically difficult (Kousky 2014). In particular, efforts to undertake retreat often raise contentious questions about ownership, value, and liability in relation to assets that are to be moved, demolished, or left behind. Even more fundamentally, retreat tends to strain community cohesion and residents' shared sense of place. The three coastal communities are each limited to one access road, with the exception of Jena, for its egress and ingress of residents. Incoming storm surge and SLR could impair these access routes during times of evacuation. Furthermore, as time progress and SLR becomes an increasing factor, certain homes and areas may be deemed uninhabitable and require relocation of homesteads and infrastructure to outside of the town limits

Action-Related Vulnerability Responses

Once major needs and priorities are defined, specific adaptation strategies can be developed, vetted, and defined. It is very important to note that many options are available when an area is projected to be flooded, either permanently or intermittently. Protection strategies involve both hard and soft defensive measures to mitigate impacts of rising seas while leaving the vulnerable structures behind these measures largely unaltered. Seawalls, revetments, and levees are examples of hard or gray protection strategies, while beach nourishment, oyster reef restoration, and living shorelines are all examples of soft protection strategies.

The following potential responses to vulnerabilities identified by the 2018 Vulnerability Assessment Reoprt could be implemented independent of one another or in any number of combinations. Consider these three examples:

1. The county could require that property purchasers and/or developers be given full information about the expected future levels of SLR, as projected in the 2018 Vulnerability Assessment Report, and the impacts of SLR on levels of service for infrastructure serving the property.

2. The county might also require that any development or redevelopment be preceded by an environmental impact analysis.

3. Rather than imposing requirements on private property owners or developers, the county could conduct a review of the sufficiency of existing shoreline stabilization measures.

Shoreline Improvement

Coastline Management

A suite of coordinated measures could preserve natural coastal buffers against storm surges and ensure the wellbeing of populations and assets located on the barrier islands and vulnerable parts of the coast. Over the longer term, specific measures should come to include more forceful encouragements to residents and businesses to move out of harm's way. Buyouts targeted at the most vulnerable properties would be one direct, if potentially expensive, option. Another measure could involve educating residents about the tax advantages and environmental and resiliency benefits of turning their properties into conversation easements.

Living Shorelines

Natural shoreline features such as salt marshes, mangroves, seagrasses, other native plants and oyster reefs to preserve and build coastal habitats. Understanding the importance of natural shoreline stabilization techniques, how they work and the benefits of these alternatives play an important role in sustaining Florida's coast. Many shorelines along Florida's coasts have been stabilized using hardened structures such as sea walls, rip rap, groins and bulkheads. While hardened stabilizers are believed to prevent shoreline erosion, they can actually increase erosion and destroy native habitat. Natural stabilizers reduce coastal erosion and provide valuable habitat using native vegetation, sand and organic material. In Florida, local, county and statewide environmental agencies have begun to enhance, protect and re-create healthy coastal habitats.

Rip-Rap Revetment

Riprap revetments are a very effective and popular method of controlling bank erosion. A revetment is a facing of stone or other armoring material to protect a streambank or shoreline. A riprap revetment consists of layered, various-sized rocks placed on a sloping bank. The most commonly used material for riprap in Florida is broken limestone. The type of stone used is usually determined by what is locally available. The variance in size and the rough angular surfaces of the rock allow the revetment to absorb the impact of the flowing water instead of deflecting the flow which could cause erosion to an adjacent bank fascia.

Storm Surge Impingement

Hard Barriers

Hard barriers are rigid structures set to prevent passage of storm surge wave impacts. The cost and maintenance requirements of storm surge barriers are likely to limit them to intensively developed areas, where they are or would be key elements in risk reduction strategies (Jiabi 2013; Walsh and Miskewitz, 2013).

Barrier Islands

When hurricanes and storms make landfall, barrier islands absorb much of their force, reducing wave energy and protecting inland areas. They also provide a sheltered environment that enables estuaries and marshes to form behind them. These zones serve many valuable ecological functions, such as reducing coastal erosion, purifying water and providing habitat for fish and birds.

Islands that have been preserved in their natural state can move with storms, shifting their shapes over time. But many human activities interfere with these natural movements, making the islands more vulnerable.

Photo 1 - Town of Horseshoe Beach (March, 1994)

Photo 2 – Town of Horseshoe Beach (May, 2017)

Barrier islands are made of sandy, erodible soil and subject to high-energy wave action. They are dynamic systems that constantly form and reform. Islands tend to migrate naturally, building up deposits in some areas and eroding in other areas. Barrier islands may shift laterally along the shore as currents carry sediments from one end of the island toward the other.

Historical photographs and input from surrounding residents suggest the barrier islands surrounding Horseshoe Beach are becoming smaller due to erosion. Many of the smaller external islands have diminished over the twenty-three year timeframe indicated in photos 1 & 2.

Berm & Dune Building

Beaches, when combined with sand dunes, reduce the risks of storm surge–related wave attack and flooding on barrier islands and the mainland. Natural beaches can be widened and dunes enlarged through beach nourishment projects to reduce coastal storm risks for developed areas, although such actions come with both benefits and costs. Beach nourishment and dune building are currently significant parts of the USACE's strategy for coastal risk reduction; thus, the committee focused substantial attention on discussion of these options and their environmental benefits and adverse impacts.

Beach nourishment projects provide fill sediment to counteract and/or repair erosion while increasing the distance of coastal infrastructure from the surf and swash zones and providing space and a source of sand that favor formation and protection of dunes. The coastal risk reduction value of dunes is in their height and volume. The height of the crest determines its value as a barrier against wave attack and flooding, while a sufficient sediment volume allows dunes to survive wave erosion during storms, maintaining the integrity of the crest. Naturally evolving dunes are often too low, narrow, mobile, or discontinuous to protect immediately landward infrastructure, and so they are often augmented by stabilizing them and increasing their height and volume through emplacement of sand-trapping fences or vegetation or by depositing sediment in fill operations.

The process of offshore sediment extraction to support beach nourishment projects also has important ecological impacts. Dredging of sand borrow areas can decrease organism abundance, total biomass, and the number and composition of species, as well as the average size of the dominant species (USACE 2001; Brooks 2006). Abundance of some benthic species may recover within a year; recovery of biomass and species diversity may occur within a year or somewhat longer, but changes in biomass composition may take longer. Long-lasting and deep borrow pits may attract a different biological community than occurred before and restricted water movement may create hypoxic or anoxic conditions (USACE 2001). However, only a small effort has been directed at assessing impacts on biological assemblages from sand removal, especially with respect to ecosystem function (Brooks 2006). Likewise, long-term impacts have not been addressed.

Oyster Reefs

Located in both subtidal and intertidal locations, oyster reefs extend across a range of low to high salinities in areas with fine to sandy sediments. Fringing oyster reefs along or just offshore of vegetated shorelines may serve to dampen wave energies and increase sediment retention. Shellfish reefs (primarily oyster, but also some mussels) have been recently advocated as a nature-based approach to combat coastal erosion. Reports have shown that erosion rates decreased by 40 percent for salt marshes located behind restored oyster reefs when compared with areas without oyster reefs; however, erosion

rates for both were still high (Scyphers 2011). The study was conducted during a period of high tropical storm activity, and results suggest that oyster reefs may help mitigate erosion from routine wave heights, but that oyster reefs are quickly overtopped during storms and are not effective at dealing with higher storm surge and wave heights common in tropical storms.

Seagrasses

Seagrasses are the dominant forms of shallow subtidal vegetation along the Atlantic Coast and the Gulf of Mexico. Because of light limitations, their distribution is typically restricted to water depths of less than 3 m (Dennison 1987). Numerous studies have explored how the seagrass canopies modulate water flow and currents (Fonseca 1982; Gambi 1990), contribute to wave attenuation, and retain and stabilize sediments in shallow coastal areas (NRC 2007). Such sediment retention can lead to sediment accretion and reduced water turbidity.

Dissipation of wave energy by seagrasses has also been proposed to play a role in reducing erosion of coastlines. Because seagrass canopies are relatively short and flexible, substantial modification of water flow is most effective when seagrasses are found in high density and distributed over a wide area in shallow water depths (Fonseca 1982; Gambi 1990). Because seagrasses are subtidal, frictional forces would quickly be reduced by higher water levels associated with storm surge.

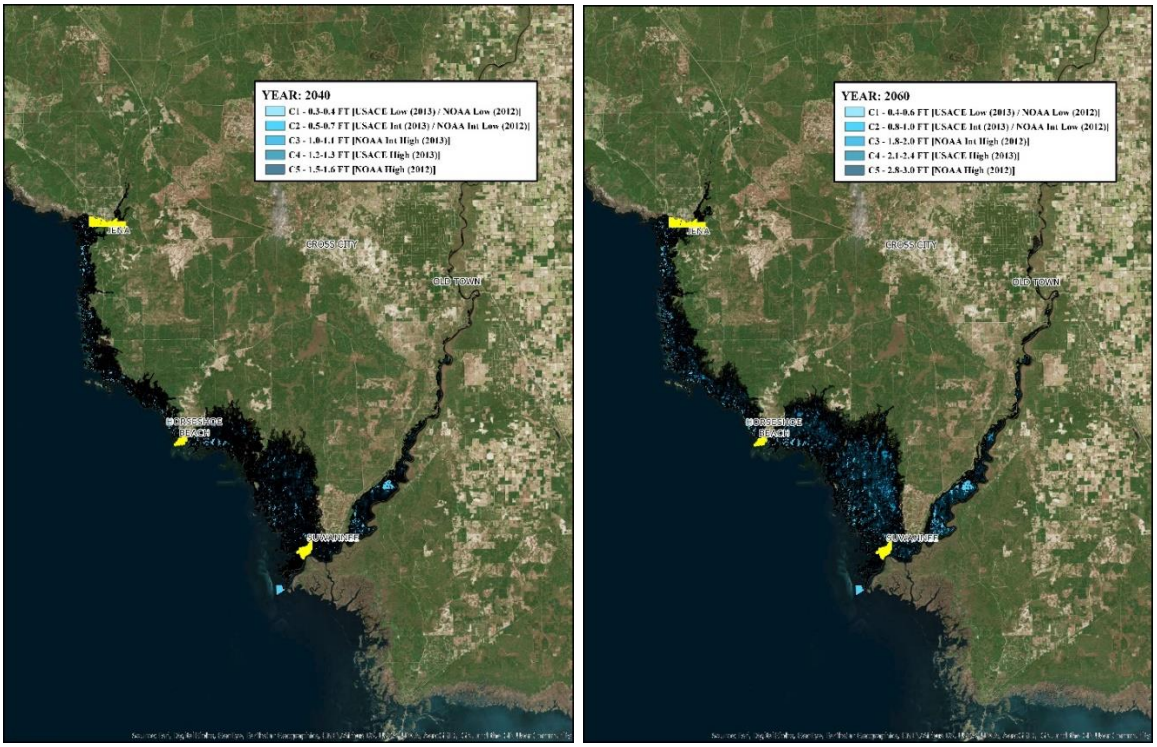
Seagrasses also provide essential fish habitat and regulate nutrients in the water column. Seagrass restoration has had more limited success than salt marsh restoration efforts, and human-created sites are often of limited size (Bell 2014).

Healthy nearshore ecosystems also provide numerous ecosystem services, including support of commercial and recreational fisheries, nutrient regulation, shoreline stability, and other activities such as ecotourism and recreation (NRC 2007; Temmerman 2013; Powers and Boyer 2014).

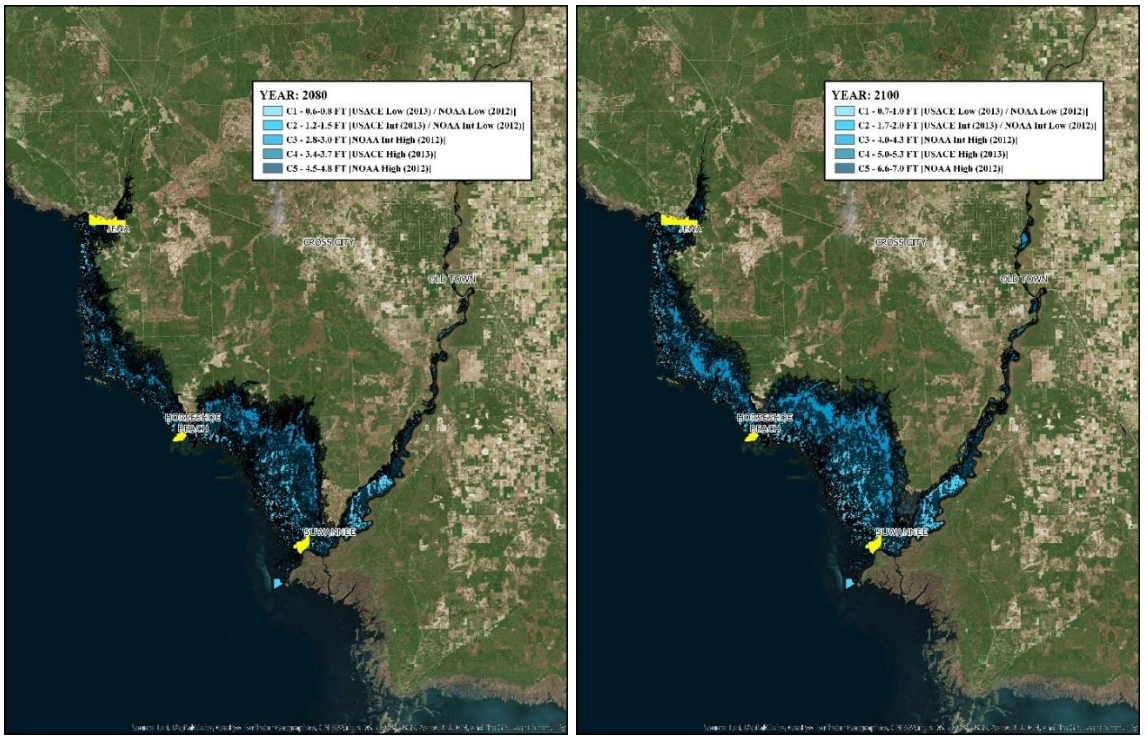
Drainage and Erosion

Flooding

The most critical vulnerability for Dixie is flooding, whether as a result of tides driven higher or coastal storms made more powerful by SLR and other aspects of climate change. Graphics expressing the sea level projections for Dixie County for years 2040, 2060, 2080 and 2100 indicate areas prone to flooding as SLR becomes more of a factor. These points deserve attention because they have a clear implication for the county. Arguments for Dixie taking a precautionary and adaptive approach to planning and capital expenditure decisions. “Precautionary” means not making or permitting irreversible investments under uncertain conditions, and “adaptive” means deferring decisions about large and/or irreversible investments until better information becomes available. Thus, in practical terms, this sort of approach would mean maintaining restrictions on development and avoiding the installation of new infrastructure, facilities, or structures that could be put at risk before the end of their useful life, pending an indication of which SLR scenario Dixie County is actually facing.



Figures 3 & 4 - Dixie County flood areas due to SLR; Year 2040 (Left) and Year 2060 (Right) [Attachment 1]



Figures 5 & 6 - Dixie county flood areas due to SLR; Year 2080 (Left) and Year 2100 (Right) [Attachment 1]

Rainfall projections concludes ultimately that "although the projected increases in rainfall may not appear all that large, they may still impact design criteria" of the county's stormwater management system.

Specific vulnerabilities associated with these features include both the county's stormwater management system, as well as the county's ability to comply with federal, state, and local water quality requirements (Clean Water Act 1972). Two capacity-limiting features could spell trouble for the county's obligation to maintain prescribed levels of service with respect to stormwater management. One is the size and state of pipes, ditches, and detention ponds, which are inadequate to their tasks by design and, and are further impeded—according to Preliminary Workshop participants—by a lack of adequate maintenance. The other is the elevation and state of coastal outfalls and spillways, which are the outermost ends of a gravity-driven system that relies entirely on relative elevation to disposition stormwater. Both of these conditions afflict a gravity-driven system in the same way: they prevent the rapid and unimpeded transfer of stormwater from land to ocean, which can in turn exacerbate or even cause flooding during precipitation events.

At the current measured rates of sea level rise for Dixie County, residents can expect 1 foot of eustatic sea level rise above the current mean tide by the year 2040; 2 feet of eustatic sea level rise above the current mean tide by the year 2065; and 3 feet of eustatic sea level rise above the current mean tide by the year 2087. Values were obtained using NOAA 2017 Intermediate curve graph formulations from the Cedar Key II, FL gauge.

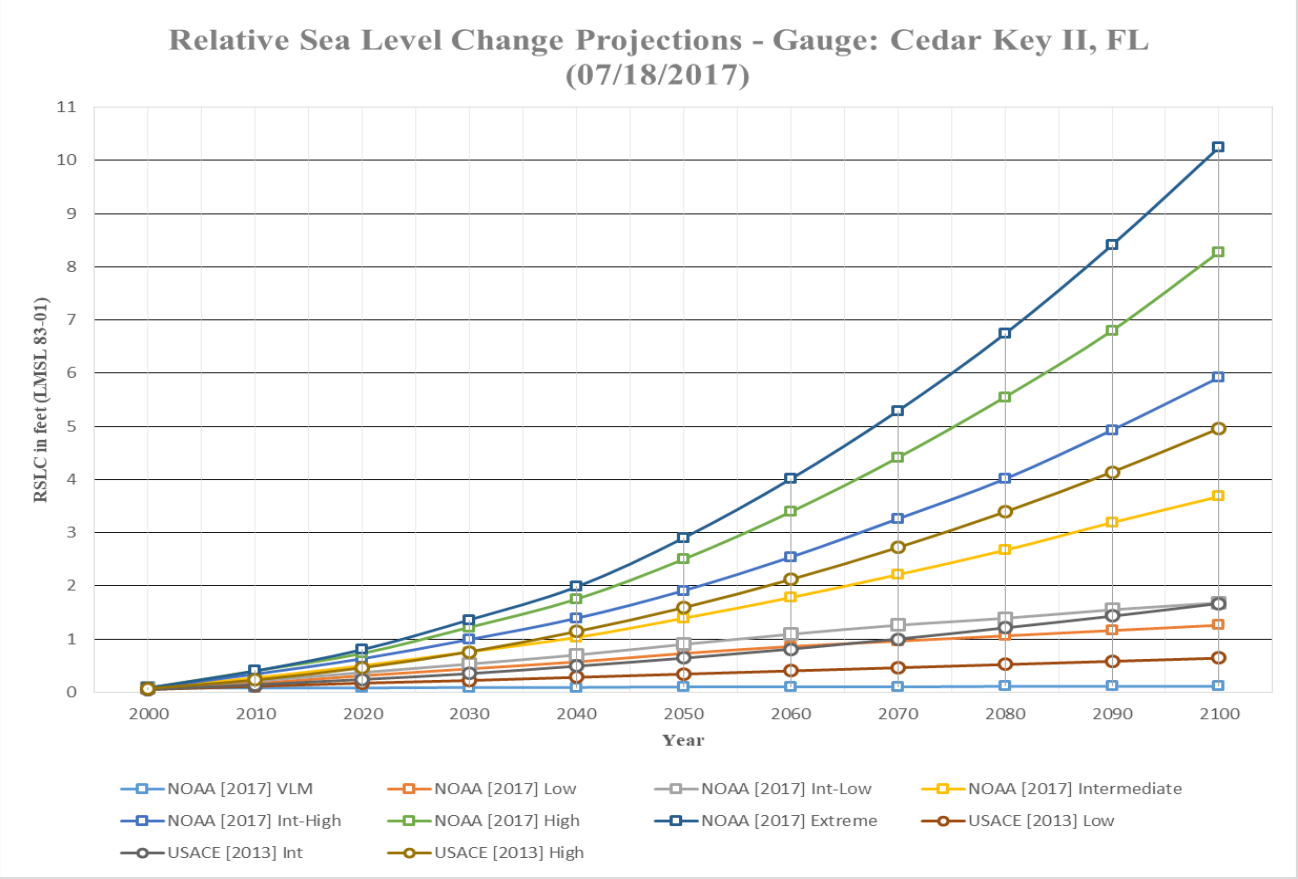


Figure 7 - RSLC (Feet) for Dixie County [Attachment 1]

Many climate change models with strong scientific bases anticipate a rapid acceleration of sea level rise above the current measured rate, caused by more rapid melting of land based ice in glaciers and the polar zones, increased releases of Green House Gases from human activities, agricultural practices, and natural sources released from melting.

There are several different options available for infrastructure protection from sea level rise and coastal flooding. These range from bulkheads of various forms of hard materials to a soft natural shoreline. The current conditions utilized primarily at the coastal communities are rip-rap revetments.

Bioswales

Bioswales and biostrips, also known as vegetated swales, are a combination of grasslands and a wide, gently sloping channel (5'-7' base width with 4:1 or flatter side slopes) designed to filter a shallow depth of untreated stormwater runoff.

Untreated stormwater runoff is intercepted from roadway gutters, parking lots or other hard, impervious paved surfaces before it enters a catch basin and is directed through a vegetated swale. The stormwater slowly travels the length of the bioswale through the vegetation, which filters out sediment and particulate matter. The slower moving water also infiltrates the soil channel, which removes additional waste and reduces water runoff volumes. The particulates and waste are degraded and broken down by biological activity. Bioswales and biostrips are important for water quality, as untreated stormwater runoff from streets usually enters catch basins and the storm drain piping system, emptying waste directly into the Gulf of Mexico. Vegetated swales cleanse the stormwater runoff, removing trash and other pollutants before the water drains into the ocean. Bioswales vegetated with native grasslands not only improve water quality but also provide habitat and aesthetic benefits.

Dredging

Dredging can be a critical process for the commercial shipping industry. Removing sediment can maintain the appropriate width and depth for enabling the safe, unobstructed passage of cargo vessels carrying oil, raw materials, and other essential commodities. Sediment removal is sometimes used as a source of materials for land-building projects. The liberated sediment can then be dried out and transported to a new location where additional land is required for building and other purposes. Sediment removal can help to restore a shoreline or beachfront to its original condition by reversing the effects of soil erosion. Dredging can clean up a waterway via the removal of trash, debris, decaying vegetation, sludge or other materials that can contaminate water and soil.

Dredging can produce a healthier aquatic eco-system that can result in a more suitable habitat for fish and other wildlife. It can also be used for trash and debris removal to keep the waterways clean and waterways flowing at full potential. Eutrophication is an excessive amount of nutrients in a water body typically caused by water runoff from the surrounding land. Eutrophication can lead to an overabundance of plant growth that results in oxygen deprivation and can cause the death of aquatic wildlife. In some cases, dredging may be the most viable remediation option when eutrophication occurs.

Photo 3 - Dredging equipment stationed outside coastline

Stormwater Conveyance

Lack of maintenance as expressed in the workshop approach to enforcement of requirements for canal maintenance and conveyances relied upon for drainage. The possible responses to system vulnerabilities discussed below would address one or more of these factors. Providing funding for those responses is integral to undertaking them.

City and County Land Development Regulations and Codes, as well as zoning regulations, can be used to direct development and redevelopment to more suitable areas where flooding and erosion are less troublesome. In many instances the 2018 FIRM update expands FEMA-designated floodplains, however, in places where they are being reduced, the need for AAAs is especially urgent. These areas are still vulnerable to flooding, but property owners who have the option to drop flood insurance will likely do so.

AAAs can complement the Coastal High Hazard Area (CHHA) footprint or expand it locally. FEMA defines the CHHA as an area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources. The CHHA is identified as Zone V on FIRMs. Special floodplain management requirements apply in V Zones, including the requirement that all buildings be elevated on piles or columns. An AAA can be designed to apply the more stringent requirements of Zone V in other areas that are not part of the Zone V designation. In summary, AAAs are tools that allow communities to apply higher standards to help protect areas that are subject to increased vulnerability to sea level rise. This may be accomplished through a benefit-cost analysis, alternatives analysis, stakeholder feedback, or even new output from a tool utilized during the Vulnerability Assessment. Communities that have already gone through this process have also identified the value of doing a "business as usual" baseline assessment that will help compare the costs anticipated by the adaptation strategies. While adaptation strategies carry a cost, sometimes a significant one, in the long run a benefit-cost analysis may show that properly planned adaptation yields a tremendous savings as compared to doing nothing.

Retreat

Evacuation procedures and coordination are a constant need for the County and municipalities, specifically regarding CR351 and CR349, which are the only evacuation routes for the Town of Horseshoe Beach and Town of Suwannee, respectively. As SLR progress and soil erosion slowly creep up the coastline, several areas may become uninhabitable or too cost burdensome to maintain which would require residents to seek alternative lodging.

Photo 4 & 5 - Single access roads leading into coastal communities; Suwannee (Left) & Horseshoe Beach (Right)

Conclusions

This Adaptation Report serves several purposes. It describes key features of the policy and legal frameworks that underlie adaptation efforts in Florida. Drawing on the 2018 Vulnerability Assessment Report and the discussion at the Community Outreach Workshops held throughout Dixie County, it provides an overview of vulnerabilities and circumstances relevant to any effort to address those vulnerabilities. Finally, in addition to these descriptions, it provides suggestions for potential use by decision makers seeking to develop and implement adaptation measures.

Strategies that reduce the consequences of coastal storms, such as hazard zoning, building elevation, land purchase, and setbacks, have high documented benefit-cost ratios, but they are given less attention by the federal government and are viewed as difficult to implement by states.

References

Bell, S. S., M. O. Hall, and M. L. Middlebrooks. 2014. The value of long-term assessment of restoration: Support from a seagrass investigation. Restoration Ecology.

Brooks, R. A., C. N. Purdy, S. S. Bell, and K. J. Sulak. 2006. The benthic community of the eastern US continental shelf: A literature synopsis of benthic faunal resources. Continental Shelf Research.

Dennison, W. C. 1987. Effects of light on seagrass photosynthesis, growth and depth distribution. Aquatic Botany.

Escambia County Local Mitigation Strategy Plan (2015).

Fonseca, M. S., J. S. Fisher, J. C. Zieman, and G. W. Thayer. 1982. Influence of the seagrass, *Zostera marina* L., on current flow. Estuarine, Coastal and Shelf Science.

Gambi, M. C., A. Nowell, and P. A. Jumars. 1990. Flume observations on flow dynamics in *Zostera marina* (eelgrass) beds. Marine Ecology Progress Series.

Hulet C., Why Public Engagement Is Necessary to Enhance Local Readiness for Climate Adaptation, (Lawrence Susskind, eds. 2015).

Jiabi, X., P. Sayers, S. Dongya, and Z. Hanghui. 2013. Broad-scale reliability analysis of the flood defence infrastructure within the Taihu Basin, China. Journal of Flood Risk Management.

Kousky C., Managing shoreline retreat: a US perspective, 124 Climatic Change 9, 9 (2014).

NRC. 2007. Mitigating Shore Erosion Along Sheltered Coasts. Washington, DC: The National Academies Press.

Powers, S. P., and K. E. Boyer. 2014. Marine restoration ecology. Chapter 22 in Marine Community Ecology and Conservation, edited by M. D. Bertness, J. F. Bruno, B. R. Silliman, and J. J. Stachowicz. Sunderland, MA: Sinauer Associates.

Scyphers, S. B., S. P. Powers, K. L. Heck, Jr., and D. Byron. 2011. Oyster reefs as natural breakwaters mitigate shoreline loss and facilitate fisheries.

Temmerman, S., P. Meire, T. J. Bouma, P. M. J. Herman, T. Ysebaert, and H. J. De Vriend. 2013. Ecosystem-based coastal defence in the face of global change.

Walsh, S., and R. Miskewitz. 2013. Impact of sea level rise on tide gate function. Journal of Environmental, Science and Health, Part A 48.

USACE. 2001. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, MS.