City of Punta Gorda Adaptation Plan

Southwest Florida Regional Planning Council
Charlotte Harbor National Estuary Program
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The Charlotte Harbor National Estuary Program is a partnership of citizens, elected officials, resource managers and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater Charlotte Harbor watershed. A cooperative decision-making process is used within the program to address diverse resource management concerns in the 4,400 square mile study area. Many of these partners also financially support the Program, which, in turn, affords the Program opportunities to fund projects such as this. The entities that have financially supported the program include the following:

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Significant portions of this document's analysis of vulnerability depends in whole or in part on the *Local Mitigation Strategy for Charlotte County/ City of Punta Gorda 2005*, approved by FEMA on April 28. 2005 with the data analyzed and report produced by the Southwest Florida Regional Planning Council and authored by Marisa Barmby, Dan Trescott, and Tim Walker the Florida Oceans and Coastal Council 2009 special report to the Florida Energy and Climate Commission and the people of Florida entitled *The effects of climate change on Florida's ocean and coastal resources*; the Intergovernmental Panel on Climate Change. (IPCC) *2007 Climate change 2007: Synthesis report* ,the 2007 report entitled *Florida and climate change: The costs of inaction.* By E. A. Stanton and F. Ackerman with the Tufts University Global Development and Environment Institute and Stockholm Environment Institute–US Center

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Table of Contents

Executive Summary

The City of Punta Gorda is currently experiencing climate change. The natural setting of the City coupled with extensive infrastructure investment in the areas closest to the coast have placed the City at the forefront of geographic areas that will be among the first to suffer the negative effects of a changing climate. Severe tropical storms and hurricanes with increased wind speeds and storm surges have already severely damaged the community. Significant losses of mature mangrove forest, water quality degradation, and barrier island geomorphic changes have already occurred in the adjacent Charlotte Harbor. Longer, more severe dry season droughts coupled with shorter duration wet seasons consisting of higher volume precipitation will generate a pattern of drought and flood impacting both natural and man-made ecosystems. Even in the lowest impact future climate change scenario predictions, the future for the City will include increased climate instability; wetter wet seasons; drier dry seasons; more extreme hot and cold events; increased coastal erosion; continuous sea-level rise; shifts in fauna and flora with reductions in temperate species and expansions of tropical invasive exotics; increasing occurrence of tropical diseases in plants, wildlife and humans; destabilization of aquatic food webs including increased harmful algae blooms; increasing strains upon and costs in infrastructure; and increased uncertainty concerning variable risk assessment with uncertain actuarial futures. In the course of the project we identified 246 climate change management adaptations that could be utilized to address the various vulnerabilities identified for the City

Currently the City of Punta Gorda is among the most progressive municipalities in the United States with regard to planning for climate change. It has already adopted comprehensive plan language to address the impacts of sea level rise, and seek strategies to combat its effects on the shoreline of the City.

This report identifies the alternative adaptations that could be undertaken to address the identified climate change vulnerabilities for the City of Punta Gorda. These adaptations are presented in the order of prioritized agreement from the public meetings. Only the highest agreement adaptation in each vulnerability area is fully developed for potential implementation. One of the utilities of this approach is that it provides a variety of adaptation options, which the City could select for implementation, adaptive management, and subsequent monitoring.

During public workshops the citizens of the City of Punta Gorda Identified 54 vulnerabilities that combined into 8 major areas of climate change vulnerability for the city including, in order of priority:

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.

The City of Punta Gorda has already undertaken a variety of affirmation adaptation actions that will assist in reducing the impacts form climate change and increasing resiliency to climate change effects. These include elevation of structure and improvements of drainage systems as part of the City's recovery from the impacts of Hurricane Charley; relocation of the public works facility to a location of lower hazard from natural disasters and coastal flooding, adoption of a Transfer of Development Rights program to protect historical and natural resource areas, and a completed Local Mitigation Strategy for natural disasters.

The 2010 City of Punta Gorda Strategic Plan Focus Area Objectives includes several affirmative adaptations that will address some of the issues of Avoidance, Minimization, Mitigation and Adaptation for Climate Change. These include:

- Enhance energy independence of city-owned property, including more use of solar and other forms of power to eventually take the city "off the grid".
- Enhance green initiatives to include adoption of green building ordinance modeled after Charlotte County, participation in Green Futures Expo & Energy Options Conference and publicizing programs in City departments.
- Achieve progress of annexations along US 41 corridor, Jones Loop Rd. (pending successful voluntary annexation of the Great Loop), US 17 corridor and other areas as deemed appropriate during the year.
- Undertake through design and/or completion of ongoing infrastructure improvements including the Public Works/Utilities Cooper Street Campus; Downtown Flooding Improvements; San Rocco/Madrid Blvd. Drainage Improvements; Carmalita Street, West of Cooper Street, Drainage & Streetscape Improvements; Multi Use Recreational Trail Phase 1 (Monaco to Aqui Esta); Multi Use Recreational Trail Phase 2 (Aqui Esta to Airport and Monaco to Taylor) – Design; Hendrickson Dam Spillway Replacement; East Side Wastewater Improvements; Reverse Osmosis Plant - Design
- Develop a bike path program that meets the requirements of Bicycle Friendly Community and prepare an application for the City to apply for that designation.
- Utilize pavers in parking areas.
- Consider expanding wastewater treatment capacity by having residential lawns, irrigated parks, golf courses etc. served by gray water.

A total of 104 acceptable and 34 unacceptable recommended adaptations were identified during the public workshops and prioritized by agreement.

The top agreed upon adaptations for each area of vulnerability include:

- 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.

These are the recommended first adaptations for development of implementation plans by the City of Punta Gorda.

Introduction

Southwest Florida is one of the most vulnerable areas in the world to the consequences of climate change, especially sea level rise and increased hurricane activity and severity. Regardless of the underlying causes of climate change, global glacial melting and expansion of warming oceans are causing sea level rise, although its extent or rate cannot as yet be predicted with certainty.

On November 19, 2007, the Charlotte Harbor National Estuary Program (CHNEP) Policy Committee added a climate change adaptation component to its Comprehensive Conservation and Management Plan (CCMP), later adopted on March 24, 2008. This set the stage for the Environmental Protection Administration (EPA) Region 4 to fund CHNEP and, its host agency, the Southwest Florida Regional Planning Council (SWFRPC) to conduct a vulnerability assessment concerning CHNEP's seven-county study area.

EPA Headquarters then named Charlotte Harbor one of six Climate Ready Estuary (CRE) pilot programs. CHNEP and SWFRPC planned to partner with a city to develop an adaptation plan through a project entitled *Development of a Climate Change Adaptation Plan for a Southwest Florida City*.

On December 17, 2008, the Punta Gorda City Council voted unanimously to participate in the CHNEP CRE pilot program. This progressive municipality had already included climate change planning in their Comprehensive Plan. The objective and policy are listed below. Additional resources associated with the City of Punta Gorda included a citizen stakeholder group, Team Punta Gorda (http://www.teampuntagorda.com/). Team Punta Gorda was initially formed as a grass-roots organization working on recovery following Hurricane Charley.

City of Punta Gorda Comprehensive Plan Climate Change Objective and Policy:

Objective 2.4.2: Address the impacts of sea level rise, and seek strategies to combat its effects on the shoreline of the City.

Policy 2.4.2.1: The City will work with the SWFRPC to determine potential sea level rise impacts on the Coastal Planning Area.

Measurement: Completion and implementation of developed coastal studies or development of model scenarios.

Elements of an Adaptation Plan

Successful adaptation to climate change in estuaries requires plans that respond to both the unique vulnerabilities and the priorities of the places they protect. Plans need to be flexible, to respond to changing conditions and information and to have realistic assessments of the degree of risk and cost that can be sustained. This document identifies the key elements of climate change adaptation planning for the City of Punta Gorda, and provides some of the information and resources that the City and the CHNEP can use in climate change adaptation. Each City must select the best order and process to develop their adaptation plan.

There are two critical elements that an EPA approved adaptation plan must include for CRE recognition:

- Description of specific implementation actions
- Monitoring and evaluation of results

In order to be recognized as "Climate Ready," the EPA expects that, at a minimum, these two elements are prepared and approved by the CHNEP management conference and EPA, as well as other appropriate reviewing organizations, such as state or local oversight programs.

In addition, there are several other components that support the preparation of these two critical elements. While not required, EPA has recommended completion of these additional components as reasonable prerequisites for the two critical elements. The development of these may depend on the specific estuary's vulnerability and the extent to which these elements are either already in place or completed. These other recommended components include:

- An assessment of vulnerability;
- A summary of considerations used to set priorities and select actions; and
- Communication with stakeholders and decision makers.

An adaptation plan can be a stand-alone document or be incorporated as an additional or new element in an existing management plan, such as the CCMP. 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, any climate strategy or 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. Initial plans can be updated and enhanced as information changes regarding vulnerability, uncertainty, management priorities, technology, adaptation methods and costs

The Current Climate of Southwest Florida and the City of Punta Gorda

The climate of southwest Florida is subtropical or tropical savanna (Hela 1952). This results in alternating wet season flooding and severe drought. There is an average of approximately 135 cm (53 inches) of annual rain (Bradley 1972). The dry season runs from November to April and the wet season from June to September (Riebsame et al. 1974). Typically, from 18 to 23% of annual rainfall occurs in dry season and 60 to 72% of the rainfall occurs in wet season (Drew and Schomer 1984). Seasonal wetlands, such as hydric pine flatwoods and wet prairies, usually become saturated and attain standing water in the middle to late wet season. It is interesting to note that the distribution of large, landscape scale hydric pine flatwoods in southern Collier and southern Lee Counties corresponds with areas of higher rainfall isoplethes of 60+ inches annually (Bamberg 1980).

Rainfall in the wet season follows a bimodal pattern, with the first peak in May or June and the second in September or October. It is of note that this pattern corresponds with peak flowering periods for the understory components of the freshwater wetland plant community. Thunderstorms are more frequent (over 100 annually) in the Fort Myers area, in the center of the southwest Florida, than at any other location along the eastern Gulf coast (Jordan 1973). Seventy-five percent of the thunderstorms occur in the summer (Jordan 1973, Duever et al. 1979). The short duration, high intensity thundershowers are the result of cyclic land-sea breeze convection in a diurnal pattern peaking during late afternoon or early evening. Thunderstorm rainfall can be very local, resulting in differences of up to five inches per month between areas less than five miles apart (Duever et al. 1979). Individual cloud volumes during thunderstorms in south Florida can range from 200 to 2,000 acre-feet (Woodley 1970).

The wind patterns of south Florida are determined by interaction of prevailing easterly tradewinds, local diurnal convective patterns in the summer, and continental cold fronts in the winter. Summer wind patterns are dominated by a daily wind shift that peaks between noon and 2:00 P.M., with an onshore sea breeze during the day and an offshore land breeze at night. Winter dry season cold fronts occur approximately once a week (Bamberg 1980). On a seasonal basis, the highest average wind speeds occur in late winter and early spring, and the lowest speeds occur in the summer. Localized strong winds of short duration are generated by summer thundershowers, extreme cold fronts, and tropical storms (Bradley 1972). On a typical day, wind speed is lowest at night, increasing through the day to the afternoon, and decreasing again in the evening (Gutfreund 1978).

Temperature in southwest Florida is primarily controlled by latitude and maritime influences (Bradley 1972). The mean annual temperature is 74 degrees Fahrenheit, the average January temperature is 64 to 65 degrees Fahrenheit, and the average August temperature is 82 degrees Fahrenheit. Southwest Florida is one of only two areas in the southeastern United States where air temperatures exceed 90 degrees Fahrenheit more than 120 days of the year. Typically, there is a one degree Fahrenheit difference between Charlotte County and Collier County. More inland areas display a greater daily range in temperature than coastal habitats.

In winter, sharp drops in temperature occur following cold fronts containing cool, dry arctic air from Canada. Cooling begins after sunset and reaches the lowest temperatures at dawn. Temperature gradients of about six to 15 degrees F can occur between coastal and inland areas a few miles apart. A similar gradient of about six to 10 degrees F occurs between high, dry land (xeric pine flatwoods) and adjacent moist lowlands (hydric pine flatwoods). On calm, cold, clear nights, frost may form in moist inland areas. A severe freeze occurs approximately once every 20 years (Bamberg 1980). According to the Federal Emergency Management Agency, since 1953 alone, disaster declarations were made in Florida six times for freezing conditions (Federal Emergency Management Agency (FEMA) 2009).

The mean annual relative humidity averages approximately 75% with the highest (80-90%) in early morning and lowest (50-70%) in the afternoon. Seasonal differences are not great: mean relative humidity tends to be lowest in April (71%) and highest in summer and fall (80%).

Evapotranspiration refers to the sum of evaporation and plant transpiration into the atmosphere. Evapotranspiration from the saturated soils of wetlands is an important control of sea breeze intensity and the formation of convective thunderstorms. Because evapotranspiration is a cooling phenomenon, land-to-water gradients are reduced, convective processes are reduced, and recently rained-upon areas receive less rainfall. The effect is a natural feedback mechanism that results in a more even spatial distribution of seasonal rainfall (Bamberg 1980). This can also ameliorate the tendency towards formation of tornadoes over hot convective dry lands. Evapotranspiration estimates for southwest Florida range from 30 to 48 inches per year (Drew and Schomer 1984).

South Florida is subject to more hurricanes than any other area of equal size in the United States (Drew and Schomer 1984). The area is subject to both Atlantic and Caribbean hurricanes. Of the 38 hurricanes that passed over southwest Florida from 1901 to 1971, 30 occurred in August to October (Jordan 1973). Tropical storms strike once every three years in southern Collier County and once every five years in the northern extents of the Southwest Florida area (Bamberg 1980).

The three primary climatic effects of hurricanes are high wind, storm surge, and heavy rain. Wind force increases by the square of the wind speed such that a 93 mph wind exerts four times as much force as a 47 mph wind. When hurricane winds attain 249 mph, as in the 1935 Labor Day hurricane, the effects on forested ecosystems, including tree fall, substrate disturbance, and propagule (cone) distribution, can be considerable (Drew and Schomer 1984).

The Punta Gorda area receives an average annual rainfall of fifty-four inches, with approximately sixty percent falling during the summer months of June through September in a typical wet season/dry season cycle. Rainfall in the winter months is generally associated with cold fronts moving across the region and is characterized by low intensity, higher duration events. The summer rainfall patterns consist of short duration, intensive convective storms typically occurring in the late afternoon. It is this type of rainfall event that causes the highest volumes of stormwater runoff with the potential of spot flooding and damaging effects to Charlotte Harbor.

Geography, Topography and General Land Use

The City of Punta Gorda is located in southwest Florida at the south shore of the confluence of the mouth of the Peace River in Charlotte County (Figure 1).

Figure 1: The City of Punta Gorda in Relation to the State of Florida

This places the City of Punta Gorda in the middle of the Charlotte Harbor National Estuary Program study area (Figure 2).

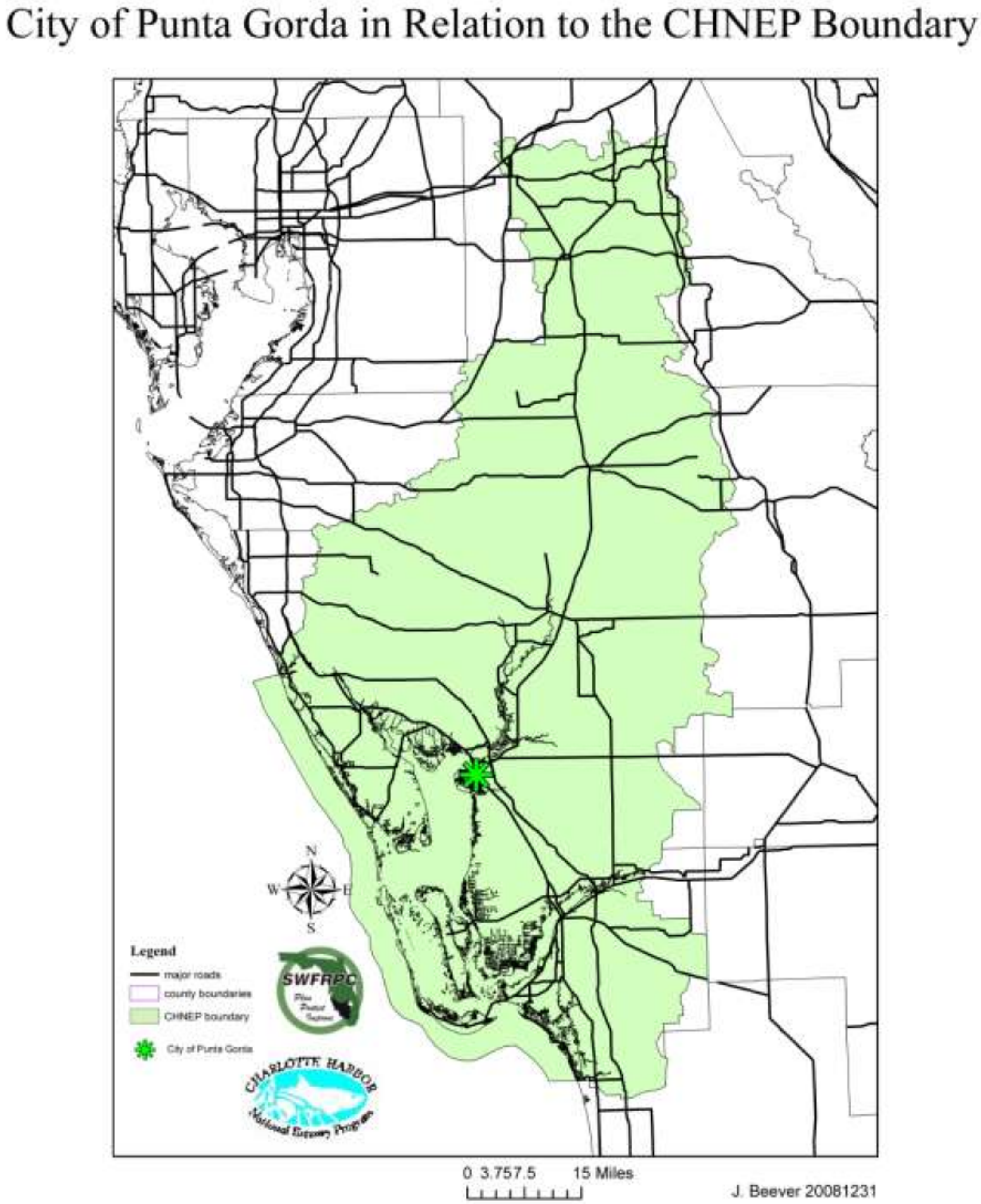


Figure 2: The City of Punta Gorda in Relation to the CHNEP Boundary

The City is very low-lying with significant areas of wetlands and open lands principally on the east shore of Charlotte Harbor and along Alligator Creek (Figures 3 and 4). The topography of the City of Punta Gorda, identified in Figure 3, and its environs is generally flat with elevations ranging from sea level to approximately fifteen feet above sea level. Three vegetative major zones can be distinguished:

- The *coastal wetlands* are predominantly tidal mud flats, mangroves, and marsh grass areas with elevations from zero to five feet above mean sea level.

- The *transitional zone* connects the coastal area with the inland prairie area. This zone varies in elevation from approximately five to 15 feet above sea level. Most human development has occurred in this transitional zone because it provides the most topographical relief with the better drained land. The relict coastal shore ridges of the transitional zone generally formed the location of the earliest transportation links including the railroad, Tamiami Trail (US 41), and US 17.

- The *inland prairie* is normally drained by overland sheet flow due to a lack of natural stream beds. The flood condition of the prairie during heavy rainfall restricts development; however, this condition enhances recharge of the underground aquifers. The inland prairies are dominated by a combination of mesic and hydric pine flatwoods, wet prairies and freshwater marshes.

Figure 3: USGS TOPO Map of the City of Punta Gorda

In the course of this study the City expanded its area by including through annexation former coastal outparcels completing the Charlotte Harbor shoreline. This boundary difference is shown between figures 3 and 4.

Figure 4: Aerial Photograph of the City of Punta Gorda

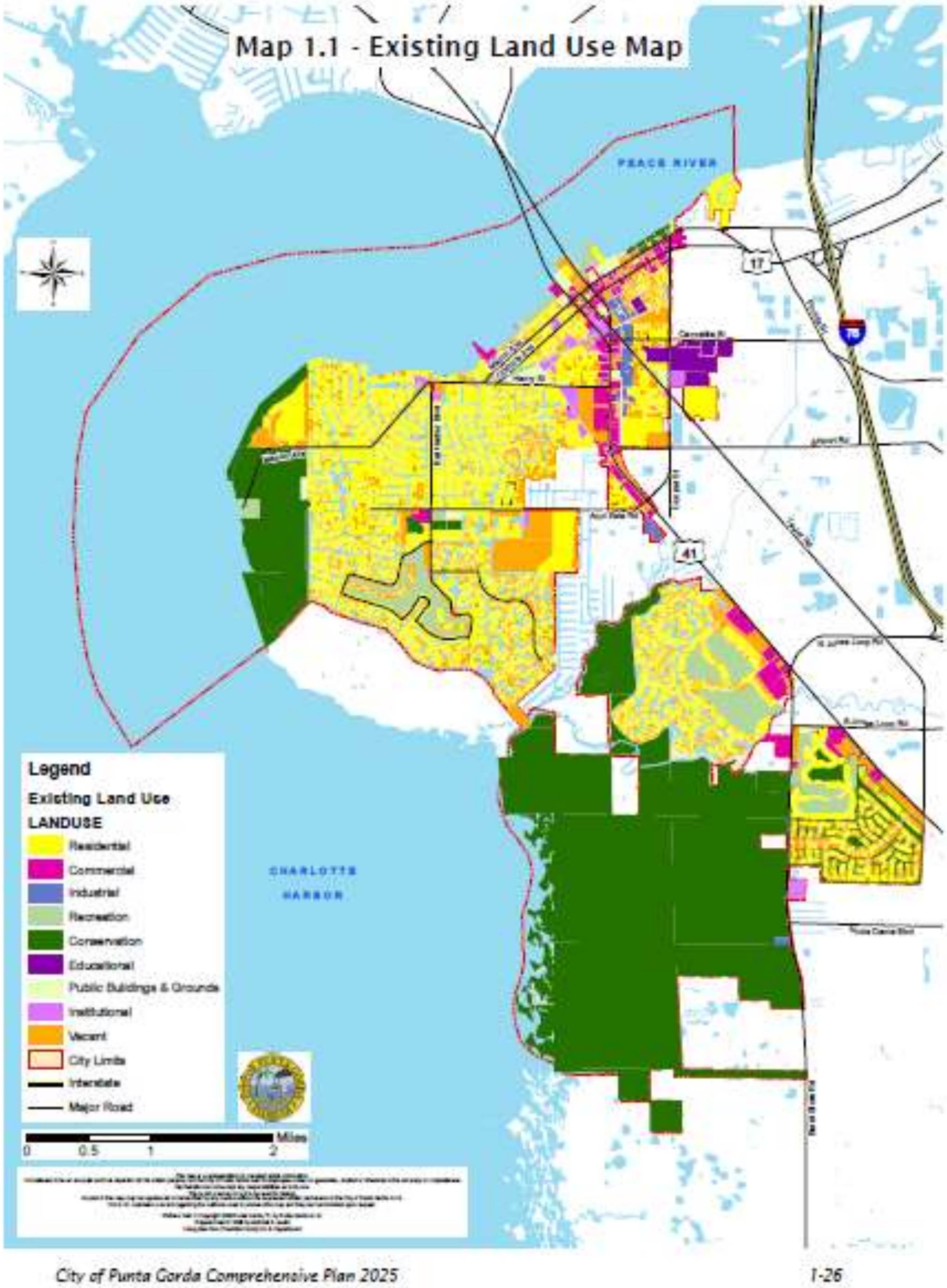


Figure 5: Existing Land Use of the City of Punta Gorda

Prior to the recent boundary change the City of Punta Gorda was 43.5 %, 11.7% Vacant Land and subsequently 44.8% developed.

Table 1 - Generalized Existing Land Uses in the City of Punta Gorda			
Land Use	**Acres**	**Square Miles**	**Percentage of Total Land Uses**
Residential	2,246.96	3.51	24.9%
Commercial	325.83	0.51	3.6%
Industrial	55.60	0.09	0.6%
Agricultural	0.00	0.00	0.0%
Recreational	434.74	0.68	4.8%
Conservation	3,924.36	6.13	43.5%
Educational	96.61	0.15	1.1%
Public Buildings & Grounds	78.05	0.12	0.9%
Institutional	88.86	0.14	1.0%
Vacant Land	1,056.91	1.65	11.7%
Right of Ways Land	711.82	1.11	7.9%
Right of Ways Water*	6,297.81	9.84	
Historic Resources**	99.21	0.16	1.1%
Total Land Uses	**9,019.74**	**14.09**	**100.0%**

Source: 2007 City Punta Gorda & Charlotte County GIS *Right of Ways Water includes all navigable water bodies used for transportation purposes and are not added into the totals for land area. ** Historic Resources are individually assigned to another generalized land use category and are not added into the totals for land area.

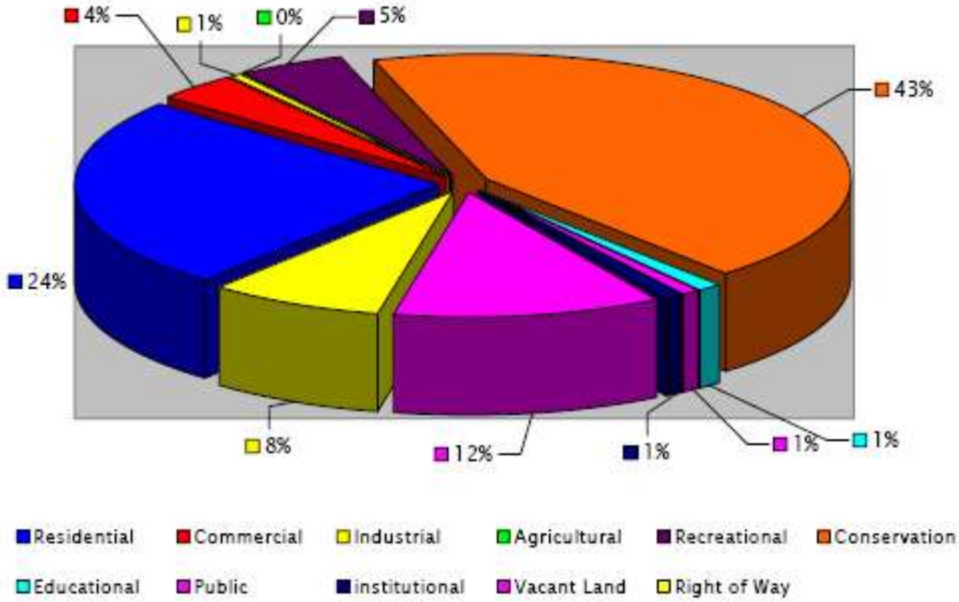


Figure 6:- The City of Punta Gorda's Existing Land Uses in Percent of Total Land Uses Expressed as a Pie Chart

City of Punta Gorda Vulnerability Assessment

The vulnerability of a city is a function both of the city's sensitivity to changes in climate as well as its adaptive capacity to adjust to changes in climate (either reactively or proactively through planning decisions). To assess its vulnerability, the city should describe the specific effects from climate change that are likely to affect key management goals. Climate change impacts will vary regionally, as will the approach taken to identify the most significant vulnerabilities. There are many different approaches to completing an assessment, from simple back-of-the-envelope approaches based on effects that are already occurring, to more sophisticated approaches that examine the links between multiple effects using predictive modeling or other tools to help project changes. Although a general understanding of vulnerability may be enough of a basis to inform adaptation actions in coastal areas, most cities may need and develop city-specific information that better characterizes the spatial distribution, intensity, and frequency of projected impacts. A more detailed and descriptive assessment may also be necessary to better inform stakeholders and to prioritize and gain support for actions. Additionally, the time frame for effects will vary according to the selected planning horizon for the city. Regardless, a vulnerability assessment could include: a description of the approach used, a summary of the most significant effects, the timeframe for the predicted effects, and any considerations for uncertainties or other factors needed to set priorities.

Risk Analysis

Natural hazards are a threat the people and property of Charlotte County face on a daily basis, and most analyses project that these hazards are likely to increase in intensity and/or frequency with climate change. The level of risk differs by hazard type, time of year, and location of the person or piece of property. Risk analysis is an essential first step in helping the people of Punta Gorda prepare to face these risks. This risk analysis includes four main components: hazard identification, profiling hazard events, asset inventory, and estimation of potential loss.

An important step in the risk analysis process is to identify those hazards that are most likely to impact the City of Punta Gorda. While there is a long list of natural hazards that have the potential of occurring in Punta Gorda, the majority of these hazards have a low probability of occurring. Thus, the hazards that have been identified for analysis in this plan because of their potential to impact the county include (in no particular order): flooding, coastal storms, wildfire, tornadoes, thunderstorms and high wind events, coastal erosion, drought, winter storms and freezes, and exotic pests and diseases.

Profiling hazard events describes the causes and characteristics of each hazard, how the hazard has impacted City of Punta Gorda in the past, and what part of Punta Gorda has been vulnerable to each specific hazard. A profile of each hazard that is covered in this plan is located in the section on each individual hazard. For a full description of the history of hazard events, please see the appropriate hazard chapter and Appendix B.

The asset inventory is a way to assess vulnerability from each hazard by looking at the types and numbers of existing buildings, infrastructure, and critical facilities located in each identified hazard area. In order to assign a monetary value for each structure, the structure's replacement value, content value, and functional use value were determined. Appendix A explains the methodology used to determine these values.

"Replacement value" is the current cost of returning a physical asset to its pre-damaged condition. It reflects present day cost of labor and materials to construct a building of particular size, type, and quality. For this analysis, value of the building, as listed in the property appraiser's records, was used. In instances when the building value was not available, the total value of the property was used.

Summary of Priority Considerations

Planning typically requires some narrowing of the scope to focus efforts on managing risk where most needed. Determining the greatest needs for a particular city will likely entail both quantitative and qualitative analyses of risk and vulnerability, as well as discussion and agreement among key estuary managers, stakeholders, and collaborators. Quantitative and qualitative climate change risk and vulnerability assessments need to be balanced with the city's management goals and objectives. In many cases, climate change will not necessitate creation of new management goals or initiatives, but rather consideration of how existing programs will be able to address or be impacted by a changing climate. A summary of this information in an adaptation plan should describe the approach taken, decisions on priorities and any uncertainties or other considerations that may affect the selection of specific activities.

Key considerations in assessing management priorities and risk include:

1. Timing of projected impacts (e.g., short-term, mid-term, long-term) relative to the timing of management decisions and actions;
2. Severity of projected impacts (e.g., catastrophic, severe, major, minor, insignificant), and geographic scale (i.e., localized vs. city-wide);
3. Probability of the occurrence of different impacts;
4. Economic or social significance/value of economic, social or environmental assets (i.e., what is being protected); and
5. Capacity of the community to undertake the action compared to the scale of the impacts, which could include:
    a. Costs associated with implementing adaptation actions (e.g., budget availability, funding opportunities);
    b. Information availability, including ongoing monitoring and research (e.g., LIDAR, GIS, mapping, indicators);
    c. Availability of adaptation options suitable for addressing risks;
    d. Timing and time horizon (e.g., decision frequency, planning horizon, implementation period);

e. Linkage to other decisions (i.e., will adaptation actions impact other decisions within the city or externally);
f. Regulatory, operational, political, and legal constraints;
g. Public awareness, support, and concern about the issue; and
h. Ability to act under uncertainty (of either the likely impacts or the effectiveness of the actions).

Communication with Stakeholders and Decision Makers

Adaptation actions will require consent from the citizens who live, work, and play in the city, as well as decision makers who will have to provide approval, funding, or both in carrying out the selected actions. National Estuary Programs (NEPs) are very experienced with appropriate communication tools for their locales, and should be able to readily incorporate climate adaptation planning into ongoing information and education programs. However, in many places communication for climate adaptation may demand either a different approach or new expertise for the NEPs. In particular, some NEPs will be trying to develop alternatives to prevent future negative outcomes that are either uncertain or unimagined. Rather than returning to historic conditions of water quality or ecosystem health, citizens and officials may have to anticipate conditions that, as yet, have not manifested in the system.

A “multi-modal” communication strategy may be necessary to address some of these unfamiliar concerns and to provide specific information on the actions that will be necessary in the watershed.

Adaptation planning must be a cooperative effort involving all stakeholders: citizens; construction, business, real estate, and agricultural interests; retirees; families; emergency services; city and county government and more. The effort should be done in cooperation with the city and/or county government, preferably as a part of the comprehensive plan update and other existing planning processes. This enables the resulting adaptation plan to take on the authority necessary to make sure recommended actions are eventually implemented and an ongoing process for adaptive planning is put in place. Comprehensive plan amendments, land development regulations and community initiatives should result, informed by the people on the ground, and approved by decision makers.

Communication efforts should stress the transparency of the process and the accountability of the entity leading the effort, whether it is the NEP, RPC, local government or a citizen group. The planning effort should involve as much of the public as possible, increasing responsiveness of the plan to local citizenry and resulting in public buy-in.

In the city of Punta Gorda, city staff was approached initially by CHNEP and SWFRPC staff to gauge interest in developing a climate change adaptation plan. Fortunately, this progressive municipality had already included climate change planning in their comprehensive plan, so there was agreement on the need for such planning and that the

CHNEP/SWFRPC team was to take the lead in the effort with the full support of city staff. On December 17, 2008, the Punta Gorda City Council voted unanimously to participate. Team Punta Gorda was suggested as a community partner to help with outreach and organization.

A series of three public meetings was decided upon, the first one to be held on April 9, 2009, followed by other meetings on June 2, 2009 and September 6, 2009. Since this effort was supported by the grant from EPA, fundraising for meeting space and other aspects was not a factor, but may be in other situations, something to be taken into consideration. Outreach, using CHNEP's press contacts, resulted in newspaper articles and interviews on local television news that helped publicize the first meeting. Also, the CHNEP and SWFRPC websites featured the event prominently, email "blasts" were sent out to regular subscribers of CHNEP E-news, and postcards were mailed to CHNEP supporters living in the Punta Gorda area. CHNEP hosted online registration for the meeting, but phone registration was also available and walk-ins were accepted.

Meeting space was donated by the Punta Gorda Isles Civic Association and the SWFRPC underwrote the refreshments. Contacts in the city staff as well as Team Punta Gorda advised that morning meetings would draw the most participants, so the meeting on April 9 was scheduled to run from 9:00 a.m. to 12:00 p.m. Thirty eight people attended, which, according to local expertise, was a good turnout. The participants included residents, people who work in the city, city staff, and seasonal visitors. Some represented specialized groups, like recreational fishermen. The attendees were asked to fill out a questionnaire when they came in which provided demographic information as well as the respondent's opinions and observations about climate, wildlife and storms in Punta Gorda. The survey and raw result data can be found in the Appendix.

The results of the survey showed that most of the participants live in Punta Gorda year-round and have been in Florida an average of 22 years. Most were from the 33950 ZIP code, indicating that they live in or near the downtown area. Most of the people who work, work in that same ZIP code. Most respondents thought that winters in Florida are becoming drier and cooler and that summers are becoming drier and warmer. Of those with an opinion, respondents generally thought that fishing in Charlotte Harbor is declining, that water quality in the Harbor is declining, that water quality in the canals of Punta Gorda is declining, and that the presence of wildlife in Punta Gorda is decreasing. It should be noted that a significant number of respondents were not sure about changes in those conditions. Most people did not feel that storms are getting more severe or frequent, but a majority felt that they expected weather to get worse in the future. A significant number felt weather would stay the same. Almost all respondents reported damage to their property from Hurricane Charley in 2004, ranging from roof and structural damage to loss of vegetation and landscaping. Most people had responded to that damage by fixing and/or upgrading roofs, windows, and garage doors, purchasing generators and shutters, and adapting their landscaping to absorb more rainfall and be less vulnerable to high winds. Many people listed other improvements they would like to make, but, for most, cost is the limiting factor.
Respondents also listed things local, state and federal government could do differently to be better prepared for storms, droughts and floods in the future. Those suggestions

included "intelligent growth", physically raising the elevations of certain roads (Aqui Esta and Olympia), improved water resource planning, public education, improved evacuation routes, irrigation restrictions, improved wetland protections, better forecasting and improved communications.

Three presentations were given before the participants were broken up into small groups for discussion. The first presentation was given by Dr. Lisa Beever of the CHNEP, giving the background of the project and the CHNEP's role. The second presentation was given by Joan LeBeau of the City of Punta Gorda, reviewing the city's concern with climate change, especially sea level rise, in the wake of the devastation from Hurricane Charley in 2004. The final presentation was by Jim Beever of the SWFRPC, who gave a primer on climate in southwest Florida and the implications of climate change for the area. These presentations are contained in the Appendix.

With all this background, the participants were divided up into several small groups of no more than eight, lead by a CHNEP or SWFRPC facilitator. Dr. Beever introduced the small group activity, which involved

- The Vulnerability Game,
- The Adaptation Game, and
- The Acceptability Game.

The Vulnerability Game was designed after a frame game called *Group Scoop*, originally *Group Grope*. *Group Scoop* and the concept of frame games were designed by Dr. Sivasailam "Thiagi" Thiagarajan. A frame game is a tested training game where one can insert their own content. For the Vulnerability Game, participants were allowed to form their own groups and were given as many index cards as they could use. They were asked to individually brainstorm climate change vulnerabilities that they and City of Punta Gorda faced. Each idea was put on a separate card. After 10 minutes, the cards were collected, shuffled, and three to five cards dealt to each participant.

Remaining cards were put in the middle.

Photograph 1: Left: Each person selecting the best cards for their hand. Right: The group selecting the top 3-5 vulnerabilities.

Each participant had to pick and discard vulnerabilities so that they had the three to five most serious vulnerabilities in their hand. The remaining cards were removed. Then, the participants shared their cards with each other and, as a group, selected the most important three to five vulnerabilities. *Group Grope* has been used in other venues by CHNEP to replace scribing ideas on an easel pad. The game is quicker because individuals are concurrently writing ideas. Other benefits include greater ownership of ideas, ability to quickly consolidate high ranked ideas, and inability for participants to be passive.

Photograph 2: Group members adding alternative adaptation strategies to the envelopes.

The Adaptation Game was based on another frame game called *Envelopes*. The top three to five vulnerabilities from the previous game were written on separate 8" x 10" envelopes. The envelopes were distributed among the group members. Each participant brainstormed alternative possible adaptations on individual index cards and placed the cards in the envelope. After a couple minutes, group members traded envelopes. Each member was able to contribute adaptation ideas to their envelopes. Group members were also encouraged to include ideas that they may not necessarily agree with, so that they might have the opportunity to reject them.

Photograph 3: General consensus to address one of the vulnerabilities.

The Acceptability Game was conducted with the participants reassembled in the main room. During the break, staff reviewed the envelopes and similar vulnerabilities from different groups were collapsed. As each vulnerability (from the envelopes) was called out, participants showed a thumbs up, thumbs down, or thumbs sideways to show the level of their agreement for addressing the vulnerability in the adaptation plan. The intent of the game was to gain a sense of agreement for each of the adaptation measures. However, the method took longer than the time allocated. Staff offered to develop a survey instrument from the Adaptation Game to be posted on the CHNEP website.

A second public workshop was held on June 2, 2009. It was scheduled to “review various adaptation strategy scenarios developed with input from earlier workshop and on-line questionnaires’. The agenda featured one major activity- a board game. The purpose of the game was to identify general support or lack of support for adaptation options. The adaptation options presented had been identified by participants of the first public workshop and were identified from the literature. “The Adaptation Game” is an original creation for this public workshop.

The game board was created in ArcGIS from aerial imagery and provided additional information such as storm surge zones and critical facilities. All areas considered for annexation, as well as existing city facilities outside of the city limits, are shown. The board included an inset for an enlargement of downtown. The board included two “parking lots,” one for city-wide adaptations and one for adaptations the participant recommends against. The board was 34 x 44 inches in size (See Figure 7).

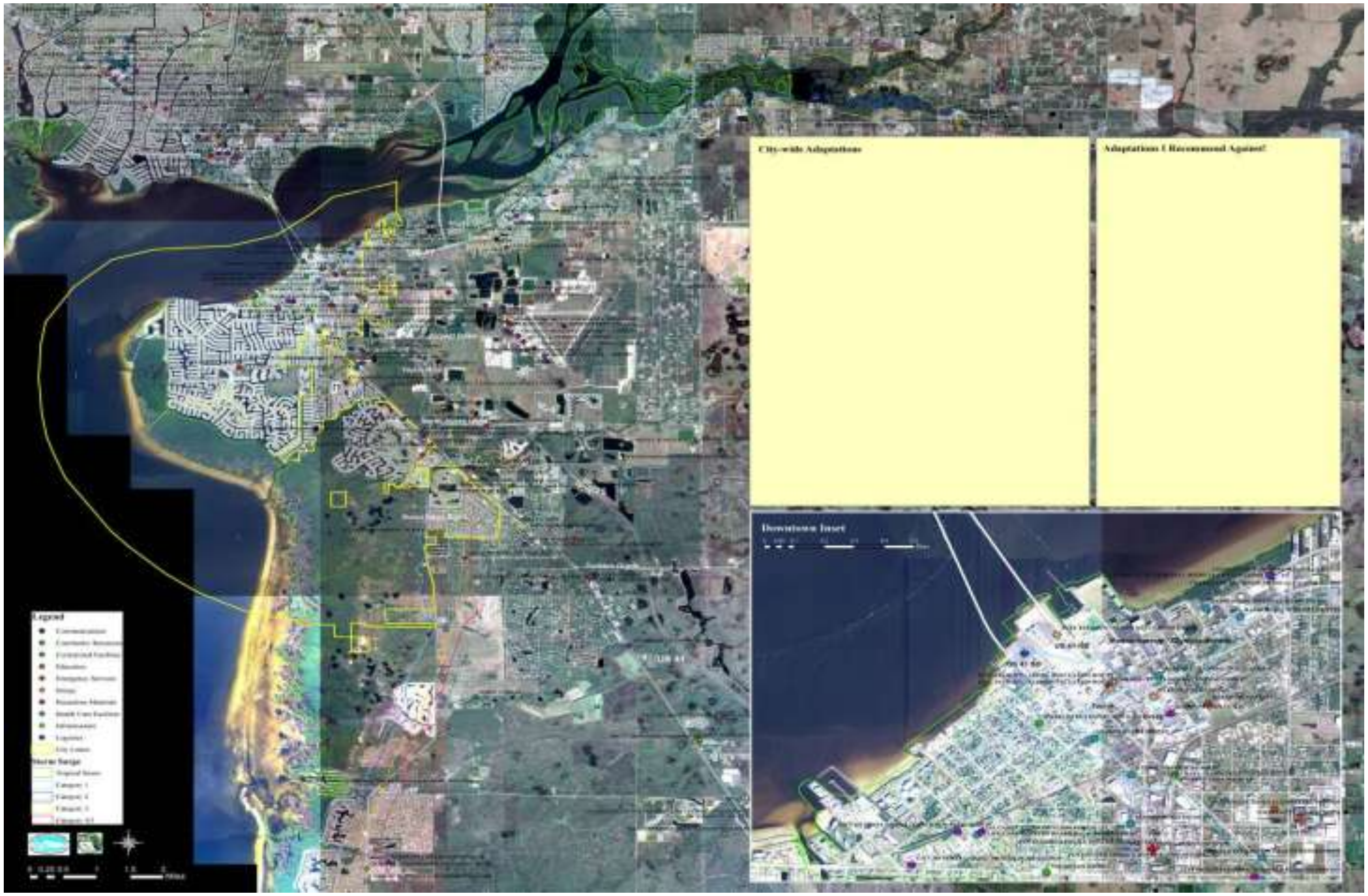


Figure 7: The Adaptation Game board helped participants recommend locations where possible adaptations should take place.

The game pieces were "EcoFriendly White Return Address Labels" printed from a word processing file. Adaptation options from the first workshop were grouped by the major vulnerabilities identified at the first workshop. Potential adaptations identified by participants had a white background and additional adaptations identified in the literature had a yellow background. This was done so that the participants would know the source of the adaptation and show that we predominately used their earlier work. The font for each adaptation was adjusted in size so each would be as large as possible. The original lists were made available to the participants over the break so that they could familiarize themselves with the list of adaptations and make initial selections. These sheets were easier to read because of the consistent font size and became a useful tool for the participants.

Six tables were set up with a game board, duplicate sheets of game labels, and a tabletop name tent identifying which vulnerability or group of related vulnerabilities that table represented. Each table had a separate set of game labels that were related to the vulnerability or group of related vulnerabilities. Participants were allowed to go to the table of their choosing and spend as much time at any individual table that they chose. Most participants were able to visit all the tables in the time available. This strategy allowed adequate room for the participants and allowed for easy sorting of the chosen adaptations.

Photograph 4: Two participants playing the Adaptation Game at the Unchecked or Unmanaged Growth table.

Participants were asked to place adaptations from the sheets onto the map where the adaptation should take place. If they wanted the adaptation to apply city-wide, they would “park” the label in the city-wide box. If they didn’t like an adaptation, they “parked” the label in the box named “Adaptations I Recommend Against.” By counting the number of times any particular adaptation was chosen, relative support for that adaptation could be determined. Likewise, undesirable adaptations were documented.

Place based adaptation recommendations are found on the following map.

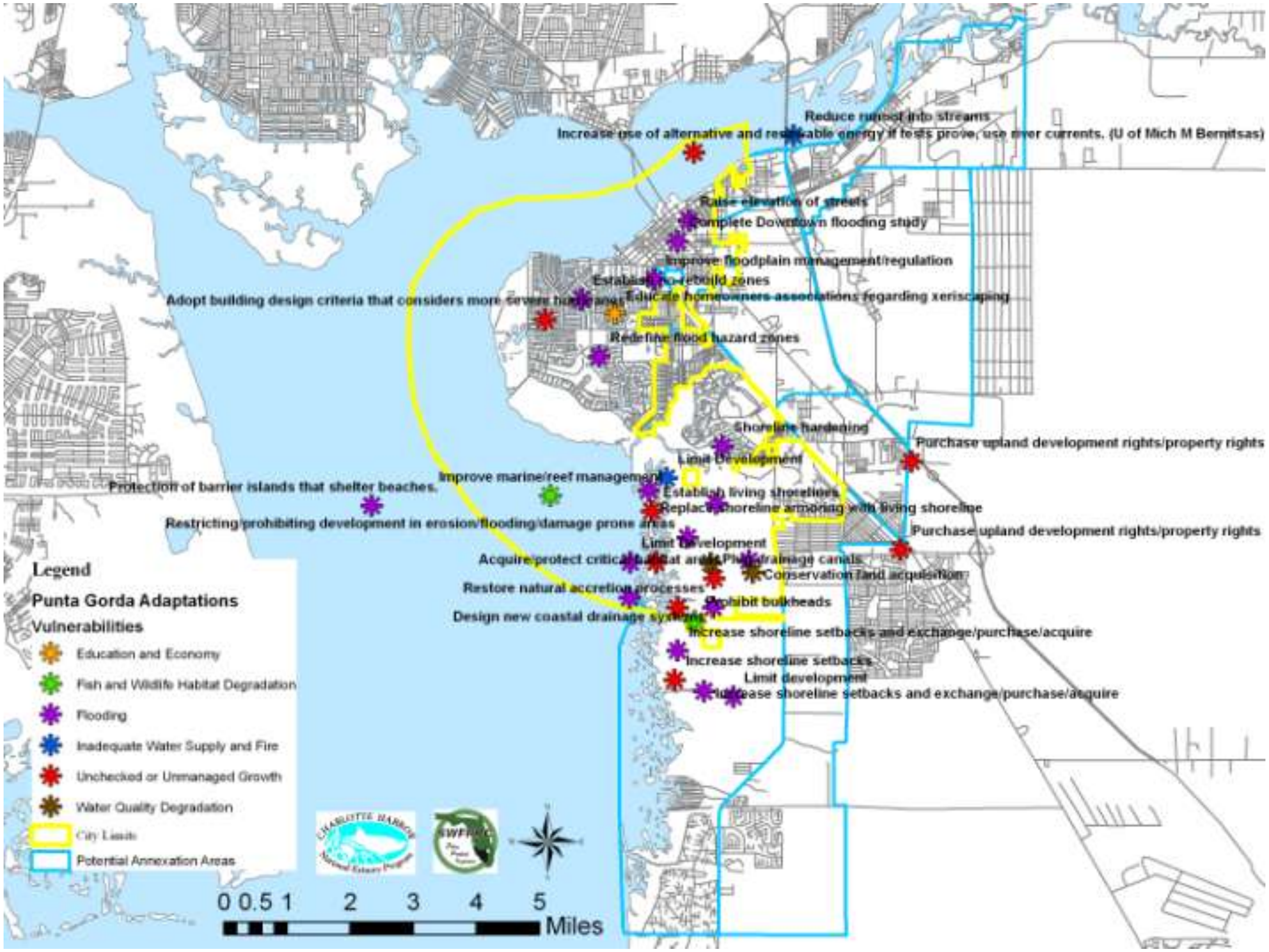


Figure 8: Placed Based Adaptation Suggestions for the City of Punta Gorda

Description of Specific Implementation Actions

Introduction

This report identifies the alternative adaptations that could be undertaken to address the identified climate change vulnerabilities for the City of Punta Gorda. These adaptations are presented in the order of prioritized agreement form the public meetings. Only the highest agreement adaptation in each vulnerability area is fully developed for potential implementation. One of the utilities of this approach is that it provides a variety of adaptation options, which the City could select for implementation.

The Florida Oceans and Coastal Council (FOCC) predicts that Florida, including southwest Florida, will respond to the adverse effects of climate change in three ways (FOCC 2009):

1. Some effects will be tolerated, meaning that no reasonable options will be found. For example, Florida may have to accept the loss of its coral reefs.

2. Some effects will be mitigated, meaning that strategies and actions will compensate for some of the adverse effects. For example, federal, state, regional or local governments may set aside additional coastal lands so that tidal wetlands can migrate inland as sea level rises, preserving these essential coastal habitats in the pattern with ecotones that should occur naturally.

3. Some effects will require adaptations, meaning that our way of life, infrastructure, and/or economy will have to change in order to maintain the same quality of life to which Floridians are accustomed. For example, buildings may need to be designed to new standards or located farther from vulnerable shorelines.

To prevent or minimize the negative impacts and to profit from the potential benefits of climate change, citizens and policymakers in the Gulf Coast region can and should take action now. There are four basic strategies – *avoidance*, *mitigation*, *minimization, mitigation*, and *adaptation* - that can reduce the region's vulnerability to the impacts of climate change and yield significant ecological, economic, and health benefits, even in the absence of major climate disruption. They should be considered a prudent and responsible approach to ensuring environmental stewardship of the region's invaluable ecological resources. Because much of the region is held in private land ownership, strategies for dealing with both climatic and human stresses on ecosystems must involve private landowners as well as governmental agencies and other sectors of society.

The easiest way to avoid the negative consequences of climate change is to not place resources or infrastructure in a location or position to be impacted. This avoidance can take the form of not building in floodplains, setting aside coastal areas to remain in natural shorelines and vegetation, placing critical facilities and shelters in locations away form and above storm surge.

The primary goal of *mitigation* is to reduce the magnitude of climate stresses on society and ecosystems. Reducing greenhouse gas emissions, for instance, can be seen as a type of "insurance policy" that aims at directly reducing the risks of global warming. Investment in the region's substantial renewable energy resources (e.g., solar, wind, and biomass) could provide incentives for new technology development and economic diversification while reducing air pollutants and greenhouse gases.

The third strategy is to reduce human disturbances and destruction of ecosystems. Employing "best practices" in land and resource use can *minimize* ecologically harmful side effects while continuing to provide significant, and often increased, economic benefits. For example, progressive zoning initiatives that integrate different land uses over a smaller area can protect natural resources and open space from suburban sprawl. Wise land-use practices can also help manage coastal areas, and best management practices in agriculture and aquaculture can achieve goals such as water conservation and reduced farm runoff.

Finally, residents, planners, land managers, and policymakers can act now to minimize the potential impacts of global climate change and better prepare the region to deal with an uncertain future through *adaptation*. One of the best ways to deal with uncertainty is to adopt learning-oriented, flexible approaches that include monitoring, periodic review, and adjustment of previous decisions in light of new information - a strategy known as adaptive management. The principal targets for adaptation include water resource management, agriculture and forestry, land and biodiversity conservation, and preparation of coastal communities to respond to sea level rise and severe coastal storms such as hurricanes.

In addition, much must be done in the Gulf Coast region to raise awareness and understanding of global climate change. This can begin by educating people of all ages about the cultural and ecological heritage at stake. But it must also involve educating them about the fundamentals of ecology and climate, and what drives them to change. Many Gulf residents' livelihoods are inextricably linked to its natural resources, and visitors from around the world come to the Gulf to enjoy and learn about its ecological heritage. Raising people's concern and understanding of climate change would help to mobilize public support for climate protection (Twilley et al.1991).

There are five generic objectives of adaptation to climate variability and change: (Klein and Tol 1997)

1. Increasing robustness of infrastructure designs and long-term investments – e.g., by extending the range of temperature or precipitation a system can withstand without failure and changing the tolerance of loss or failure;

2. Increasing the flexibility of vulnerable managed systems – e.g., by allowing mid-term adjustments (including changes of activities or location) and/or reducing economic lifetimes (including increasing depreciation);

3. Enhancing the adaptability of vulnerable natural systems – e.g., by reducing other (non-climatic) stresses and removing barriers to migration (including establishing eco-corridors);

4. Reversing trends that increase vulnerability (also termed "maladaptation") – e.g., by introducing setback lines for development in vulnerable areas, such as floodplains and coastal zones; and

5. Improving societal awareness and preparedness – e.g., by informing the public of the risks and possible consequences of climate change and setting up early-warning systems.

Given uncertainties and the long time frame of climate change impacts (Willows and Connell, 2003); two general types of adaptation options discussed here may often be the most appropriate and most readily funded:

• *No-regrets:* These are options that are justified by current climate conditions, and are further justified when climate change is considered. For example, reducing water pollution could improve potable water supplies. The pollution reductions may be even more valuable should climate change reduce water supplies or degrade water quality. The same can be said for introducing market reforms. However, an irrigation scheme for a drought-prone area may become more attractive when periods of drought, as a result of climate change, occur more often or become more severe.

• *Low-regrets:* Low regrets changes are those made because of climate change, but at a minimal cost. Thus, there is "low regret" if the investment proves not to be needed under future climate conditions. For example, incorporating risks of climate change in design of infrastructure may offer improved protection against current extreme climate events, as well as potential future events under climate change, while increasing costs only marginally (hence the "low" regret).

Specific Adaptations by Group

In the following discussion the identified adaptations are grouped by similar actions. During public workshops the citizens of the City of Punta Gorda Identified 54 vulnerabilities that combined into 8 major areas of climate change vulnerability for the city including, in order of priority:

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.

This section of the report identifies the crucial areas where adaptation planning and implementation will be needed to avoid, minimize and mitigate the anticipated effects to the natural and man-altered areas of southwest Florida. Some effects, such as air temperature and water temperature, will be experienced throughout the City of Punta Gorda and the southwest Florida region. Other effects such as sea level rise and habitat shifts will occur in specific geographic and clinal locations.

In the course the vulnerability assessment and regional adaptation planning project, we identified 246 climate change adaptations (Beever et al. 2009) that could be utilized to address the various vulnerabilities identified for the region.

Prioritized Vulnerabilities and Adaptations for the City of Punta Gorda

Vulnerability 1: Fish and Wildlife Habitat Degradation

The range of potential impacts on species and ecosystems in the City of Punta Gorda include the following:

Negative effects on calcifying organisms *(oysters, clams and other animals that incorporate calcium in their body or shell)*

Increased atmospheric concentrations of carbon dioxide are expected to contribute to increased acidity (lower pH) of sea water. Marine organisms with calcium carbonate shells or skeletons, such as clams, and plankton at the base of the food chain can be adversely affected by decreases in pH and carbonate saturation state (IPPC 2007b; Bates 2007). A higher carbonate saturation state favors the precipitation of calcium carbonate, a mineral, while a lower state supports its dissolution into the water. Carbonate-depositing organisms will have to expend more energy to maintain shell construction and structural integrity in a lower pH environment (Peterson et al. 2007; SCCP 2008; FOCC 2009; USEPA CRE 2008).

With decreases in the pH of seawater, some marine plants may show increases in production until a particular threshold is met, and then will show a decline (FOCC 2009). Some marine organisms will not be able to tolerate decreases in pH (FOCC 2009). It is probable that the die-offs of sponges, seagrasses, and other important components of coastal and marine ecosystems from increased sea surface temperatures will become more frequent (FOCC 2009; USEPA CRE 2008). Ocean acidification may lead to shifts in marine ecosystem structure and dynamics that can alter the biological production and export from the ocean surface of organic carbon and calcium carbonate (Royal Society 2005). Important fisheries habitats, such as oyster bars, will markedly decline or disappear (Kleypas et al.2006; Ishimatsu et. al. 2005).

The geographic range of some marine species will shift northward as sea-surface temperatures continue to rise. The species composition of Florida's native marine and estuarine communities will change, perhaps drastically. With further rises in water and atmospheric temperatures, conditions will probably become more favorable for certain exotic plant and animal species to invade Florida's coastal waters (FOCC 2009). As marine species shift northward with overall warmer ocean temperatures, this shift may have either negative or positive impacts. Some species may be able to survive farther north than in current ranges, but interactions among communities with new species compositions cannot be predicted. Moreover, reproduction in some fishes decreases in warmer temperatures, potentially resulting in population decreases (Straile and Stenseth 2007).

Increased numbers and altered ranges of jellyfish are expected with some invasion of exotic jellyfish species, and with increased predation on local prey species. Some highly vulnerable prey species may be significantly affected (Perry and Yeager 2006; FOCC 2009; USEPA CRE 2008).

Algal blooms

Harmful blooms are caused by microscopic algae in the water column that can produce biological toxins, such as those generated by red tide in coastal marine waters; blue-green algae in estuarine waters; or larger species of marine and estuarine algae that grow on the bottom, which can smother corals and other native plants and animals. Environmental factors, including light, temperature, and nutrient availability, set the upper limit to the buildup of biomass in marine algae (Smyda 1997). The algae that cause harmful blooms in coastal marine and estuarine waters are favored over other algal species when water temperature is high and becomes thermally stratified (Paerl and Huisman 2008; Peperzak 2005; Van Dolah 2000; FOCC 2009; Twilley et al. 1991; Coastal States Organization Climate Change Work Group 2007; Holman 2008; USEPA Office of Policy, Planning and Evaluation 1997; USEPA CRE 2008). The increased occurrence, intensity, and toxicity of harmful algal blooms may result in the disruption of coastal marine and estuarine food webs, more frequent fish kills, and adverse impacts to people in or near an affected coastal area (Smyda 1997; Paerl and Huisman 2008; Van Dolah 2000). Harmful algal blooms have been reported throughout Florida's coastal marine and estuarine waters (Carder and Steward 1985).

Photograph 5: Red Tide Algae Bloom.

 Source: FWC 2009

Increases in global surface temperatures will lead to a reduction in water quality due to increased growth of nuisance algae and lower oxygen levels (USEPA CRE 2008; Rubinoff et al. 2008; Holman 2008; USNOAA 2008).

If climate change systematically increases nutrient availability and this alters the amount of available light and the stability of the water column, there may be substantive changes in the productivity, composition, and biomass of marine algae, including harmful species (Smetacek and Cloern 2008). In contrast, permanent reductions of freshwater flows in rivers from both human activities and climate change could substantially reduce biological productivity in estuaries (FOCC 2009; Twilley et al. 1991).

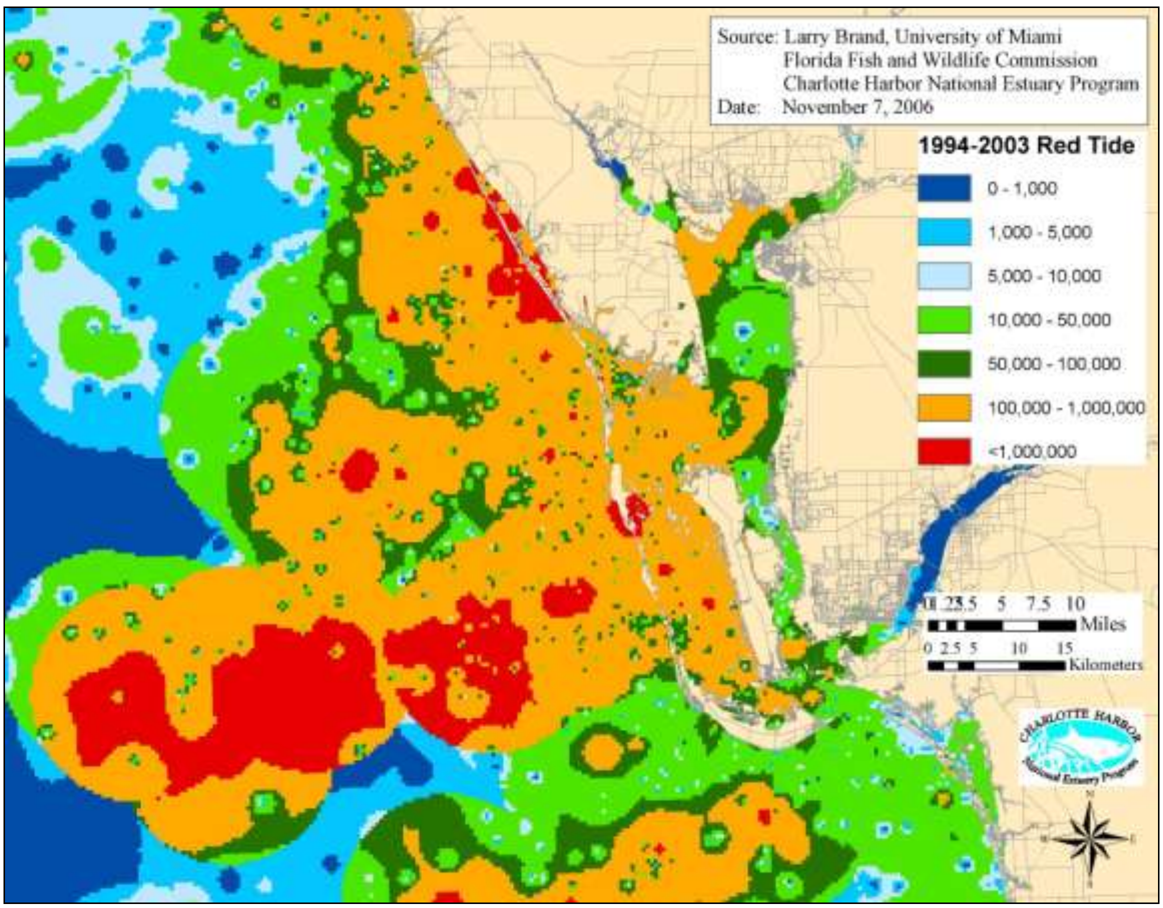


Figure 9: Intensity and location of red tides in Charlotte Harbor and nearshore areas 1994-2003. Source indicated on key.

Negative effects on seagrass

Sea level rise is expected to cause migration of seagrass beds landward with subsequent depletion of existing beds at the deeper waterward edges due to less penetration of sunlight. This coupled with increased turbidity from erosion and breakup of coastlines, increased storm season runoff, and human activities, will likely lead to die-off at deeper edges. Where natural shoreline exists, seagrass beds are expected to migrate into appropriate depths. Where opportunities for landward migration of the shallow subtidal zone is blocked by human bulkheads or other barriers, the seagrass beds will be reduced and then disappear if the water depths at the sea wall barriers exceeds the light extinction coefficient for the seagrasses (USCCSP 2008; USEPA CRE 2008).

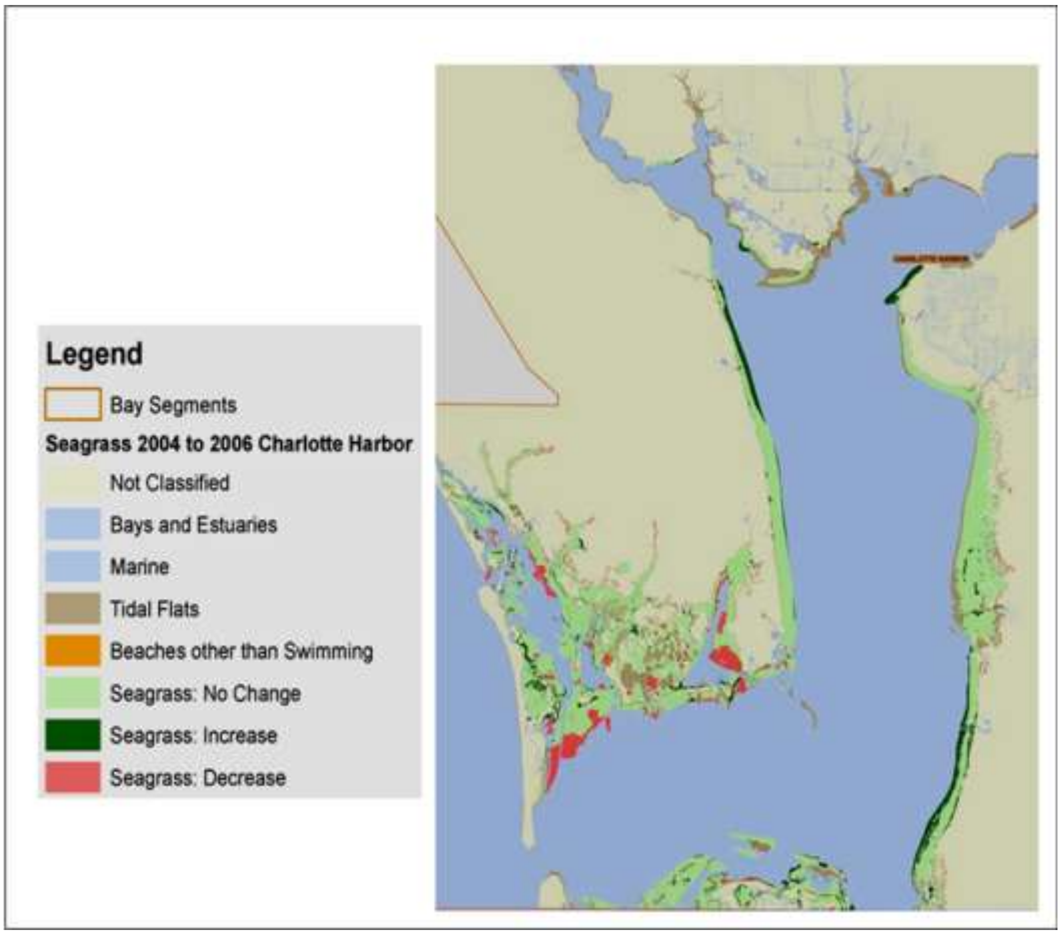


Figure 10: 2004-2006 Seagrass Extent in Upper Charlotte Harbor.

Source Corbett et al. 2006; Kaufman/SWFWMD 2007

Hypoxia, stratification and nutrients

Climate-related changes in freshwater runoff to coastal marine systems, coupled with changes in stratification (or layering) patterns linked to warming and altered salinity, will change the quantity and availability of nutrients in estuarine systems (Boyd and Doney 2002). Changes in the absolute and relative availability of nutrients will lead to changes in microscopic plants (phytoplankton) and microbial activity in the marine food web (Arrigo 2005). Induced changes may result in food webs that are less efficient in transferring energy to higher levels, thus affecting the productivity of economically important fish and other plant and animal life (Arrigo 2005).

Increased runoff in some areas, coupled with human population increases in Florida, will lead to the increased transport of nutrients to coastal waters, contributing to hypoxia (IPPC 2007b) and leading to adverse impacts on bottom-feeding fish and sessile (attached to the bottom) organisms (IPPC 2007b). Locations that have experienced hypoxia may experience longer hypoxic episodes or more frequent recurrence of hypoxia (Osterman et al. 2007). Increased density stratification within estuaries could also occur with increased precipitation and runoff. New locations with hypoxia may develop in coastal areas where they previously have not appeared (Osterman et al. 2007).

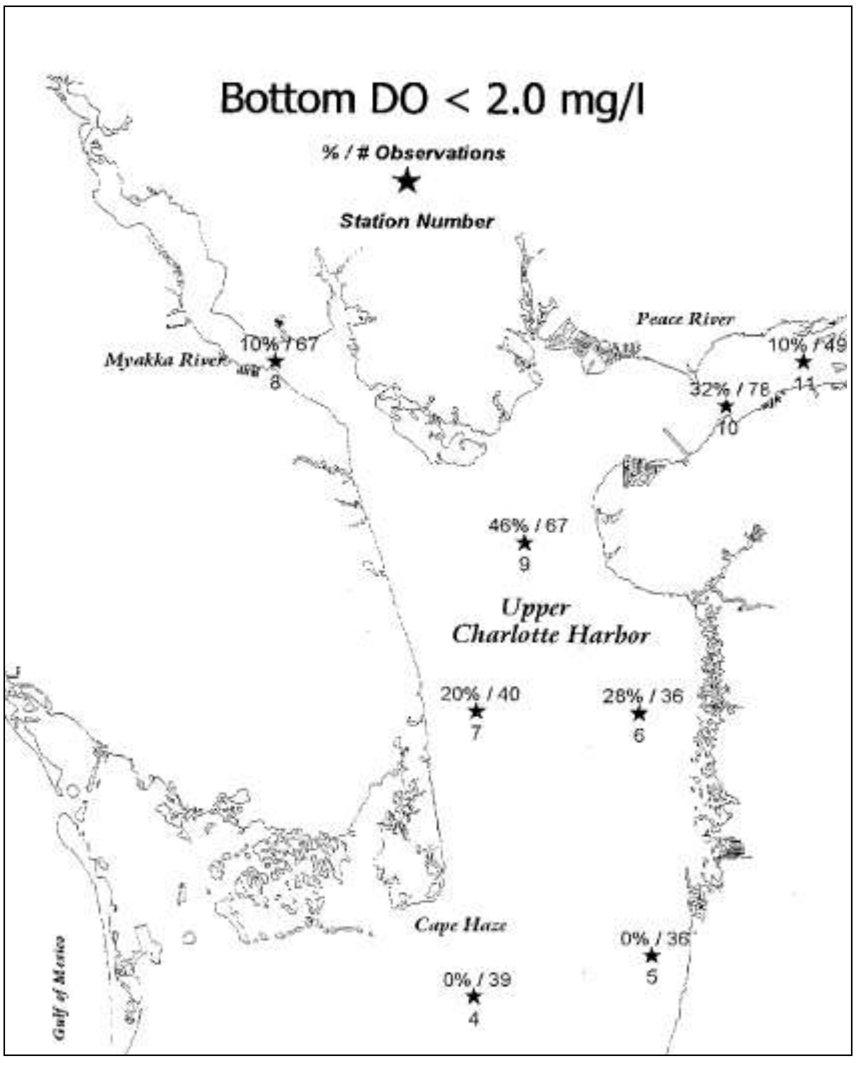


Figure 11: Historic occurrence of hypoxia, July through October.
Source: Heyl 1997

As sea-surface temperatures continue to rise, die-offs of marine fauna incapable of moving to cooler water are likely to become more frequent. Other factors, such as low levels of dissolved oxygen, the addition of nutrients and other land-based sources of pollution, and harmful algal blooms, will exacerbate these die-offs. The conditions that have contributed to fish diseases and various die-offs in the Florida Keys may move to more northern latitudes. As sea surface temperatures continue to increase, the impacts may begin to affect more northerly coastal and marine environments that have thus far escaped these problems (FOCC 2009).

Marine thermal stratification will change dissolved oxygen levels at different water depths. This will result in changes to zonation for animal and plant life and increase the probability of fish and other marine life kills (Coastal States Organization Climate Change Work Group 2007; Holman 2008; FOCC 2009; USEPA CRE 2008)

Changes to coastal wetlands

Although southwest Florida tide ranges are relatively small, tidal effects extend far inland because much of the state is so flat and low in relative elevation. Because sea level change has been relatively constant and slow for a long time, tidal wetlands such as mangrove forests and salt marshes have been able to grow into expansive habitats for estuarine and marine life. However, these tidal wetlands are sensitive to the rate of sea level rise and can perish if that rate exceeds their capacity to adapt. With rising sea levels, sandbars and shoals, estuarine beaches, salt flats, and coastal forests will be altered, and changes in freshwater inflow from tidal rivers will affect salinity regimes in estuaries as well as patterns of animal use. Major redistributions of mainland and barrier island sediments may have compensatory or larger benefits for wetland, seagrass, or fish and wildlife communities, but these processes cannot be forecast with existing models.

Sea level change is an important long-term influence on all mangroves and salt marshes (Gilman et al. 2008). Based on available evidence, of all the climate change outcomes, relative sea level rise may be the greatest threat to mangroves. Most mangrove sediment surface elevations are not keeping pace with sea level rise, although longer term studies from a larger number of regions are needed. Rising sea level will have the greatest impact on mangroves experiencing net lowering in sediment elevation, where there is limited area for landward migration.

Depending on the rate and extent of local sea level change, mangrove and salt marsh systems will respond differently (Titus and Richman 2005, 1987, Wanless et al.1994). If rates of sea level rise are slow, some mangrove salt marsh vegetation will migrate upward and inland and grow without much change in composition. If rates are too high, the salt marsh may be overgrown by other species, particularly mangroves, or converted to open bodies of water. If there is no accretion of inorganic sediment or peat, the seaward portions of the salt marsh become flooded so that marsh grass drowns and marsh soils erode; portions of the high marsh become low marsh; and adjacent upland areas are flooded at spring tide, becoming high marsh. Sea level rise in southwest Florida has been relatively constant for the past 3,200 years at around 0.4 mm/yr, (0.02 in/yr) but is now thought to be rising at rates of 3 to 4 mm/yr (0.12 to 0.16 in.) based on tide measurements from Key West (Wanless et al.1994). If sea level rise continues at this present rate, many of Florida's coastal mangrove and salt marshes will be impacted.

Don Cahoon (Cahoon et al. 1999) of the USGS has stated that if wetlands plant communities are unable to keep vertical pace with sea level rise they will likely be unable to keep pace with lateral migration upslope. This can occur because on some soil types when saltwater inundates formerly unsubmerged uplands sulfate reduction reactions can cause the land to sink up to six inches in micro-tidal areas that shift from nontidal wetlands directly to open subtidal waters (Titus, Pers. Comm. 2009). This would be mediated by fetch and wave action as well as by the emergent vegetation that is present, since both red mangrove (*Rhizophora mangle)* and saltmarsh cordgrass (*Spartina alterniflora)* can colonize low energy intertidal zones.

Estuarine circulation, salinity, and faunal use patterns are already changing with changes in climate and sea level (Peterson et al. 2008). Many tidal wetlands are keeping pace with sea level changes (Estevez 1988). Some are accreting vertically, migrating up-slope, or both (Williams et al. 1999; Raabe et al. 2004; Desantis et al. 2007). The rate of sea level rise will be critical for tidal wetlands.

Extirpation of cooler water temperate fishes that seasonally visit the Charlotte Harbor estuaries and alteration of reproductive rates and maturation in invertebrate species leading to declining populations can be expected from increases in global surface water temperatures (USEPA CRE 2008; Rubinoff et al. 2008; Holman 2008; USNOAA 2008).

There will be changes associated with inundation of coastal wetlands and marshes including altered tidal ranges, tidal asymmetry leading to changes in tidal mixing, changes in sediment transport, migration of estuarine salinity gradients inland, migration inland of marsh species zonation, altered diversity of foundation dominant plant species, structural and functional habitat changes, and less sunlight available to submerged marsh plants (USEPA CRE 2008 ;USNOAA 2008; Titus 1998; Bollman 2007; Volk 2008a).

Higher maximum temperatures, with more hot days and heat waves over nearly all land areas will negatively affect wetlands and freshwater bodies. There will be increased heat stress in fishes and wildlife, and increased animal mortality from heat stress. With increasing temperature, many invasive tropical species are likely to extend their ranges northward. Native plants and animals, already stressed and greatly reduced in their ranges, could be put at further risk by warmer temperatures and reduced availability of freshwater (Twilley et al. 2001; USEPA CRE 2008).

In many areas tidal saltwater and connected freshwater wetlands will become open water as water depths exceed the depths tolerated by emergent and submergent vegetation (USCCSP 2008; USNOAA 2008; USEPA CRE 2008).

Changes in precipitation will affect different wetlands differently with regional increases or decreases depending on the type and landscape position. Local extirpations of fish, amphibians, or water-dispersed plants are expected due to drought conditions that isolate and dry down tributaries and connected wetlands (USEPA CRE 2008; Holman 2008; FOCC 2009).

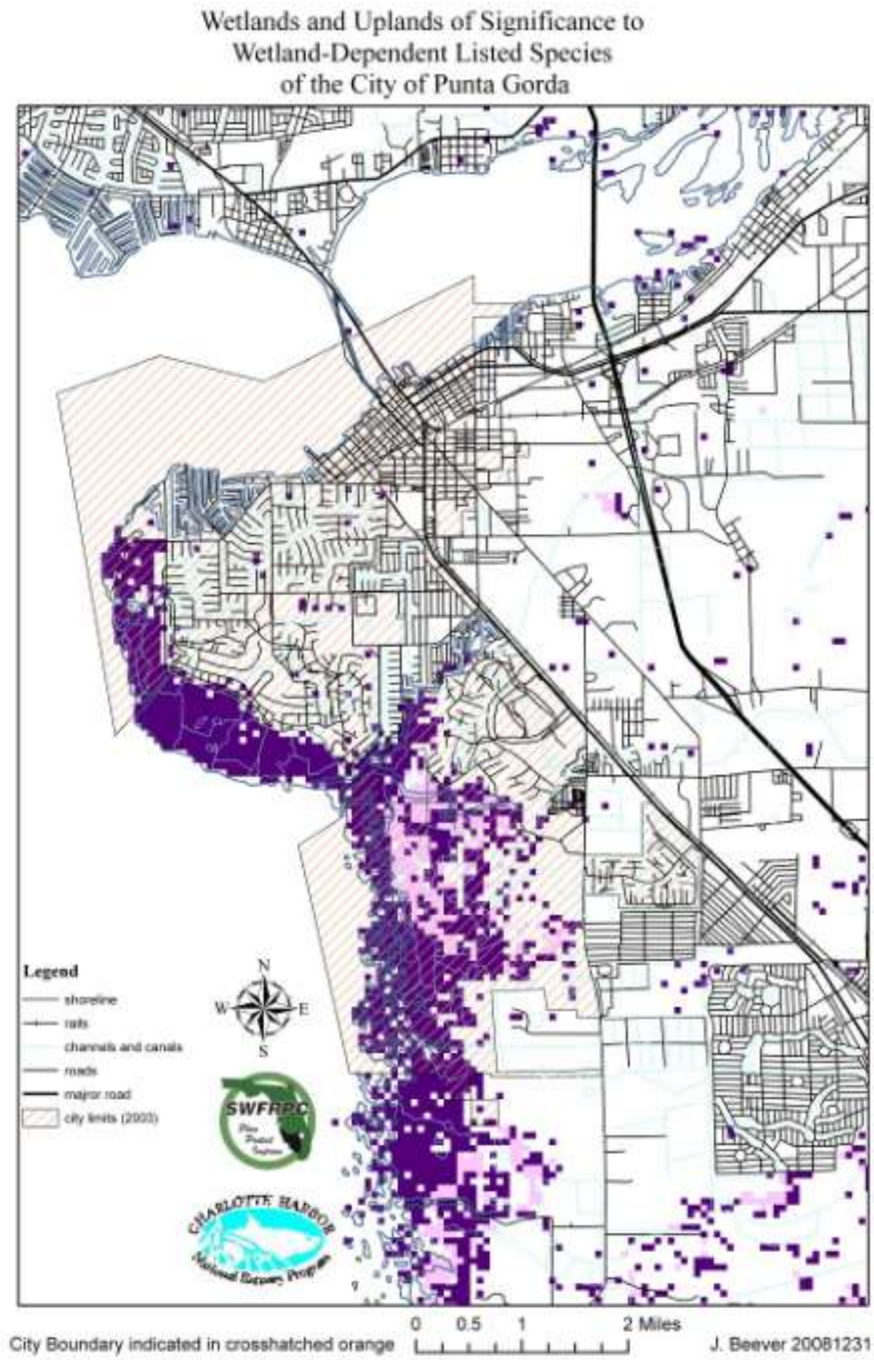


Figure 12: Wetlands and Uplands of Significance to Wetland Dependent Species

Source: FWC 2006

Coastal and wetland up-gradient translocation

As rising sea temperatures causes a five to 10% increase in hurricane wind speeds, storm events will result in increased beach erosion and losses of mangroves, marshes, and other wildlife habitats (USCCSP 2008; USNOAA 2008; USEPA CRE 2008). With sea level rise there will be an increased inundation of low marsh dominated by *Spartina* and *Juncus*. Subsequently there will be a migration up-gradient and inland of low marsh habitat into the high marsh areas with a resultant expansion of low marsh and a depletion of high marsh if high marsh does not have adjacent native upland to migrate into (USCCSP 2008; USEPA CRE 2008). More frequent or longer lasting droughts and reduced freshwater inflows could increase the incidence of extreme salt concentrations in coastal ecosystems, resulting in a decline of valuable habitats such as the mangroves and seagrasses (Twilley et al. 2001).

Shoreline nourishment, or the addition of sand to an eroded shore, may be utilized as a mitigation factor to protect shorelines and human infrastructure. However, it disturbs indigenous biota living on and in the beach, and disrupts species that use the shoreline for nesting, nursing, and breeding. Wetlands elsewhere are perishing as estuarine and coastal forests and swamps are retreating and being replaced by marsh vegetation (Williams et al. 1999; Raabe et al. 2004; Desantis et al. 2007). Open estuarine waters, some brackish marshes, and mangroves in south Florida estuaries are expanding (Glick and Clough 2006; Hine and Belknap 1986). Even at constant rates of sea level rise, some tidal wetlands will eventually be “pinched out” where their upslope migration is prevented by upland defenses such as seawalls (Estevez 1988; Schleupner 2008).

Native and non-native marine and estuarine species range shifts and disease
Florida’s native marine and estuarine systems will change species composition, perhaps drastically, as climate changes (Williams and Jackson 2007, Fields et al. 1993). The impacts on living communities may stem from changing maximum and minimum water temperatures, rather than from changing annual means.

The spread of invasive species may involve a gradual pushing out of native species of plants and animals (Holman 2008; FOCC 2009; USEPA CRE 2008). By giving introduced species an earlier start, and increasing the magnitude of their growth and recruitment compared with natives, global warming may facilitate a shift to dominance by non-native species, accelerating the homogenization of global animal and plant life (Stachowicz et al. 2002).

The frequency and intensity of extreme climate events are likely to have a major impact on future fisheries production in both inland and marine systems (IPCC 2007b; Brander 2007). Non-native, larger-bodied bivalves, a group of mollusks that includes oysters and clams, will be the most successful invaders, while native, large-bodied bivalves may be more sensitive to environmental changes. Consequently, the native species may either shift their ranges or become locally extirpated as climate shifts (Kaustuv et al. 2001).

Changes to phenology of anadromous fishes and other estuarine fishes will follow changes in fresh flows, tide levels, and timing of river flows (Peterson et al. 2007; USEPA CRE 2008). The cycle of spawning, eggs, early larval stages, nursery escape to vegetated wetlands, juvenile movement into seagrass beds, and adult entry to deeper waters or specialized habitats can be disrupted by the patterns of distribution and volumes of freshwater flows into the estuary.

And, as sea level rise alters hydrology, water quality and habitats in wetlands with migration of estuarine salinity gradients, there will be reduced production of low-salinity mangroves with impacts on wood storks, roseate spoonbills and crocodiles and shifts from estuarine to marine character (USEPA CRE 2008; Holman 2008; Ogden et al. 1999).

The effects of disease in marine organisms are likely to become more severe, since warmer temperatures generally favor the development of pathogens relative to their hosts (Harvell et al. 2002). Non-native, tropical invasive species could overwhelm Florida's native temperate marine and estuarine systems (Bibby et al. 2007). Projections of future conditions portend further impacts on the distribution and abundance of fishes that are sensitive to relatively small temperature changes. Some species may not persist. Other, currently rare species may become dominant (Straile and Stenseth 2007).

Lower-diversity wetlands will replace high-diversity wetlands in the tidal freshwater reaches of coastal rivers (Van Arman et al. 2005). Major spatial shifts in wetland communities, including invasions of exotic species, will occur (Dahdouh-Guebas et al. 2005). More lowland coastal forests will be lost during the next one to three centuries as tidal wetlands expand across low-lying coastal areas (Castaneda and Putz 2007). Most tidal wetlands in areas with low freshwater and sediment supplies will "drown" where sea level rise outpaces their ability to accrete vertically (Nyman et al. 1993). More than half of the salt marsh, shoals, and mudflats critical to birds and fishes foraging in Florida estuaries could be lost during the 21st century (Glick and Clough 2006). Recreational and commercial fish species that depend on shallow water or intertidal and subtidal plant communities will be at risk (Glick and Clough 2006). The loss of tidal wetlands will result in dangerous losses of the coastal systems that buffer storm impacts (Badola and Hussain 2005).

The coastal systems most vulnerable to sea level rise include freshwater marshes and forested wetlands in subsiding delta regions, mangroves in limestone areas, coastal marshes with human-altered patterns and areas with extensive human development (Twilley et al. 2001).

Changes to up-gradient wetland and upland habitats

Climate change is predicted to be one of the greatest drivers of ecological change in the coming century. Increases in temperature over the last century have clearly been linked to shifts in species distributions (Parmesan 2006). Given the magnitude of projected future climatic changes, Lawler et al. (2009) expects even larger range shifts over the next 100 years. These changes will, in turn, alter ecological communities and the functioning of ecosystems. Despite the seriousness of predicted climate change, the uncertainty in climate-change projections makes it difficult for conservation managers and planners to proactively respond to climate stresses. To address one aspect of this uncertainty, Lawler et al. (2009) identified predictions of faunal change for which a high level of consensus was exhibited by different climate models. Specifically, they assessed the potential effects of 30 coupled atmosphere-ocean general circulational model (AOGCM) future-climate simulations on the geographic ranges of 2,954 species of birds, mammals and amphibians in the Western Hemisphere. Eighty percent of the climate projections based on a relatively low greenhouse gas emissions scenario result in the local loss of at least 10% of the vertebrate fauna over much of North America. The largest changes in fauna are not predicted for Florida.

Upland plant communities along tidal rivers and estuaries will be replaced by low-lying, flood-prone lands. Increased saline flooding will strip adjacent upland soils of their organic content (Williams et al 1999; Raabe et al. 2007).

Increased air temperatures affecting wetland hydrology will alter salinity gradients. Subsequently there will be altered species distributions associated with salinity and the timing, depth, and duration of inundation. Species interactions will be altered and metabolic activity decreased with drought. Many species will experience increased risk of disease and parasitism. Changes in drought and salinity will open niches for invasive species (USEPA CRE 2008; Holman 2008; FOCC 2009, Peterson et al. 2007; Lee County Visitor and Convention Bureau 2008).

Changes in soil moisture could shift forest dynamics and composition. For instance, natural pine forests can tolerate lower soil moisture than oak-pine forests (Twilley et al. 2001).

Shifts in behavior phenology of perching birds, seabirds, and farmland birds have been observed and are expected to continue. Perching birds will breed earlier in the calendar year. Seabird populations are expected to decline due to reduction in needed prey items at the right locations at the right time of the year. Farmland birds are expected to decline due to reduced food items being available at breeding time. This disjuncture between the breeding season and vital food or other resources availability is termed “mismatching” (Eaton et al. 2008; USEPA CRE 2008).

Open grassland and forest areas in south Florida could become more vulnerable to damaging invasion by exotic species such as Chinese tallow, *Melaleuca* and *Casuarina* trees (Twilley et al. 2001).

Climate change will affect the phenology of pest and beneficial insects by altering reproductive cycles, feeding and predation, and mismatching with host plants and pollinators (Backlund et al. 2008). For example, moth phenology will be shifted to earlier dates. This will affect birds and other animals that depend upon the moths for food, the host plant vegetation that moth larvae feed on, and the plants that depend upon the moths for pollination (Eaton et al. 2008; USEPA CRE 2008). There will be both positive and negative outcomes depending upon the phenological sequence and nature of the participants. In any case significant change could be expected.

Air temperature increases will affect soil temperatures in uplands and other areas where reptiles nest. The increased soil temperatures may affect nesting lizards, changing hatchling gender determination, fitness, and hatch date, which may expose hatchlings to different prey availability and predation potentials (Telemeco 2009). Climate changes will affect amphibian populations' ranges, health, and phenology (Backlund et al. 2008; FOCC 2009; USEPA CRE 2008). .Increased air temperatures will also affect animal health, resulting in reduced feeding; reduced reproduction; reduced milk production (in mammals) for offspring; and increased pathogens and parasites (Backlund et al. 2008).

Increased air temperatures and reductions in freeze events will result in mangrove habitat moving northward, replacing salt marsh in some areas (Doyle et al. 2003, Root et al. 2003, Twilley et al. 2001, Twilley et al. 2001). Reduced frost frequency would allow expansion of black mangrove forests inland overtaking marshes (Twilley et al. 2001).

In freshwater streams, warmer water temperatures and a longer growing season could reduce habitat for cooler-water species, particularly fish, insects, snails, and shellfish. In very shallow water systems, higher temperatures could lead to oxygen depletion and cause potentially massive die-offs of fish and invertebrates (Twilley et al. 2001).

The timing of seasonal temperature changes is expected to disrupt predator/prey availability; food and reproductive cycles; patterns of upstream faunal migration; disruption of temperature-driven behavior including breeding and hibernation; and disruption of biological ocean-estuary exchanges of fishes and invertebrates (Peterson et al. 2007). Events occurring in spring or summer may occur later or have a longer "window". Events occurring in fall or winter may occur later or have a smaller "window". Events dependent on seasonal rainfall may occur differently with changes in rainfall patterns. Some animal and plant populations may migrate northward or inland to conditions supporting their required limiting life/reproductive cycles. There may be local extirpation of some plant and animal populations with replacement by exotic species tolerant of/or advantaged by the new climate conditions.

With flooding there will be changes to available habitat for burrowing species (USNOAA 2008; USEPA CRE 2008).

Drought caused by increased atmospheric temperatures will result in water stress on plant, animal and human communities. There will be increased mortality due to water stress and decreased resources (USNOAA 2008; USEPA CRE 2008).

Listed Animal Species

As of April 21, 2009 the southwest Florida study area provides habitat for 32 State Listed Species, with 11 of these Federally Listed.

Listed Animal Species of the City of Punta Gorda Area in the Order of Endangerment, as of June 24, 2009

State Endangered Species

West Indian manatee (*Trichechus manatus latirostris*), peregrine falcon (*Falco peregrinus*), wood stork (*Mycteria americana*), American crocodile (*Crocodylus acutus*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*), small-toothed sawfish (*Pristis pectinata*), shortnose sturgeon (*Acipenser brevirostrum*)

State Threatened Species

Southeastern American kestrel (*Falco sparverius paulus*), Florida sandhill crane (*Grus canadensis pratensis*), least tern (*Sterna antillarum*), Florida scrub jay (*Aphelocoma coerulescens*), eastern indigo snake (*Drymarchon corais couperi*), Atlantic loggerhead turtle (*Caretta caretta*), gopher tortoise (*Gopherus polyphemus*)

State Species of Special Concern

Sherman's fox squirrel (*Sciurus niger shermani*), roseate spoonbill (*Platalea ajaja*), little blue heron (*Egretta caerulea*), reddish egret (*Egretta rufescens*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), white ibis (*Eudocimus albus*), brown pelican (*Pelecanus occidentalis*), American oystercatcher (*Haematopus palliatus*), black skimmer (*Rhynchops niger*), burrowing owl (*Athene cunicularia floridana*), American alligator (*Alligator mississippiensis*), Atlantic (Gulf) sturgeon (*Acipenser oxyrinchus desotoi*), mangrove rivulus (*Rivulus marmoratus*)

All of the listed species inhabiting the City of Punta Gorda can be expected to be impacted by potential climate change effects including habitat losses and translocations of habitat. Eleven listed animal species occur in the waters of the marine and estuarine ecosystems of southwest Florida including West Indian manatee (*Trichechus manatus latirostris*), American crocodile (*Crocodylus acutus*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*), Atlantic loggerhead turtle (*Caretta caretta*), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic (Gulf) sturgeon (*Acipenser oxyrinchus desotoi*) and small-toothed sawfish (*Pristis pectinata*). The small-toothed sawfish will encounter several problems from climate change in its critical habitats in the estuary:

- Changes in freshwater releases from the peace river watershed
- Increased storm frequency
- Increased storm severity
- Increased water temperature
- Increased harmful algae blooms
- Increased nutrient run-off from watershed from increased precipitation
- Decreased dissolved oxygen
- Decreased in-river submerged aquatic vegetation
- Decreased forage fish

Photograph 6: Small-toothed sawfish (Pristis pectinata) in the Caloosahatchee River.

Source: FWC 2008

Photograph 7: American crocodile in the Peace River.
Source: FWC

Twenty-six listed animal species utilize the mangrove habitats of Punta Gorda including West Indian manatee (*Trichechus manatus latirostris*), peregrine falcon (*Falco peregrinus*), wood stork (*Mycteria americana*), American crocodile (*Crocodylus acutus*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*), small-toothed sawfish (*Pristis pectinata*), shortnose sturgeon (*Acipenser brevirostrum*), southeastern American kestrel (*Falco sparverius paulus*), least tern (*Sterna antillarum*), eastern indigo snake (*Drymarchon corais couperi*), Atlantic loggerhead turtle (*Caretta caretta*), roseate spoonbill (*Platalea ajaja*), little blue heron (*Egretta caerulea*), reddish egret (*Egretta rufescens*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), white ibis (*Eudocimus albus*), brown pelican (*Pelecanus occidentalis*), American oystercatcher (*Haematopus palliatus*), black skimmer (*Rhynchops niger*), American alligator (*Alligator mississippiensis*), Atlantic (Gulf) sturgeon (*Acipenser oxyrinchus desotoi*), and mangrove rivulus (Rivulus marmoratus).

The eastern brown pelican, a state species of special concern, nests predominantly on overwash mangrove islands and forages over open water, mudflats, and seagrass beds in the shallow waters of estuaries, creeks, and nearshore areas. Brown pelican rookeries are located on isolated red mangrove islands with a substantial water depth barrier that protects the nests from mainland predators. Diet consists of fish of all sizes. Foraging consists of plummeting dives, short plunges, and swimming scoops of fish. Historically, brown pelican populations were reduced as a result of pesticides. Today, the greatest threats to brown pelicans are still human-caused. Brown pelicans and their nesting/roosting/loafing sites are vulnerable to disturbance from construction activities and monofilament line entanglement. Brown pelicans are especially susceptible to death and injury caused by sport fishing equipment. It has been estimated that over 500 individuals die each year as a result of entanglement with fishing tackle (Schreiber 1978).

The brown pelican provides an example of the interaction of stressors to negatively impact successful nesting at mangrove overwash island rookeries. Nesting on overwash mangrove island rookeries will be threatened by increased sea levels, increased storm frequency, and increased storm severity. The forage fish that the young nestlings depend upon will be negatively affected by increased nutrient run-off from increased precipitation in the watershed that will stimulate and maintain increased harmful algae blooms. Increases in water temperature will move forage fish schools into the Gulf of Mexico away from rookeries and tidal passes. In addition, global warming will assist in the expansion of the summer range of the magnificent frigate bird (*Fregata magnificens*) in the Charlotte Harbor area. The frigate bird is a food stealer and predator on young chicks. With increased presence there can be an expected increase in food stealing from parents attempting to feed young, resulting in malnutrition or starvation for chicks, and increased direct predation on chicks.

Photograph 8: Brown pelican (Pelecanus occidentalis) and magnificent frigate bird (Fregata magnificens).

Source: USFWS 2008

Tricolored herons (*Egretta tricolor*), little blue herons (*Egretta caerulea*), white ibis (*Eudocimus albus*), and snowy egrets (*Egretta thula*) forage and nest in mangroves. Little blue herons and white ibis are the most common of the listed wading bird species observed in mangroves in southwest Florida (Beever 2005). Diet consists of small fish, crustaceans, insects, frogs, and lizards (Ogden 1978a). Nesting in mangroves typically occurs on overwash islands. They appear to prefer to forage in freshwater habitats even when nesting in saltwater wetlands. The little blue heron forages throughout the wet and dry season in mangroves. Adjacent tidal wetlands are used throughout the year with greater emphasis during low tides on seagrass beds. The snowy egret forages throughout the wet and dry season in mangrove wetlands of the proper depth to allow for their foraging methods. Snowy egrets are the third most abundant listed wading bird observed. Preferred foraging areas are the seagrass beds and mudflats adjacent to the mangroves. Their diet consists of crustaceans, insects, and small fish (Ogden 1978c).

Reddish egrets (*Egretta rufescens*) and roseate spoonbills (*Platalea ajaja*) are obligate mangrove breeders. Reddish egrets forage on the sandbars and mudflats adjacent to mangroves, in an active fashion with spread wings and rapid steps over unvegetated bottoms. Reddish egrets are the least abundant of the listed wading birds associated with mangroves. Reddish egrets utilize a limited set of saltwater habitats that allow for use of their unique foraging method. Diet consists of crustaceans and small fish. Kale and Maehr (1991) indicate that red mangrove rookeries are used during the December through June breeding period. Roseate spoonbills use dry-down pools in the high marsh, and during low tides, adjacent to mangroves. Preferred foraging areas included sheltered coves. They often forage in groups and with other wading birds including wood storks, great egret (*Casmerodius albus*), white ibis, and snowy egret. Roseate spoonbills nest exclusively in mangrove forests, typically on overwash islands, and forage wherever concentrations of small fish and crustaceans allow the birds to utilize their unique bills for feeding (Ogden 1978b).

A wide variety of shorebird species forage on the mudflats of mangrove estuaries. Among the state listed species are the threatened least tern (*Sterna antillarum*); the black skimmer (*Rhynchops niger*), a species of special concern; and the American oystercatcher (*Haematopus palliatus*), also a species of special concern. Least terns and roseate terns require open beach or bare substrates for nesting near areas where schools of forage fish concentrate. American oystercatchers utilize oyster bars and mudflat areas in mangroves and nest on bare unvegetated shores. Foraging occurs throughout the year with seasonal movements tracking warmer conditions.

Mangrove rivulus (*Rivulus marmoratus*) is a small fish living only in and around mangrove areas as far north as Indian River County south through the Keys and north to Tampa Bay on the west coast of Florida (Taylor and Snelson 1992). It is the only species of *Rivulus* in North America and has adapted to conditions of varying water levels and low oxygen levels of the mangrove community. It is an important link in the food chain, as it has been found to constitute part of the diet of many organisms including the wood stork .It is listed as a species of special concern by the state because of its limited distribution and vulnerability to loss of its habitat.

Saltwater marshes support 23 listed animal species in the City of Punta Gorda. Freshwater marsh support 19 listed animal species. Marsh species that have preferred hydrologic needs for prey item selection include the wood stork and a variety of wading birds with water depth niche partitioning including roseate spoonbill, little blue heron, reddish egret, snowy egret, and tricolored heron.

There are also problems for listed species and other wildlife with inland retreat from the coast by humans. Most southwest Florida xeric oak scrub is coastal or along rivers and streams. Inland retreat will eliminate the rarest of the upland habitats with endemic animals such as the Florida scrub jay and endemic listed plants. The interior pinelands and other uplands are the last refuge in southwest Florida of the Florida panther, Florida black bear, Sherman's fox squirrel and red-cockaded woodpecker.

Coastal Erosion and Sea Level Rise

Global sea level rise is one of the most likely effects of global warming. Along much of the Florida coast, the sea level already has risen seven to nine inches per century. Because of local factors such as island subsidence and groundwater depletion, sea level rise will vary by location. For southwest Florida, the sea level is likely to rise 10 to 36 inches by 2100. As sea level rises, coastal areas in Florida, particularly wetlands and lowlands along the Gulf coast, will be inundated. Adverse impacts in these areas could include loss of land and structures, loss of wildlife habitat, accelerated coastal erosion, exacerbated flooding and increased vulnerability to storm damage, and increased salinity of rivers, bays, and aquifers, which would threaten supplies of freshwater.

Sea level rise will change coastlines in many ways (USEPA CRE 2008; Volk 2008; Bollman 2007; Titus 1998), including erosion with landward migration of coastlines, and barrier island disintegration. Where retreat is possible for natural systems, there will be a migration of mangrove and marsh species, altered plant community structural diversity with potential changes in dominant or foundation species, and structural and functional habitat changes. The ability of barrier islands to shield coastal areas from higher storm surges and the destructive effects of hurricanes will be reduced through time (Fiedler et al. 2001; Titus 1998; USEPA CRE 2008). Coastal transportation infrastructure will be impacted by increased overwash and breaching of coastal roads (Sallenger et al. 2005 and 2006). Low barrier islands will vanish, exposing marshes and estuaries of Charlotte Harbor to open-coast; high fetch conditions (Sallenger et al. 2009).

NOAA defines beach erosion as "the carrying away of beach materials by wave action, tidal currents, or wind." Coastal erosion is a natural process even in pristine environments; however, in areas where human activity negatively impacts the shoreline, coastal erosion can become a serious problem. It is estimated that coastal erosion in the U.S. costs $700 million annually (National Sea Grant Office).

Beach sand originates mainly from rivers and streams which carry it directly to the ocean. Sand also comes from the gradual weathering of exposed rock formations and cliffs along the shore, and from the deterioration of shell, coral, and other skeletal fragments of marine life.

Wave action, wind, and currents move sand up and down the coast. This movement is called long-shore transport. Sand is also moved onshore and offshore by waves, tides, and currents. During storms, high-energy waves often erode sand from the beach and deposit it offshore as submerged sandbars. This sand is then moved back onshore by low-energy waves in periods of calm weather. Sand that is moved offshore by winter storms, leaving steep narrow beaches, is returned to the shore by gentle waves of summer, creating wide, gently sloping beaches (National Sea Grant Office).

Erosion and accretion of sediment on coasts are natural processes influenced by beach slope, sediment size and shape, wave energy, tides, storm surge, and nearshore circulation, among other things. Human activities such as dredging, river modification, removal of backshore vegetation, and installation of protective structures such as breakwaters can profoundly alter shorelines, mainly by affecting the sediment supply (National Sea Grant Office).

According to the Evaluation of Erosion Hazards Study prepared for FEMA by the H. John Heinz III Center for Science, Economics, and the Environment, the average annual erosion rate on the Atlantic coast is roughly two to three feet per year and up to six feet per year for states bordering the Gulf of Mexico. Charlotte County currently has several miles of its beaches classified as critical erosion areas.

Over 409 miles, or approximately 50% of Florida's beaches are already experiencing erosion. At present, about 299 of the state's 825 miles of sandy beaches are experiencing "critical erosion", a level of erosion which threatens substantial development, recreational, cultural, or environmental interests. While some of this erosion is due to natural forces and imprudent coastal development, a significant amount of coastal erosion in Florida is directly attributable to the construction and maintenance of navigation inlets and shoreline hardening. Florida has over 60 inlets around the state, many have been artificially deepened to accommodate commercial and recreational vessels and they employ jetties to prevent sand from filling in the channels. A by-product of this practice is that the jetties and the inlet channels have interrupted the natural flow of sand along the beach causing an accumulation of sand in the inlet channel and at the jetty on one side of the inlet, and a loss of sand to the beaches on the other side of the inlet (Department of Environmental Protection Bureau of Beaches and Coastal Systems Beach Erosion Control).

Currently, none of the structures that fall within the boundaries of the City of Punta Gorda fall within the Coastal Erosion Hazard Area and no structures in Punta Gorda's boundaries are considered at risk for losses to coastal erosion. As sea level rises this will change.

The primary vehicle for implementing beach management planning recommendations to address coastal erosion is the Florida Beach Erosion Control Program, which is a program established for the purpose of working in concert with local, state, and federal governmental entities to achieve the protection, preservation and restoration of the coastal sandy beach resources of the state. Under the program, financial assistance in an amount up to 50 percent of project costs is available to Florida's county and municipal governments, community development districts, or special taxing districts for shore protection and preservation activities located on the Gulf of Mexico, Atlantic Ocean, or Straits of Florida. This is not a useful mechanism for addressing the coastal erosion that will impact the City of Punta Gorda.

Coastal shorelines, beaches, mangroves, low marsh, river and creek shorelines will experience higher tides including higher high tides, higher normal tides, and higher low tides as a result of sea level rise resulting from increased temperature and expansion of water volume (Titus 1998; USEPA CRE 2008; Folland & Karl 2001; IPCC 2007c).

Development of Sea Level Rise Maps

Current trends and policies regarding land use, conservation and shoreline protection provided a starting point for developing maps of the city's likely land use response to sea level rise. Nevertheless, because those policies do not precisely correspond to existing land use categories, and because those categories can change over time, some analysis and judgment is necessary to develop the maps. This section explains and documents the procedures used to create the maps. A detailed discussion of the process used to determine the likely extents of coastal protection/hardening can be found in Appendix VI.

This sea level rise portion of the study began by examining three sea level rise "severity" scenarios: best case, worst case, and moderate case are based upon the results of Table 2, below. This table is based on using Tables 9-1 and 9-2 of the USEPA Report "The Probability of Sea Level Rise." Basically, the formula is to multiply the historic sea level rise (2.3 mm/yr) in Southwest Florida (closest point used is St. Petersburg, Fl., Table 9-2) by the number of future years from 1990, plus the Normalized Sea Level Projections in Table 9-1. For the study the 90% probability is considered the best case, the 50% probability the moderate case, and the 5% probability the worst case scenario.

Probability (%)	2025		2050		2075		2100		2150		2200	
	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches
90 (best)	7	2.8	13	5.0	20	7.7	26	10.4	40	15.7	53	21.0
80	9	3.6	17	6.6	26	10.1	35	13.9	53	20.8	71	28.1
70	11	4.4	20	7.8	30	11.6	41	16.3	63	24.7	85	33.6
60	12	4.7	22	8.6	34	13.2	45	17.8	72	28.3	99	39.1
50 (moderate)	13	5.1	24	9.4	37	14.4	50	19.8	80	31.4	112	44.2
40	14	5.5	27	10.6	41	16.0	55	21.8	90	35.4	126	49.7
30	16	6.3	29	11.3	44	17.1	61	24.1	102	40.1	146	57.6
20	17	6.7	32	12.5	49	19.1	69	27.3	117	46.0	173	68.2
10	20	7.9	37	14.5	57	22.3	80	31.6	143	56.2	222	87.5
5 (worst)	22	8.7	41	16.1	63	24.6	91	35.9	171	67.2	279	110.0
2.5	25	9.9	45	17.6	70	27.4	103	40.7	204	80.2	344	135.6
1	27	10.6	49	19.2	77	30.1	117	46.2	247	97.2	450	177.3
Mean	13	5.1	25	9.8	38	14.8	52	20.6	88	34.6	129	50.9

***The results of this table are based on using Tables 9-1 and 9-2 of the USEPA Report "The Probability of Sea Level Rise".**

Table 2: Sea Level Projection by Year for Southwest Florida

While the IPCC (2007d) has been a standard for current planning purposes, several researchers and scientists that express non-empirical opinions (Rahmstorf 2007) based on other methods of modeling consider the IPCC projections to be conservative and expect climate change to be more severe. This is because the A2 scenario as presented in IPCC's Fourth Assessment Report (2007) excludes some of the feedback mechanisms that could accelerate the melting of the Greenland and Antarctic ice sheets.

During our literature review, we found that Stanton and Ackerman (2007) foresee a different set of climate future extremes that include either a response to climate change by humans to reduce green house gases, or inaction, a likely scenario at the time of their report's publication. Florida's future climate depends on overall emissions of greenhouse gases today and in the decades to come, and - because carbon dioxide persists in the atmosphere for a century or more - on the impacts of accumulated past emissions. Stanton and Ackerman compared two scenarios: an optimistic *rapid stabilization case* and a pessimistic *business-as-usual case*. These scenarios represent plausible extremes of what is expected to happen if the world succeeds in a robust program of climate mitigation, versus what is expected to happen if very little is done to address climate change. The difference between the two is the avoidable damage to Florida. It can be seen as the benefits of mitigation, or, from an opposite perspective, the costs of inaction.

The Rapid Stabilization Case (of green house gas emissions) includes the lowest levels of future emissions under discussion today including a 50% reduction in current global emissions and an 80% reduction in current U.S. emissions by 2050, where precipitation remains stable and hurricane intensity remains in the current range. The "Business-as-Usual Case," or No-Action Case, includes steadily increasing greenhouse gas (GHG) emissions throughout this century modeled on the high end of the likely range of the IPCC's A2 scenario (2007a) with climate instability impacts of less rain in Florida with increases in hurricane intensity.

The business-as-usual case assumes steadily increasing emissions, along with uncertain extreme weather, in which atmospheric concentrations of carbon dioxide exceed the critical 450 parts per million (ppm) threshold by 2030 and reach 850 ppm by 2100. In this case, referred to by the IPCC as, "likely", Florida's average annual temperatures will be 5° F higher than today in 2050 and 10°F higher in 2100. Sea level rise will reach 23 inches above mean sea level by 2050, and 45 inches by 2100.

The estimates for sea level rise under the business-as-usual case diverge in scale somewhat from the U.S. Geological Survey (USGS 2007) maps. Geographic Information System (GIS) technology makes it possible to show an approximation of Florida's coastline at 27 inches of sea level rise, which is projected to be reached by around 2060 in the business-as-usual case. This is equivalent to the 80% probable sea level rise predicted in the IPCC's Fourth Assessment Report (2007). For simplicity, Stanton and Ackerman (2007) refer to the land area that would be inundated in Florida with 27 inches of sea level rise as the year 2060 "vulnerable zone." The 2060 vulnerable zone includes nine percent of Florida's current land area, or some 4,700 square miles. Absent successful steps to build up or otherwise protect them, which will be expensive and in some areas is likely impossible, these lands will be submerged at normal high tide. Almost one tenth of Florida's current population, or 1.5 million people, already live in this vulnerable zone.

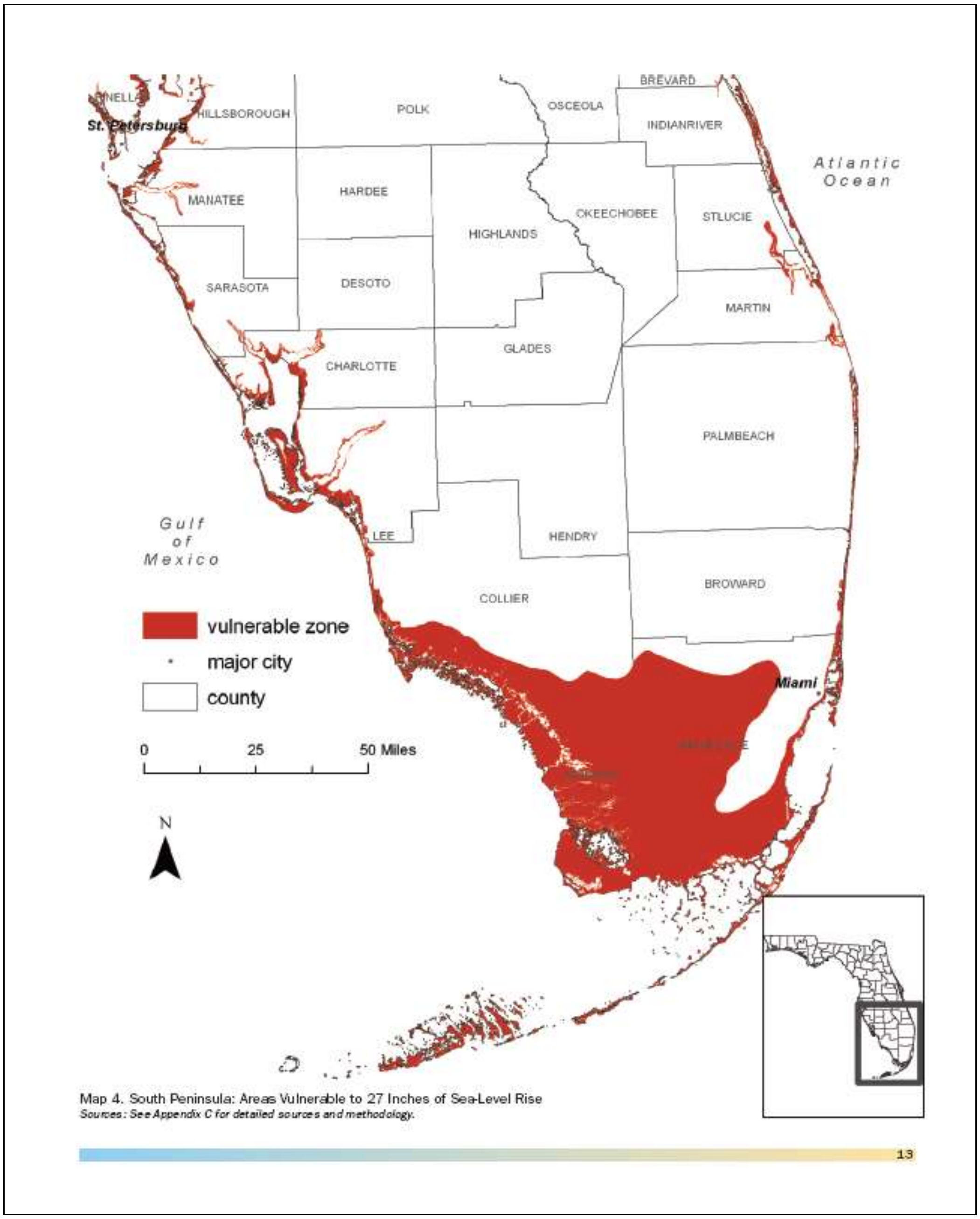


Figure 13: South Florida Peninsula: Areas Vulnerable to 27 Inches of Sea level Rise (20% probable by the year 2100 and 80% probable by the year 2020)
Source: Stanton and Ackerman 2007

Probability (%)	2025		2050		2075		2100		2150		2200	
	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches
Rapid Stabilization Case	41	1.8	9	3.5	13	5.3	18	7.1	22	8.8	27	10.5
90 (least)	7	2.8	13	5.0	20	7.7	26	10.4	40	15.7	53	21.0
80	9	3.6	17	6.6	26	10.1	35	13.9	53	20.8	71	28.1
70	11	4.4	20	7.8	30	11.6	41	16.3	63	24.7	85	33.6
60	12	4.7	22	8.6	34	13.2	45	17.8	72	28.3	99	39.1
50 (moderate)	13	5.1	24	9.4	37	14.4	50	19.8	80	31.4	112	44.2
40	14	5.5	27	10.6	41	16.0	55	21.8	90	35.4	126	49.7
30	16	6.3	29	11.3	44	17.1	61	24.1	102	40.1	146	57.6
20	17	6.7	32	12.5	49	19.1	69	27.3	117	46.0	173	68.2
10	20	7.9	37	14.5	57	22.3	80	31.6	143	56.2	222	87.5
5 (worst)	22	8.7	41	16.1	63	24.6	91	35.9	171	67.2	279	110.0
2.5	25	9.9	45	17.6	70	27.4	103	40.7	204	80.2	344	135.6
1	27	10.6	49	19.2	77	30.1	117	46.2	247	97.2	450	177.3
Business as Usual	29	11.3	57	22.6	86	34	115	45.3	247	97	450	177

*The results of this table are based on using Tables 9-1 and 9-2 of the USEPA Report "The Probability of Sea Level Rise". Basically, the formula is to multiply the historic sea level rise (2.3 mm/yr) in Southwest Florida (closest point used is St. Petersburg, Fl., Table 9-2) by the future number of years from 1990 plus the Normalized Sea Level Projections in Table 9-1 and Table ES-2. Two Future Climate Scenarios for Florida Stanton and Ackerman 2007

Table 3: Combined Sea Level Projections by Year for Southwest Florida

Sources: IPCC 2007, Stanton and Ackerman 2007

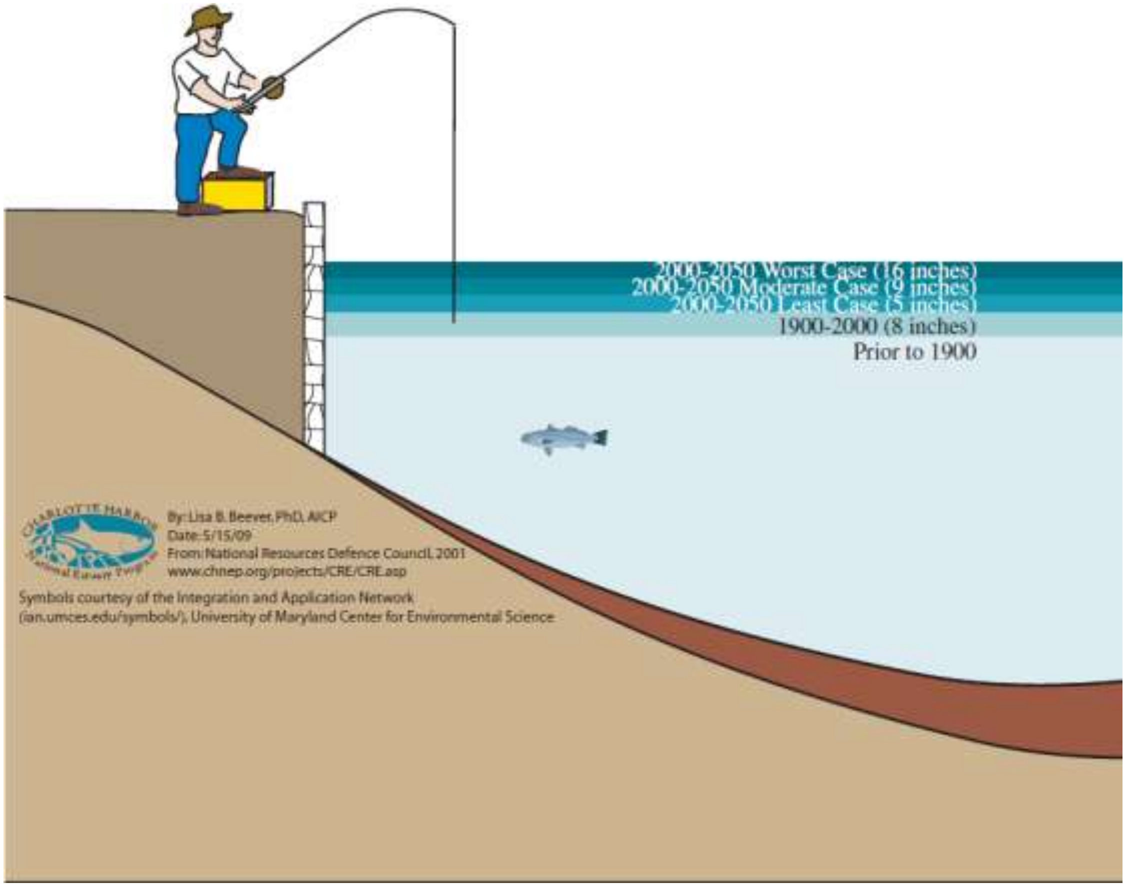


Figure 14: Sea level rise in three different probabilities least case (90% probable), moderate case (50% probable) and worst case (5% probable) in the year 2050 for Charlotte Harbor at Punta Gorda.
Source: IPCC 2007

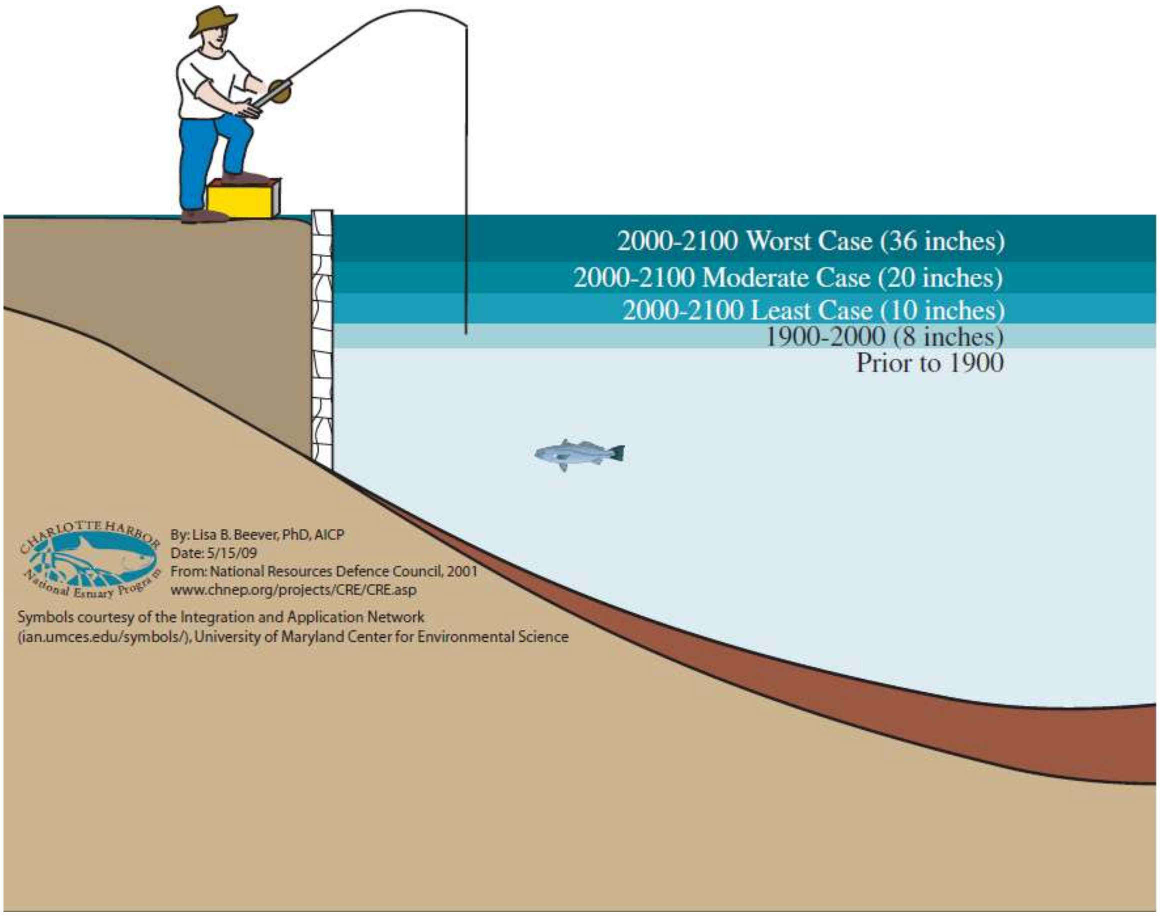


Figure 15: Sea level rise in three different probabilities least case (90% probable), moderate case (50% probable) and worst case (5% probable) in the year 2100 for Charlotte Harbor at Punta Gorda.
Source: IPCC 2007

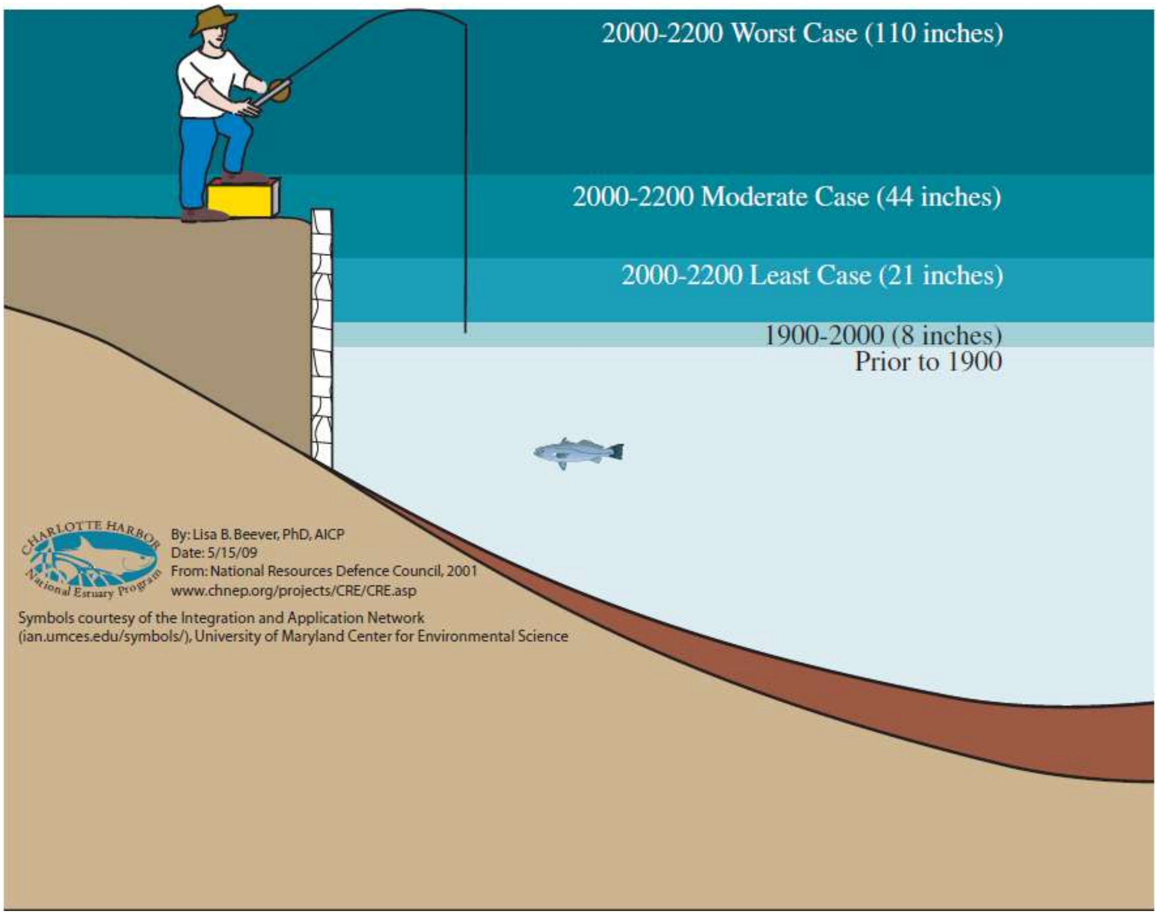


Figure 16: Sea level rise in three different probabilities least case (90% probable), moderate case (50% probable) and worst case (5% probable) in the year 2200 for Charlotte Harbor at Punta Gorda.
Source: IPCC 2007

Utilizing the most recent available land cover data from the FWC (2003) and currently available LIDAR elevation, it is possible to project the amount of habitat that would be subject to future inundation from various levels of sea level rise. The following tables and graphs display the results for Lee and Collier Counties, which are the two counties with complete LIDAR data at this time. There are currently gaps in the LIDAR data for Charlotte and Sarasota Counties.

The elevations analyzed (0.5, 1.0, 1.5, 2.0, 3.0, 4.0 and 9.0 feet NGVD) correspond to the following climate change scenarios:

Elevation in NGVD	**Rapid Stabilization Case**	**90% (least)**	**50% (moderate)**	**5% (worst)**	**Business as Usual**
Half Foot	2084	2059	2030	2014	2011
One Foot	2222	2107	2063	2036	2027
Two Feet	2398	2214	2109	2075	2053
Three Feet	2575	2270	2158	2100	2079
Four Feet	2751	2327	2208	2109	2101
Nine Feet	3633	2610	2338	2174	2153

Table 4: Predicted year of different elevation levels (NGVD) of sea level rise for different future scenarios

Source: IPCC 2007 and Stanton and Ackerman 2007with analysis by SWFRPC 2009.

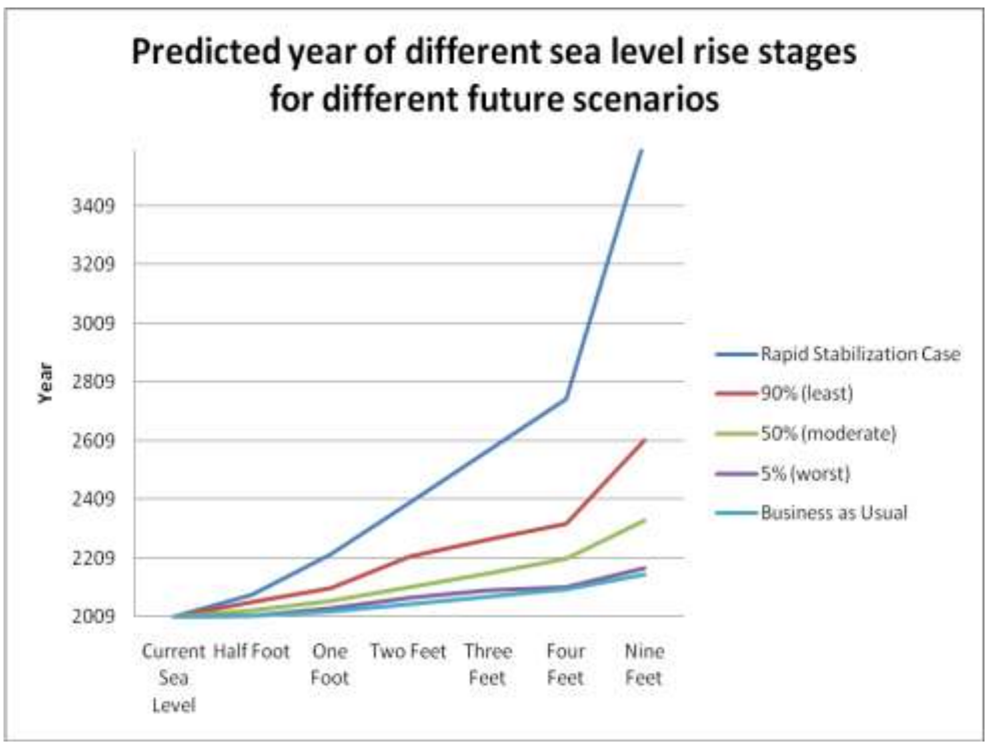


Figure 17: Approximate predicted year of different elevation levels (NGVD) of sea level rise for different future scenarios

Source: IPCC 2007 and Stanton and Ackerman 2007with analysis by SWFRPC 2009.

Elevation in feet	0	0.5	1.0	1.5	2.0	3.0	4.0	5.0
Bare Soil/Clear-cut	0.0	2.2	29.6	32.0	32.0	32.2	32.2	32.2
Cypress Swamp	0.0	2.9	89.8	91.1	91.3	91.3	91.3	91.3
Dry Prairie	0.0	23.3	145.5	213.3	220.8	224.7	227.1	227.5
Freshwater Marsh and Wet Prairie	0.0	5.6	73.5	78.1	79.7	85.9	87.3	87.5
Grassland	0.0	4.7	4.9	4.9	4.9	4.9	4.9	4.9
Hardwood Hammocks and Forest	0.0	0.5	89.8	134.4	140.1	142.0	142.2	142.2
Hardwood Swamp	0.0	0.9	111.1	114.4	114.4	115.5	115.5	115.5
High Impact Urban	0.0	55.2	3,117.7	3,136.5	3,964.4	3,967.4	3,967.9	3,999.2
Improved Pasture	0.0	0.0	0.1	45.7	45.7	45.7	45.7	45.7
Low Impact Urban	0.0	135.8	349.7	473.6	513.8	574.2	615.9	753.0
Mangrove Swamp	0.0	2,618.3	2,736.2	2,736.6	2,736.6	2,736.6	2,736.6	2,736.6
Mixed Pine-Hardwood Forest	0.0	1.6	50.5	76.8	82.1	83.4	83.9	83.9
Mixed Wetland Forest	0.0	2.4	67.5	72.1	72.4	72.5	72.5	72.5
Open Water	0.0	10,351.4	10,736.9	10,745.7	10,751.7	10,773.5	10,775.7	10,776.2
Other Agriculture	0.0	0.0	0.0	1.8	4.7	4.7	4.7	4.7
Pinelands	0.0	9.7	271.5	312.5	318.2	318.7	319.0	319.0
Salt Marsh	0.0	220.9	683.7	684.3	684.3	684.3	684.3	684.3
Shrub Swamp	0.0	3.1	57.6	60.9	62.2	62.9	63.1	63.1
Shrub and Brushland	0.0	30.1	36.2	51.5	53.5	55.5	56.7	59.3
Tidal Flat	0.0	16.1	16.1	16.1	16.1	16.1	16.1	16.1
Total	0.0	13,484.6	18,667.9	19,082.5	19,989.0	20,092.3	20,142.6	20,314.8
Increase between stage	0.0	13,484.6	5,183.3	414.6	906.5	103.3	50.3	172.3

Table 5: Acres of habitat or land use at and below different elevations in the City of Punta Gorda 2009. Note number includes the prior acreage.

Source: SWFRPC 2009

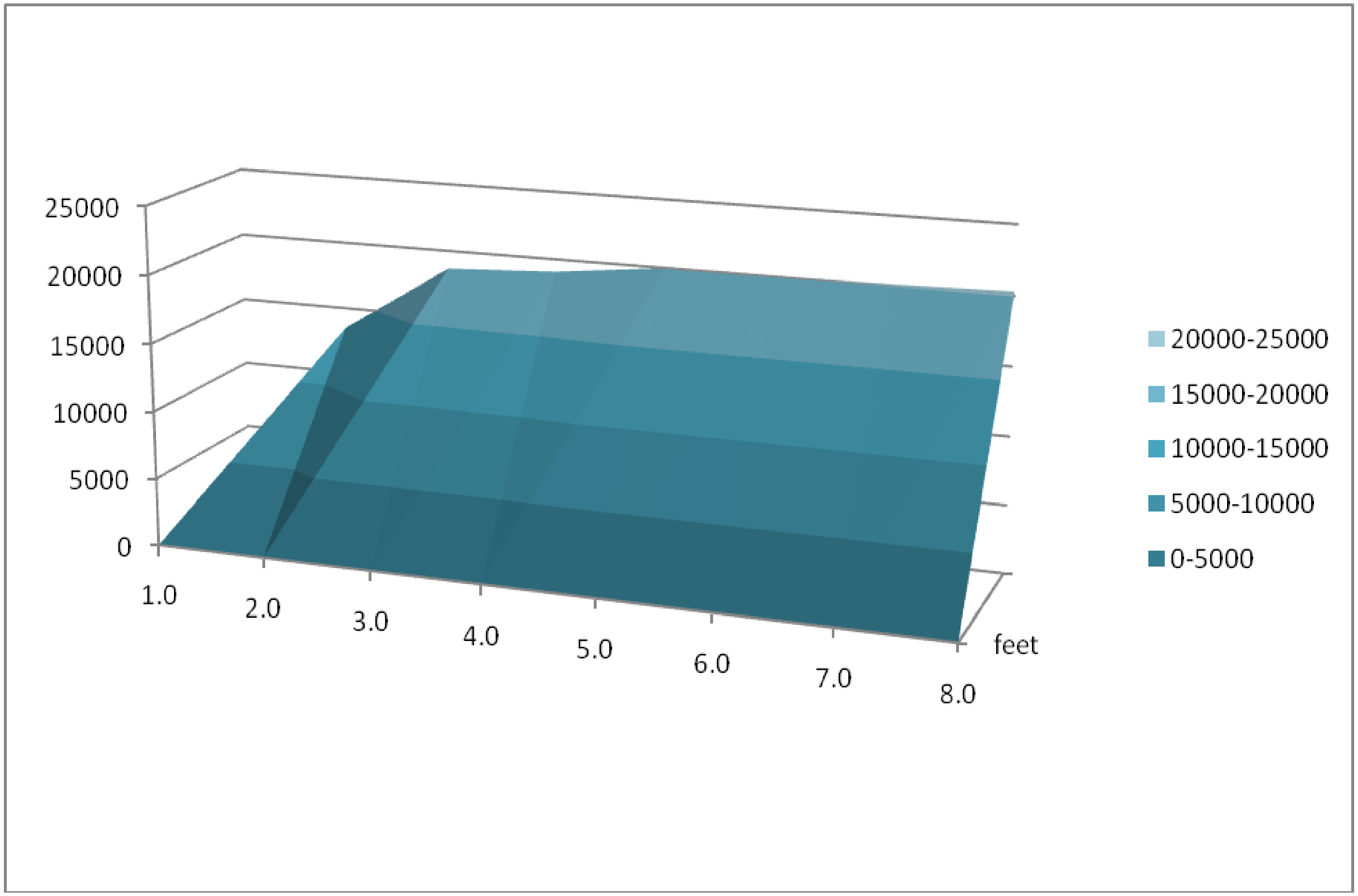
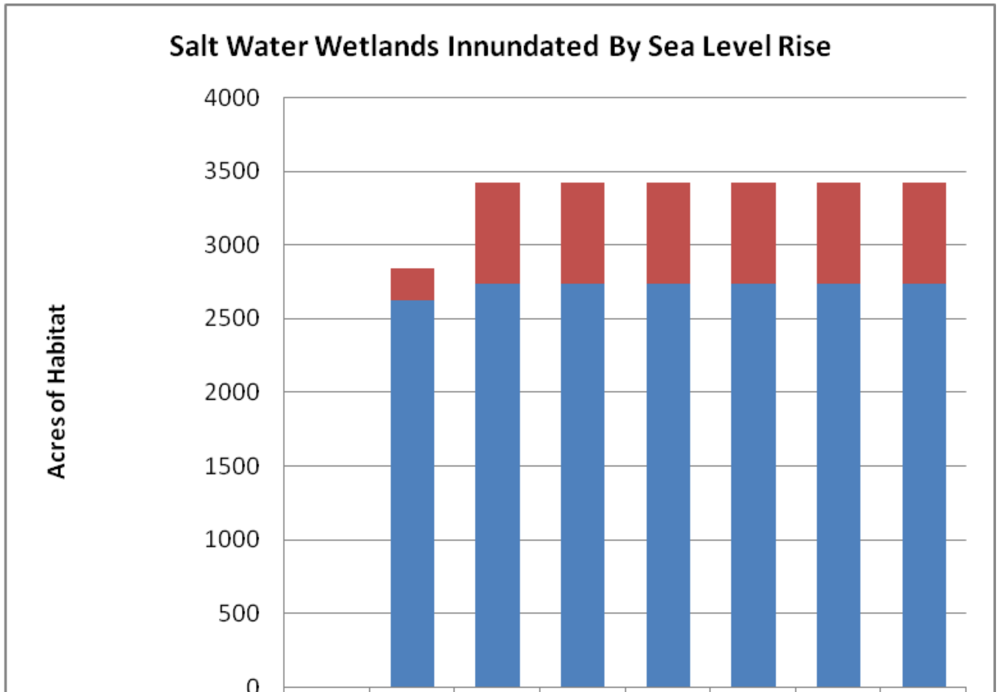


Figure 18: Acres of habitat or land at and below different elevations in the City of Punta Gorda 2009

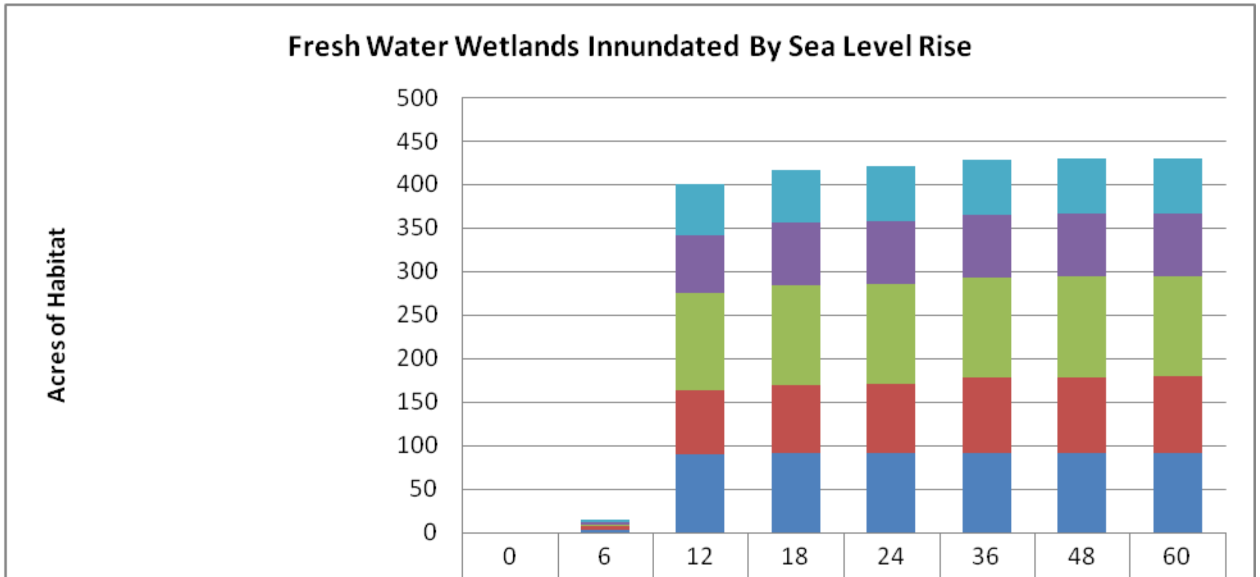
Source: SWFRPC 2009



	0	6	12	18	24	36	48	60
Salt Marsh	0	220.9	683.7	684.3	684.3	684.3	684.3	684.3
Mangrove Swamp	0	2618.3	2736.2	2736.6	2736.6	2736.6	2736.6	2736.6

Figure 12: Acres of mangrove and salt marsh habitat at and below different elevations in the City of Punta Gorda 2009

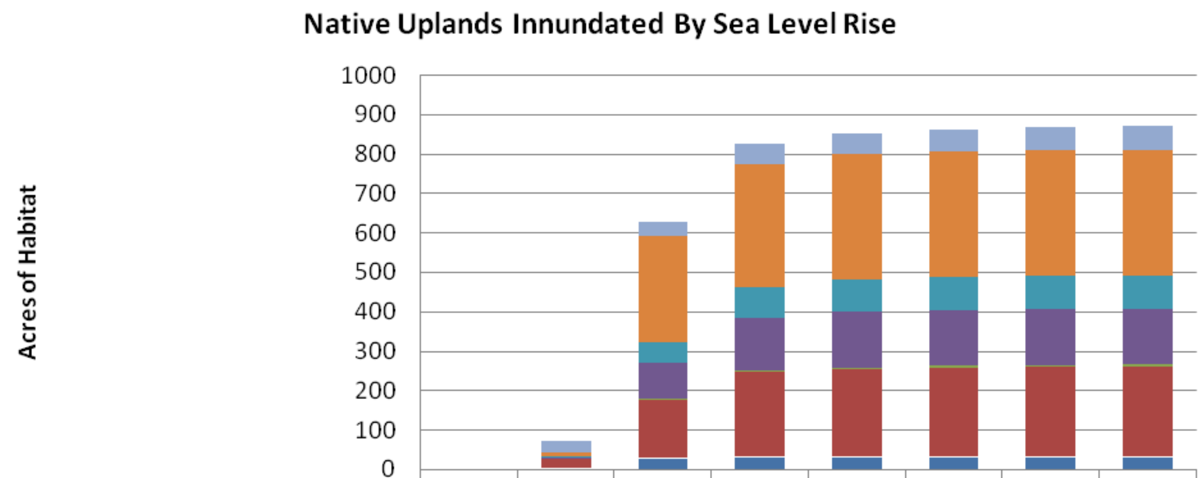
Source: SWFRPC 2009



	0	6	12	18	24	36	48	60
Shrub Swamp	0	3.1	57.6	60.9	62.2	62.9	63.1	63.1
Mixed Wetland Forest	0	2.4	67.5	72.1	72.4	72.5	72.5	72.5
Hardwood Swamp	0	0.9	111.1	114.4	114.4	115.5	115.5	115.5
Freshwater Marsh and Wet Prairie	0	5.6	73.5	78.1	79.7	85.9	87.3	87.5
Cypress Swamp	0	2.9	89.8	91.1	91.3	91.3	91.3	91.3

Figure 19: Acres of freshwater wetlands habitat in the City of Punta Gorda at and below different elevations 2009

Source: SWFRPC 2009



	0	6	12	18	24	36	48	60
Shrub and Brushland	0	30.1	36.2	51.5	53.5	55.5	56.7	59.3
Pinelands	0	9.7	271.5	312.5	318.2	318.7	319.0	319.0
Mixed Pine-Hardwood Forest	0	1.6	50.5	76.8	82.1	83.4	83.9	83.9
Hardwood Hammocks and Forest	0	0.5	89.8	134.4	140.1	142.0	142.2	142.2
Grassland	0	4.7	4.9	4.9	4.9	4.9	4.9	4.9
Dry Prairie	0	23.3	145.5	213.3	220.8	224.7	227.1	227.5
Bare Soil/Clearcut	0	2.2	29.6	32.0	32.0	32.2	32.2	32.2

Figure 20: Acres of uplands habitat in the City of Punta Gorda at and below different elevations 2009

Source: SWFRPC 2009

Habitat and Species Changes

The Sea Level Affecting Marshes Model (SLAMM) was developed with USEPA funding in the mid 1980s (Park et al. 1986), and SLAMM2 was used to simulate 20% of the coast of the contiguous United States for the USEPA Report to Congress on the potential effects of global climate change (Park et al. 1989a, Park et al. 1989b, Park 1991, Titus et al. 1991). Subsequently, more detailed studies were undertaken with SLAMM 3, including simulations of St. Mary's Estuary, FL-GA (Lee et al. 1991, Lee et al. 1992, Park et al. 1991), Puget Sound (Park et al. 1993), and south Florida (Park et al. 1993). More recently SLAMM4 was applied to all of San Francisco Bay, Humboldt Bay, and large areas of Delaware Bay and Galveston Bay (Galbraith et al. 2002, Galbraith et al. 2003).

SLAMM Version 4.1 is the latest version of the SLAMM Model, developed in 2005 and based on SLAMM 4.0. SLAMM 4.1 provides additional sea level rise scenarios based on the findings of the IPCC Third Assessment Report (IPCC 2001a) and additional data examination tools to ensure that data quality is acceptable. Model flexibility has been improved with respect to accretion rates, and the model now accepts data from the USGS seamless data distribution tool (seamless.usgs.gov). To accurately model erosion in larger sites, maximum fetch is now calculated on a cell-by-cell basis rather than being input as a site characteristic.

SLAMM simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise. A complex decision tree incorporating geometric and qualitative relationships is used to represent transfers among coastal classes. Each site is divided into cells of equal area, and each class within a cell is simulated separately. Earlier versions of SLAMM used cells that were usually 500 by 500 meters or 250 by 250 meters. Version 4.1 uses cells that are 30 m by 30 m, based on NOAA tidal data, Fish & Wildlife Service National Wetland Inventory data, and USGS Digital Elevation Model data that are readily available for downloading from the Web. Map distributions of wetlands are predicted under conditions of accelerated sea level rise, and results are summarized in tabular and graphical form.

Relative sea level change is computed for each site for each time step; it is the sum of the historic eustatic trend, the site-specific rate of change of elevation due to subsidence and isostatic adjustment, and the accelerated rise depending on the scenario chosen (Titus et al. 1991). Sea level rise is offset by sedimentation and accretion using average or site-specific values. For each time step, the fractional conversion from one class to another is computed on the basis of the relative change in elevation divided by the elevational range of the class in that cell. For that reason, marshes that extend across wide tidal ranges are only slowly converted to unvegetated tidal flats. If a cell is protected by a dike or levee it is not permitted to change. The existence of these dikes can severely affect the ability of wetlands to migrate onto adjacent shorelines. Diked wetlands are assumed to be subject to inundation when relative sea level change is greater than 2 m, although that assumption can be changed. In one study, alternate management scenarios involving maintenance of dikes were simulated (Park et al. 1993).

In addition to the effects of inundation represented by the simple geometric model described above, second-order effects occur due to changes in the spatial relationships among the coastal elements. In particular, the model computes exposure to wave action: if the fetch (the distance across which wind-driven waves can be formed) is greater than nine km, the model assumes moderate erosion. If a cell is exposed to open ocean, severe erosion of wetlands is assumed. Beach erosion is modeled using a relationship reported by Bruun (1962) whereby recession is 100 times the change in sea level. Wetlands on the lee side of coastal barriers are subject to conversion due to overwash as erosion of backshore and dune areas occurs and as other lowlands are drowned. Erosion of dry lands is ignored; in the absence of site-specific information, this could underestimate the availability of sediment to replenish wetlands where accelerated bluff erosion could be expected to occur. Coastal swamps and fresh marshes migrate onto adjacent uplands as a response of the water table to rising sea level close to the coast; this could be modified to take advantage of more site-specific predictions of water table elevations.

The model was run given the minimum, mean, and maximum estimates of each of the SRES (Special Report on Emissions Scenarios). A brief description of each of these scenarios can be found in the SLAMM 4.1 technical documentation (Glick 2006); more extensive descriptions are in the Intergovernmental Panel on Climate Change report (IPCC 2001a). For simplicity, this report will focus on the A1 scenario in which the future world includes very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. In particular, the A1B scenario assumes that energy sources will be balanced across all sources (fossil, nuclear, solar, etc.).

According to the model, significant overwash is predicted for the barrier islands around Charlotte Harbor resulting in major upland loss. Saturation and inundation will also negatively affect uplands that are predicted to decrease by 35 to 55% depending on whether the mean or maximum scenario is run. Existing tidal flats are also predicted to be all but eliminated by sea level rise. Mangroves are predicted thrive under these scenarios increasing by 75% to 119% provided the sea level rise is gradual.

Habitat	Initial Condition	Percent of Initial	Year 2100	Area Changed	Percent Loss	Percent Loss
	Acres (Hectares)		*Acres (Hectares)*	*Acres (Hectares)*	*Mean*	*Maximum*
Upland	93,378 (37,805)	23%	60,436 (24,468)	-32,942 (-13,337)	-35%	-55%
Hardwood Swamp	12,350 (5,000)	3%	7,894 (3,196)	-4,456 (-1,804)	-36%	-51%
Cypress Swamp	77 (31)	0%	79 (32)	2 (1)	3%	5%
Inland Freshwater Marsh	3,115(1,261)	1%	2,559 (1,036)	-556 (-225)	-18%	-55%
Transitional Salt Marsh	180 (73)	0%	37 (15)	-143 (-58)	-79%	-167%
Saltmarsh	3,418 (1,384)	1%	373 (151)	-3,046 (-1,233)	-89%	-98%
Mangrove	45,885 (18,577)	11%	80,361 (32,535)	34,476 (13,958)	75%	119%
Estuarine Beach	1,215 (492)	0%	353 (143)	-862 (-349)	-71%	-76%
Tidal Flat	56,402 (22,835)	14%	1,512 (612)	-54,891 (-22,223)	-97%	-99%
Marine Beach	240 (97)	0%	173 (70)	-67 (-27)	-28%	-100%
Hard bottom Intertidal	7 (3)	0%	7 (3)	0	0%	0%
Inland Open Water	1,277 (517)	0%	524 (212)	-753 (-305)	-59%	73%
Estuarine Open Water	125,775(50,921)	31%	184,017 (74,501)	58,243 (23,580)	46%	48%
Marine Open Water	56,047 (22,691)	14%	61,036 (24,711)	4,989 (2,020)	9%	11%
SUM	161,687		161,685			

Table 6: SLAMM 4.1 Predictions of Habitat Fates under Scenario A1B, Mean (Max) for Charlotte Harbor, FL

Source: Glick 2006, SWFRPC 2008

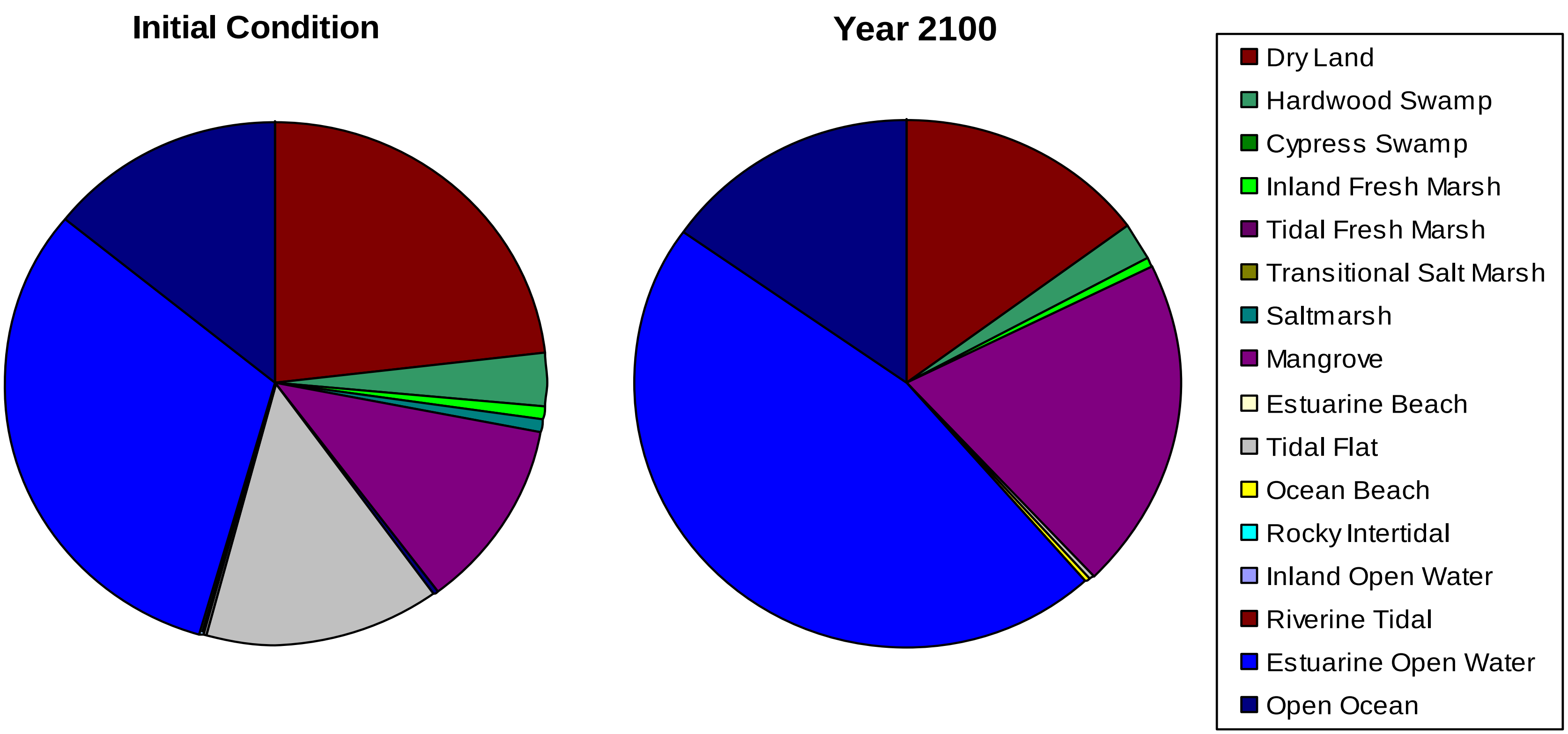


Figure 21: SLAMM Predictions of Habitat Fate under Scenario A1B, Mean for Charlotte Harbor, FL. In Pie Chart Format

Source: Glick 2006, SWFRPC 2008

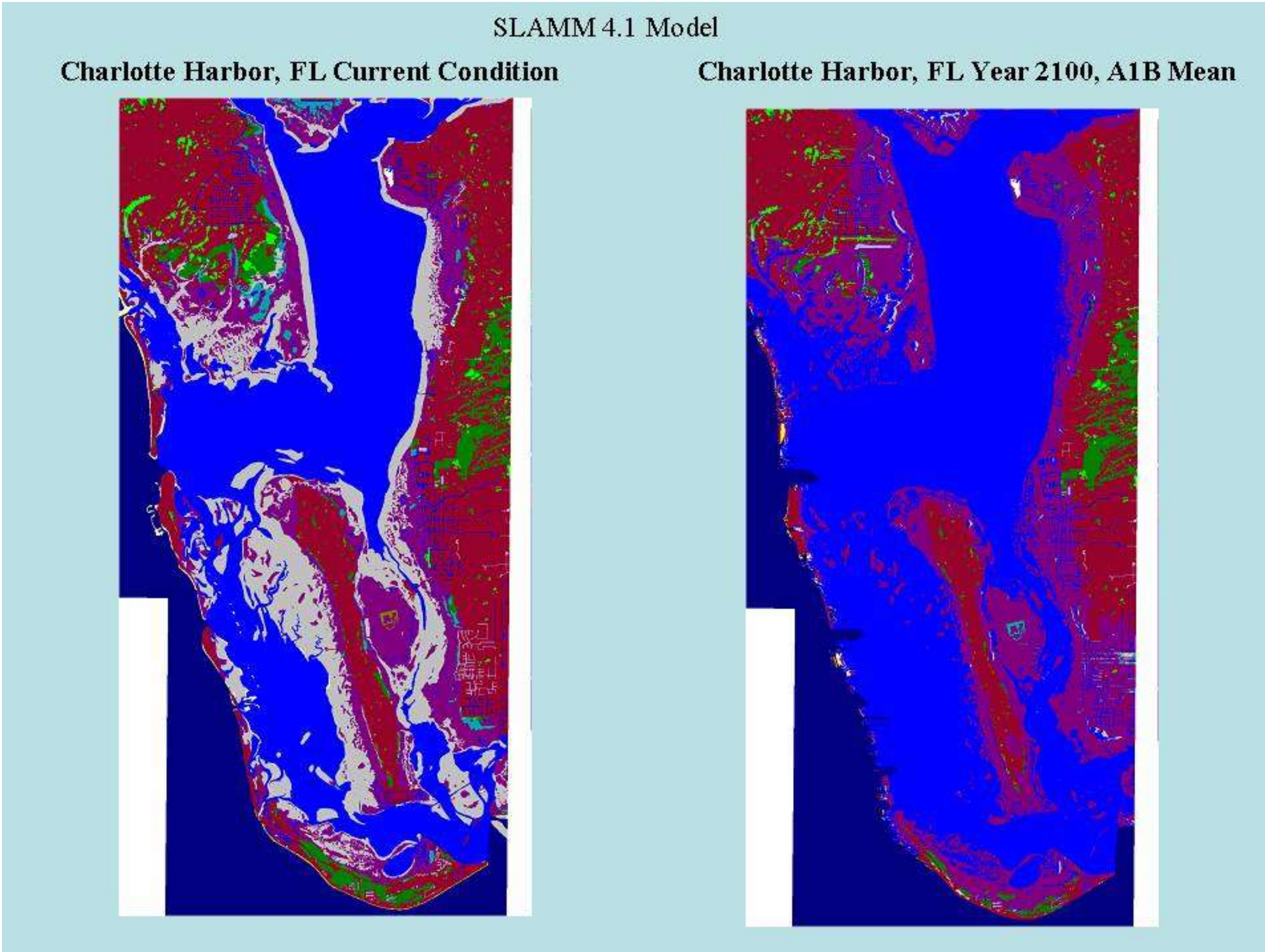


Figure 22: SLAMM Predictions of Habitat Fate under Scenario A1B, Mean for Charlotte Harbor, FL. In Arial View Format

Source: Glick 1993, SWFRPC 2008

Habitat Migration

Conceptual diagrams are a technique developed by the University of Maryland Center for Environmental Science Integration and Application Network (IAN) to communicate science. The technique uses Adobe Illustrator and symbol libraries designed to communicate to an international audience. This conceptual diagramming technique was used to illustrate application of several principals of climate change as they related to southwest Florida native ecosystems.

"Figure 23: Habitat Structure 2000 Southwest Florida" is a conceptual diagram that identifies a typical cross-section of southwest Florida native ecosystems from the estuary to the high oak scrub. Such habitats include the estuary, seagrass, mangrove, tropical hardwood hammock, tidal and freshwater creeks, pine flatwoods, and oak scrub.

Several climate change processes were applied to the typical cross-section to observe potential impacts to create "Figure 24: Habitat Structure 2200 Southwest Florida". The processes include:

- Sea level rise;
- Increasing water temperature;
- Geomorphic changes related to
    - movement of the shoreline to maintain the coastal energy gradient; and
    - sediment accretion by mangroves.

Effects of these processes include:

- Landward migration of the Gulf of Mexico,
- increasing evapotranspiration,
- changes in rainfall patterns,
- movement of tidal creeks up into the freshwater creek systems,
- water table changes as a result of sea level rise, shoreline movements, rainfall changes, and mangrove sediment accretion,
- compression of freshwater wetland and upland systems,
- compression of estuarine areas, and
- loss of suitable seagrass areas.

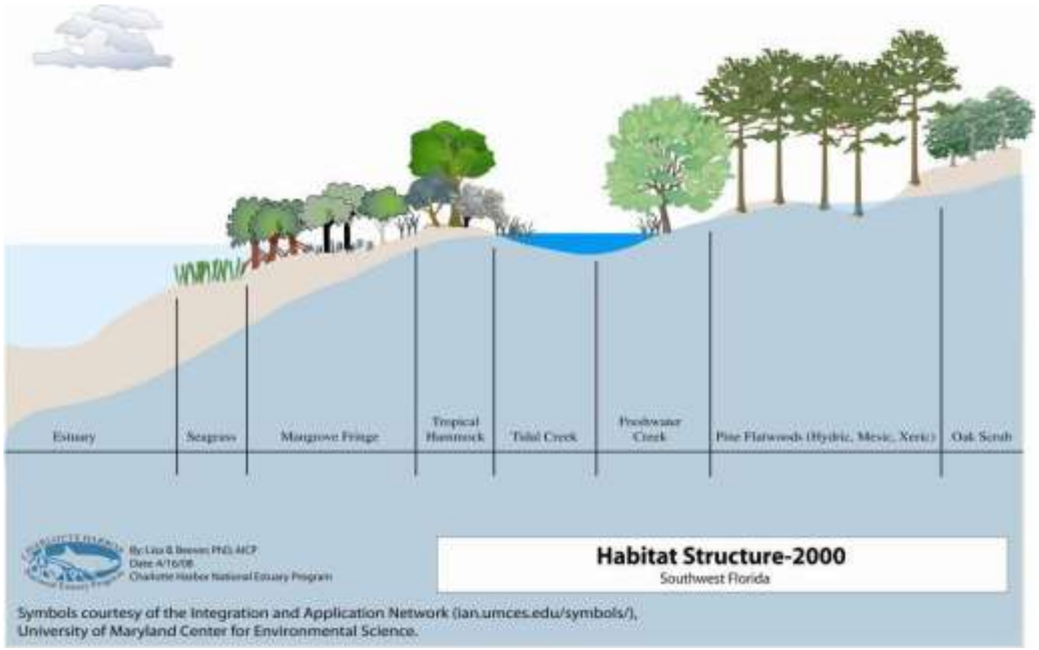


Figure 23: Habitat Structure 2000 Southwest Florida

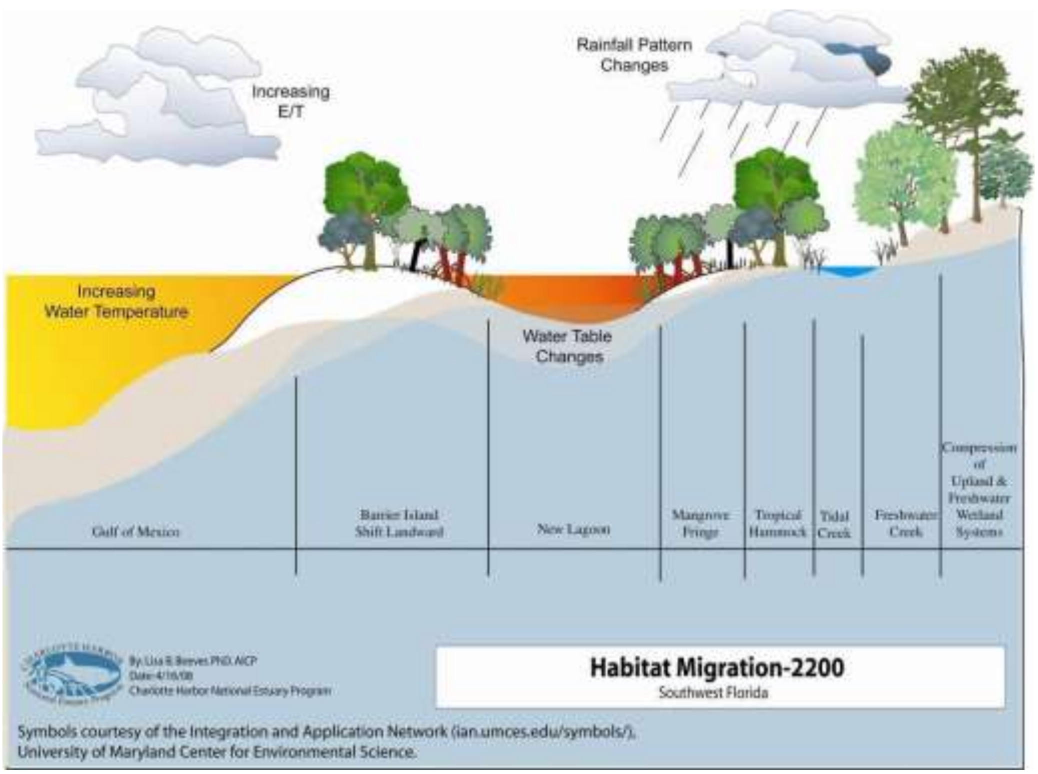


Figure 24: Habitat Structure 2200 Southwest Florida

Exotic Pests and Diseases

Florida's natural ecosystems are coming under increasing attack by invading exotic species which displace native species, thereby degrading the diversity of local flora and fauna. Florida has ecosystems unique in the lower 48 states, but has more nonnative species than any state other than Hawaii. Many of these species have become sufficiently abundant or otherwise destructive to be considered pests (UF IFAS). With its plant-friendly south temperate/subtropical climate and ongoing influx of human "transplants," Florida particularly suffers from the introduction and unchecked growth of exotic plants. Almost half (1,180) of the 3,834 plant species in Florida have arrived here since European occupation (UF IFAS).

Because plants are the base of the food chain, exotic "takeovers" can jeopardize plant dependent wildlife and the whole ecosystem. The Florida Exotic Pest Plant Council (FLEPPC) has identified 64 nonnative invasive species that are invading and disrupting native plant communities (1999 list). Plant pests include hydrilla (*Hydrilla verticillata*), old world climbing fern (*Lygodium microphyllum*), and melaleuca (UF IFAS).

Agriculture, landscaping, and natural places in Charlotte County are susceptible to exotic pests and diseases. Significant pests affecting Florida's agriculture have included the Mediterranean fruit fly, the brown citrus aphid, plant-feeding snails, chrysanthemum white rust, the golden nematode, red ring disease of coconut, citrus canker, pine bark beetle, and the Asian gypsy moth. Aside from a loss of agricultural crops to pests and diseases, exotic pests have other costs associated with them. Significant public monies are spent in the attempt to control invasive species.

Climate change is highly likely to increase the exotic pest plant problem. Many exotic species are from the tropical latitudes, so, as temperatures increase, their range is increased as well. Also, exotic species tend to be more efficient pioneers in disturbed areas than native species. In the wake of wildfires and floods, not to mention continuing development, more niches will be opened up to exotics.

Because of its tropical climate, unique animal and plant life, and robust $6 billion agriculture industry, Florida is inherently susceptible to the introduction of foreign plant and animal pests and diseases. The state has been plagued by repeated outbreaks of exotic pests and diseases over the past few years. USDA and the Florida Department of Agriculture and Consumer Services (FDACS) spent about $25 million to eradicate Mediterranean fruit fly (Medfly) outbreaks from Tampa and surrounding areas in 1997; efforts to eradicate bacterial citrus canker from Florida costs more than $10 million annually (USDA 2005).

Medfly, citrus canker, and melaleuca are just a few examples of alien invasive species that have had a huge impact on Florida residents, growers, and the state's environment in recent years. Medfly is a devastating pest of more than 200 varieties of fruits, nuts, and vegetables. Citrus canker, a serious disease of most citrus, causes lesions on leaves, stems, and fruit, as well as premature fruit drop. In Florida, not only is there an abundance of commercial citrus crops to serve as hosts, but there is a plethora of backyard citrus, as well. Melaleuca and other noxious weeds threaten to crowd out native Florida vegetation and deplete essential natural resources, including unique ecosystems such as the Everglades (USDA 2003).

But these eradication expenses alone do not reflect the full impact on Florida growers. The full impact must include lost production areas and lost opportunities to market products in domestic and foreign markets because of quarantining. The costs of controlling and eradicating pest and disease outbreaks are ultimately borne by consumers in the form of higher grocery costs (USDA 2005).

Following is a brief description of three recent outbreaks of citrus canker as tracked by the Department of Agriculture and Consumer Services.

October 20, 2004, Eastern Charlotte County:
Citrus canker was confirmed positive in a Hamlin orange grove located in Township 40S, Range 26E, and Section 12 in eastern Charlotte County, east of Highway 31, near the Desoto County line. An existing infection was widespread throughout the grove due to Hurricane Charley. Control action and a survey of the surrounding area was undertaken.

October 20, 2004, Punta Gorda:
Citrus canker was confirmed positive on two residential properties in Punta Gorda. Both trees were part of the USDA Sentinel Tree Survey Program. The trees were found to be infected and all were removed. One property was adjacent to a previously positive grove. The other property had three positive trees (a sour orange, lemon, and tangerine).

October 12, 2004, Charlotte County:
Two orange trees were confirmed for citrus canker in a commercial grove. This grove is located approximately 10 miles south of Punta Gorda. Both positive trees and a buffer area were destroyed. A control action of the exposed trees was undertaken.

Animal disease organisms can live for months in meat and meat products, such as sausage and many types of canned hams sold abroad. Foot-and-mouth disease, African swine fever, and classical swine fever (hog cholera) are a few of the several livestock diseases that could cost billions of dollars to eradicate if introduced into U.S. livestock. These diseases are not currently present in the United States but are known to occur in many foreign countries from which travelers and importers bring meat products (USDA 2005).

Charlotte County agriculture is as susceptible to exotic pests and disease as any other agricultural entity. Significant pests to affect Florida's agriculture have included the Mediterranean fly, the brown citrus aphid, plant feeding snails, pine bark beetle, chrysanthemum white rust, golden nematode, red ring disease of coconut, citrus canker, and Asian gypsy moth.

In addition to Charlotte County's agriculture being at risk, the natural environment is threatened. The natural environment and its uniqueness is a tourism draw for Charlotte County. Invasive species can create a monoculture environment. As Charlotte County loses some of its native plant and wildlife species, the uniqueness of the area can decrease, which can ultimately lead to fewer "nature" tourists and fewer tourism dollars.

Florida's increasing popularity as a tourism destination and transportation hub for commerce with Latin America and other regions of the globe has exacerbated the problem of damage from invasive pests and diseases. Some 48 million visitors entered Florida through airports, seaports and highways in 1998, an increase of 3.7% over the previous year. Airports and seaports are filled with passengers and cargo that could carry invasive species to Florida farms and groves. Florida's recent battles against the Mediterranean fruitfly and the ongoing eradication of citrus canker underscore the need for effective port inspections, pest and disease detection programs, and timely eradication capabilities (Florida Fruit and Vegetable Association).

Table 7: Adaptations to Address Fish and Wildlife Habitat Vulnerabilities (from the public workshop)

Adaptation Option	**Climate Stressor Addressed**	**Additional Management Goals Addressed**	**Benefits**	**Constraints**	**Examples**	**Level of Support (%)**
Seagrass protection and restoration	Fish and Wildlife Habitat Degradation	Water Quality Degradation	Stabilizes sediment; does not require costly construction procedures, maintains and increases habitat; Enhances fishery	Seasonality – grasses diminish in winter months; Light availability is essential; restoration success is greater than creation; Cost	CHNEP: Biennial Seagrass mapping, Boat Propeller Scar in Seagrass Study, Madley et al. 2009; Hardee County Peace River Submerged Aquatic Vegetation Study, ; Chesapeake Bay (Living Shoreline Stewardship Initiative); Tampa Bay NEP; FDEP NW District; Seagrass Recovery (Indian Rocks, FL);	62.5
Remove invasive species and restore native species	Fish and Wildlife Habitat Degradation	Fire (*Melaleuca*)	Maintains and increases habitat	Continuing costs; long term effort with monitoring	CHNEP: Tippecanoe East Exotic Species Project, Control of Invasive Grasses in the Myakka River Watershed by Park Volunteers, Venetian Waterway Park Brazilian Pepper Eradication, Charlotte County Spiny-tailed iguana eradication project, Peace River	50

					(Polk County)Invasive Plant Management,	
Mangrove restoration	Fish and Wildlife Habitat Degradation	Water Quality Degradation, Flooding	Provides protective barrier; maintains and increases habitat; benefits listed animal species; Stabilizes sediment; Enhances fishery	Conditions must be right for survival (e.g., fetch, substrate); can be affected by storms and seasonal changes; Cost	CHNEP: Post-Hurricane Restoration of Red Mangrove Shorelines in a Southwest Florida Estuary: Improving Corridors for Seasonal Fish Movements; Charlotte Sea Grant;	50
Incorporate wetland protection into infrastructure planning	Fish and Wildlife Habitat Degradation	Water Quality Degradation, Unchecked Growth, Flooding	Reduces impacts to hydrology, water quality and habitats, maintains and increases habitat; Increased knowledge-based planning; reduces uncertainty	Requires thought and time, does not maximize short-term profit, may not be standard practice for out-of-State and foreign investors and contractors; Cost	9J-5 F.S.; CHNEP: Charlotte County Environmental Compliance, Filter Marsh & BMP Maintenance, Tern Bay Reclaim Water Line, Charlotte County, USGS surface-water and groundwater stations, Hydrologic Conditions Analysis	50
Explicitly indicate in local master plans which areas will retain natural shorelines	Fish and Wildlife Habitat Degradation	Water Quality Degradation, Unchecked Growth, Flooding	Reduces uncertainty on DO approvals, reserves shoreline for natural ectonal shifts, maintains and increases habitat	Reduces speculation, may not be standard practice for out-of-State and foreign investors and contractors, may result in takings claims	City of Sanibel,	50

Habitat protection/retention	Fish and Wildlife Habitat Degradation	Water Quality Degradation, Unchecked Growth, Flooding	Maintains and increases habitat; Increased knowledge-based planning; reduces uncertainty; Stabilizes sediment; Enhances fishery	Varies with method of protection, habitat will need to be maintained	CHNEP: Charlotte Flatwoods Environmental Park, Shell Creek - Charlotte County Environmentally Sensitive Lands Program, Shell Creek - Charlotte County Environmentally Sensitive Lands Program	50
Regulate import of exotics	Fish and Wildlife Habitat Degradation		Reduces the introduction of invasive exotic species, protects native species	Cost of regulation and enforcement, economic impact to exotic importers	CHNEP: Charlotte County Spiny-tailed iguana eradication project, Aquatic Nuisance Species Surveillance and Education Network, FWC Exotic Freshwater Fishes Poster, Southwest Florida Exotic Species Workshop: December 2006	50
Establish funds for land purchase	Fish and Wildlife Habitat Degradation	Flooding	Maintains and increases habitat	Cost of funds, difficult during economic downturn	CHNEP: Workshop on the community's responsibility to incorporate environmentally sustainable practices in their fundraising activities	37.5
Collect data on and map existing conditions	Fish and Wildlife Habitat Degradation	Flooding	Increased knowledge-based planning; reduces uncertainty	Cost of date collection and mapping	CHNEP: A water quality monitoring project to ascertain the extent local	37.5

					septic systems have on Charlotte Harbor waterways, Peace River Water Quality Monitoring, Southwest Florida Regional Ambient Monitoring Program, CHEC Water Quality Website, FrogWatch WebSite, Benthic Invertebrate Species Richness and Diversity Comparison, Charlotte Harbor Tidal Shoreline Survey Project	
Fertilizer regulation	Fish and Wildlife Habitat Degradation	Water Quality Degradation	Protects water quality; Reduces algae blooms; Enhances fishery ; Maintains and increases habitat	State regulated with weak preemption; Cost	SWFRPC Resolution(07-01) March 15, 2007; Charlotte County Fertilizer Ordinance 2008-028; CHNEP: Support of Fertilizer Ordinances	37.5
Conservation land acquisition	Fish and Wildlife Habitat Degradation	Unmanaged Growth	Maintains and increases habitat; Enhances fishery	Cost	CHNEP: Charlotte Flatwoods Environmental Park, Shell Creek - Charlotte County Environmentally Sensitive Lands Program, Bayshore Live Oaks Park, Charlotte County Park Land Acquisition, Conservation Charlotte, Burchers	37.5

					Property, Shell Creek, Integrated Habitat Network	
Incorporate wetland protection into transportation planning	Fish and Wildlife Habitat Degradation	Flooding	Maintains and increases habitat; Increased knowledge-based planning; reduces uncertainty	Cost	Houston-Galveston long-range transportation plan	37.5
Establish early warning sites and gather baseline data	Fish and Wildlife Habitat Degradation		Increased knowledge-based planning; reduces uncertainty	Cost	CHNEP: Spectral and epiphyte attenuation enhancement of an existing Charlotte Harbor light model with respect to seagrasses, Atmospheric Deposition Studies, Coastal Charlotte Harbor Monitoring Network	25
Develop GIS-based decision-making/ visualization tools	Fish and Wildlife Habitat Degradation	Flooding	Increased knowledge-based planning; reduces uncertainty	Cost	CHNEP: Pre-Development Vegetation Map for Charlotte and Manatee Counties, Biennial Seagrass Mapping, Pre-Development land cover mapping of the Peace River Basin; Topography Map of Charlotte County	25
Monitor fish catches and adjust limits	Fish and Wildlife Habitat Degradation		Can increase fishery stocks and maintain sustainable fishery	Cost of regulation and enforcement, economic impact to fisheries	CHNEP: Independent Fisheries Monitoring Project, NOAA Marine Fisheries Review, Wildlife and Fish Law	25

					Violations Reported Online	
Establish migration routes for wildlife	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Reduces changes of local extinction, increases gene flow, allows migration with shifting conditions, Maintains and increases habitat	Cost	CHNEP: Post-Hurricane Restoration of Red Mangrove Shorelines in a Southwest Florida Estuary: Improving Corridors for Seasonal Fish Movements,	25
Improve reef/marine management	Fish and Wildlife Habitat Degradation		Can improve opportunities for fishing and ecotourism, reduce negative impacts of reefs; can enhances some fisheries	Cost of Management	CHNEP: Fisheries Independent Monitoring Program, NOAA Marine Fisheries Review, Incorporating Public Input on Sea Turtle Sightings in Charlotte Harbor	25
Design estuaries with dynamic boundaries and buffers	Fish and Wildlife Habitat Degradation	Water Quality Degradation, Flooding	Maintains and increases habitat; Stabilizes sediment; Enhances fishery	Cost	CHNEP: Post-Hurricane Restoration of Red Mangrove Shorelines in a Southwest Florida Estuary, Request state house and senate bills pre-empting local rules concerning wetland protection not be adopted, Charlotte Harbor Tidal Shoreline Survey Project	25

Establish living shorelines	Fish and Wildlife Habitat Degradation	Water Quality Degradation, Flooding	Reduces negative effects of armoring (erosion; lack of retreat space); maintains beach habitat; Maintains and increases habitat; Stabilizes sediment; Enhances fishery when done correctly	Cost, requires more planning and materials than armoring; Some forms of living shorelines are just as or more damaging than bulkheads	Peconic Bay (NY); Living Shorelines Stewardship Initiative (Chesapeake Bay); CHNEP: Post-Hurricane Restoration of Red Mangrove Shorelines in a Southwest Florida Estuary	25
Restore natural inlets and accretion	Fish and Wildlife Habitat Degradation	Flooding	Maintains and increases habitat; Stabilizes sediment; Enhances fishery	Cost	CHNEP: Boca Grande Pass Enhancement	25
Controls/ restrictions on growth	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Reduces wasteful growth, reduces supportive tax burden for speculation, allows concurrency	Cost of regulation	CHNEP: Request state house and senate bills pre-empting local rules concerning wetland protection not be adopted.	25
Establish and use land exchange programs	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Provides infill incentives; Allows valuation of all land use; Properly designed it can protect habitats without public funding	Cost of maintaining the land exchange program		25
Strengthen rules that prevent the introduction of invasive species	Fish and Wildlife Habitat Degradation		Reduces the introduction of invasive exotic species, protects native species	Cost of regulation; Federal and State rules are not strong in prevention of the spread of know or new invasive exotics. Very limited restrictions on sale of exotics	CHNEP: Southwest Florida Exotic Species Workshop: December 2006, 12th annual Benedict Symposium and Exotics Workshop for Southwest Florida	25

Prohibit *new* bulkheads	Fish and Wildlife Habitat Degradation		Maintains and increases habitat; Stabilizes sediment; Enhances fishery; Allows ecotonal shifts with sea level rise; Reduces erosion; Reduces toe-of wall habitat loss	Cost of regulation		12.5
Build fish hatcheries	Fish and Wildlife Habitat Degradation		Can enhance certain fisheries	Can result in decreased genetic diversity and predator/prey imbalance		12.5
Use of CLIP. FNAI, etc to prioritize land purchases	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Maintains and increases habitat	Land Acquisition planning must be regularly updated.		12.5
Allow coastal wetlands to migrate inland	Fish and Wildlife Habitat Degradation	Flooding	Maintains and increases habitat; Enhances fishery	Reduces speculation, may not be standard practice for out-of-State and foreign investors and contractors, may result in takings claims	Buzzards Bay, MA	12.5
Improve site planning controls	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Reduces Hydrologic, water quality and Habitat impacts of scraped earth site development	Cost of regulation	Update of the City of Punta Gorda landscape ordinance; CHNEP: Filter Marsh & BMP Maintenance, Charlotte County Environmental Compliance	12.5
Minimize habitat alteration	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Maintains and increases habitat; Stabilizes sediment; Reduces Hydrologic, water quality and Habitat impacts of scraped earth site development	Contrary to land development interests	Shell Creek Environmentally Sensitive Lands Program, Isolated Wetland Restoration at the Charlotte Harbor Buffer	12.5

					Preserve, Charlotte Harbor and Myakka River Restoration	
Plant submerged aquatic vegetation	Fish and Wildlife Habitat Degradation	Water Quality Degradation	Maintains and increases habitat; Stabilizes sediment; Enhances fishery	Can have a low success rate if source of loss of SAV is not addressed	CHNEP: Charlotte Harbor Tidal Shoreline Survey Project, Seagrass Video, Biennial Seagrass Mapping, Boat Propeller Scar in Seagrass Study, Seagrass Wading Trips, Seagrass Exploration for PGA Kids,	12.5
All measures to reduce local GHG emissions	Fish and Wildlife Habitat Degradation		Maintains and increases habitat	There is doubt within a portion of the public and decision makers concerning the effects of GHG	Strategies and policies in the EAR review of the City of Punta Gorda Comprehensive Plan	12.5
Promote catch and release fishing	Fish and Wildlife Habitat Degradation		Can maintain sustainable fishery	Cost of regulation	CHNEP: Fisheries Independent Monitoring Program, NOAA Marine Fisheries Review, Wildlife and Fish Law Violations Reported Online, Portable Fisherman’s Educational Kiosk/Display	12.5

Adapt protections of critical biogeochemical zones	Fish and Wildlife Habitat Degradation		Maintains and increases habitat; Enhances fishery	Cost of identifying and protecting the zones; May require federal or state designation for protection	CHNEP: Integrated Habitat Network	12.5
Establish seed banks	Fish and Wildlife Habitat Degradation		Maintains biodiversity of native vegetation	Cost of establishing and maintaining seed bank; Site to reestablish vegetation		12.5
Establish strong laws to protect habitat	Fish and Wildlife Habitat Degradation	Unmanaged Growth, Flooding	Maintains and increases habitat; Can increase fishery stocks and maintain sustainable fishery	Cost of regulation	CHNEP: Request state house and senate bills pre-empting local rules concerning wetland protection not be adopted.	12.5
Create dunes	Fish and Wildlife Habitat Degradation	Flooding	Maintains and increases habitat	Cost, requires more planning and materials than armoring; Some forms of living shorelines are just as or more damaging than bulkheads		12.5
Stopped unchecked commercial fishing	Fish and Wildlife Habitat Degradation		Can increase fishery stocks and maintain sustainable fishery	State regulated; Cost of regulation		12.5

Table 8: Adaptations to Address Fish and Wildlife Habitat Vulnerabilities Recommended Against (from the public workshop)

Stop fishing tournaments	Fish and Wildlife Habitat Degradation					37.5

Do nothing	Fish and Wildlife Habitat Degradation					37.5
Stop unchecked commercial fishing	Fish and Wildlife Habitat Degradation					37.5

Adaptation: Seagrass Protection and Restoration

Seagrass Restoration was the most popular adaptation measure proposed to address climate change impacts in the City of Punta Gorda to fish and wildlife habitats. The following is a discussion on how this adaptation could be implemented for the City of Punta Gorda.

In order to restore seagrass it is important to know how much seagrass could be restored based upon historical, current, and future conditions, what are the causes that result in seagrass not growing in all the available locations it could grow, and what would be the most successful methods of restoration?

Seagrass Protection areas need to occur along the City's northern and western boundaries where sparse seagrass beds are vulnerable to propeller scarring. In 1995, the Florida Department of Environmental Protection's Florida Marine Research Institute (FMRI) now known as the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute (FWRI) undertook the mapping of seagrass areas which had experienced scarring. According to FMRI Technical Report TR-1 (Sargent et al., 1995), approximately 7,440 acres or slightly more than half of City's seagrasses have sustained some degree of scarring, with some 5,910 being moderately or severely scarred. In 2004, FWRI updated the report for the Charlotte Harbor using the same methods employed in the 1995 study. The report used 2003 aerial survey and photography data determined 8,236 acres or 58% of Charlotte County's seagrasses have some degree of scarring. Though the extents of moderately scarred areas were similar in the two studies, the degree of severe scarring increased over the 10 year period from 286 acres in 1993 to 1,840 acres in 2003. The most recent seagrass occurrences along the City boundaries are identified on Figure 25. The City needs to review projects which may impact seagrasses and coordinate with the jurisdictional agencies to promote seagrass protection.

Figure 25: Seagrass coverage map from the City of Punta Gorda Comprehensive Plan in the Tidal Peace River in the region of the City of Punta Gorda

The Charlotte Harbor National Estuary Program (CHNEP) identified the need to develop water quality targets that preserve and restore seagrass health throughout the estuarine system. The resource based water quality targets address the Priority Problems identified in the CHNEP Comprehensive Conservation and Management Plan (CCMP) of Hydrologic Alterations and Water Quality Degradation. Initial resource based water quality targets were developed based on measured depth of seagrass growth and percent light requirements (CHNEP 2006).

Establishment of seagrass targets provides a necessary basis for management decisions regarding water quality and other issues that can influence the distribution and persistence of this valuable submerged habitat. The primary goal of the seagrass target development project (Janicki et al. 2009) was to establish targets designed to maintain and/or restore seagrass coverage to its historical extent. Restoration targets were defined through an analysis of historic and recent aerial surveys of the study area. Historic photos of the area were taken around 1950. As many alterations have occurred to the shoreline in the study area, as well as channelization of the Intracoastal Waterway (ICW), the analyses accounted for these changes as non-restorable areas. Additionally, trends in seagrass coverage throughout the CHNEP, based on recent aerial surveys, have been identified.

The following is a map of the 1950's extent of sea grasses in proximity to the city of Punta Gorda.

Figure 26: Baseline seagrass coverage in Tidal Peace River in the region of the City of Punta Gorda

Analysis of aerial photography provides the following table with the extents of seagrasses in the same area for 1988, 1994, 1999, 2001, 2004, and 2006. Tidal Peace River seagrass coverage has decreased in recent surveys since a peak in 1994.

Annual seagrass coverage (acreage) in Tidal Peace River and the total SWFWMD portion of the CHNEP						
Harbor Segment	**1988**	**1994**	**1999**	**2001**	**2004**	**2006**
Tidal Peace River	414	573	302	376	295	341
TOTAL CHNEP	20,039	20,421	19,841	20,115	20,185	20,320

Table 9: Annual seagrass coverage (acreages) in the Tidal Peace River and the total SWFWMD portion of the CHNEP.

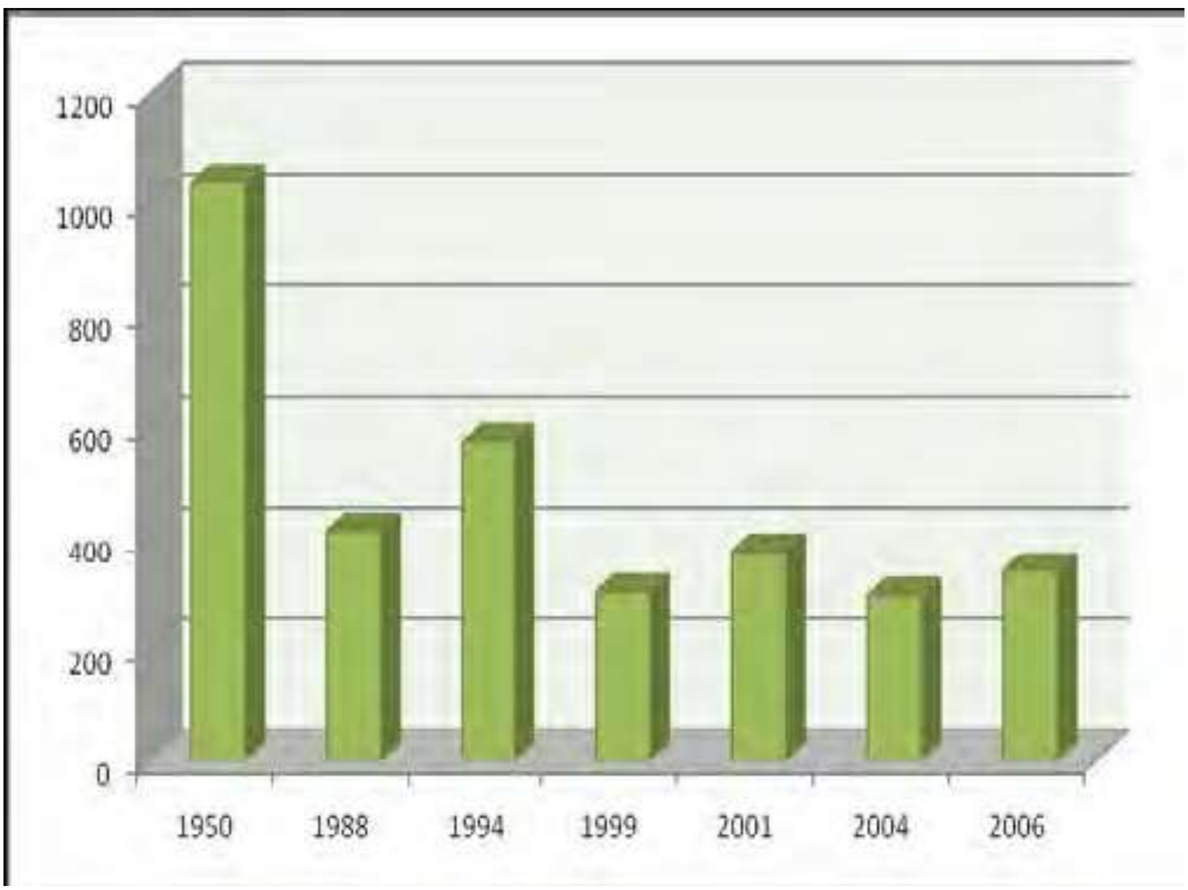


Figure 27: Annual seagrass acreages in Tidal Peace River

Persistence maps were also created based on the recent surveys used to identify areas where seagrasses have been most likely to be found within the CHNEP. Figures 28 through 31 present the results of the persistence analysis. Unfortunately the waters adjacent to the City of Punta Gorda are split into three different analysis segments. The most persistent seagrass areas are generally located in the near-shore portions of the estuary, which tend to be shallower. In contrast, the least persistent areas are more likely found in deeper portions of the harbor. Additionally, the results of the persistence analysis show that some areas never have been, nor will likely be, well-suited for seagrass recovery.

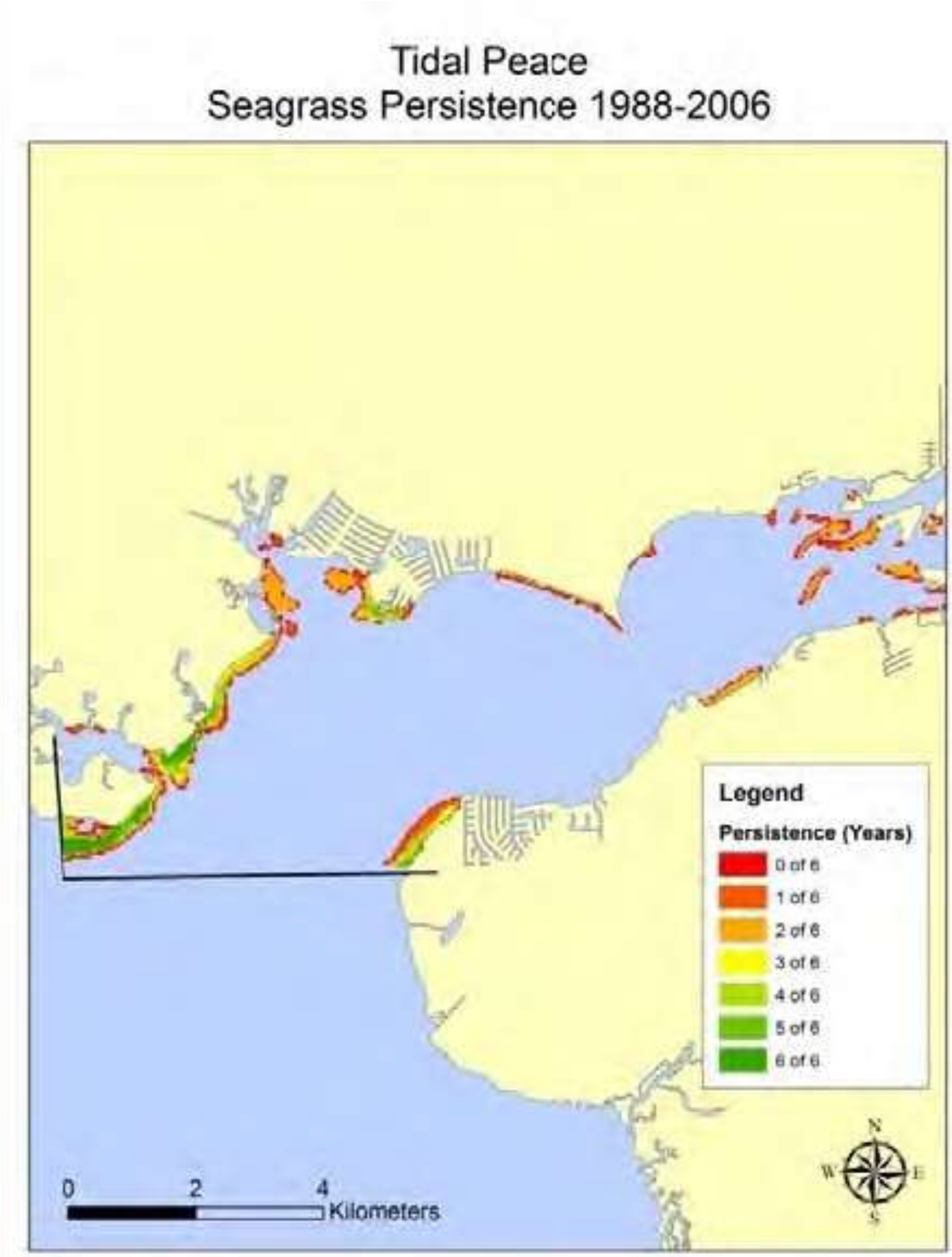


Figure 28: Seagrass persistence in Tidal Peace River, 1988-2006

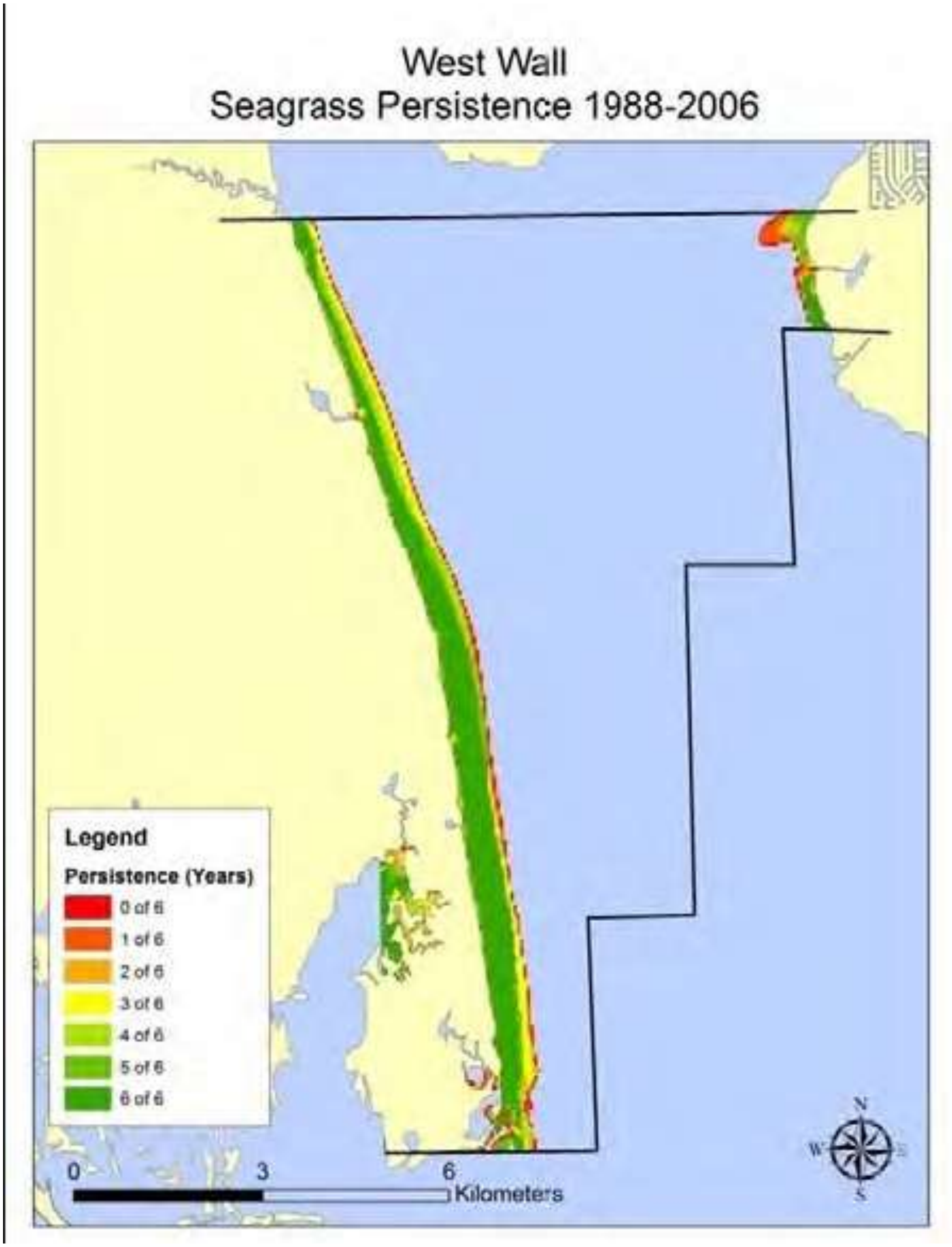


Figure 29: Seagrass persistence in West Wall, 1988-2006

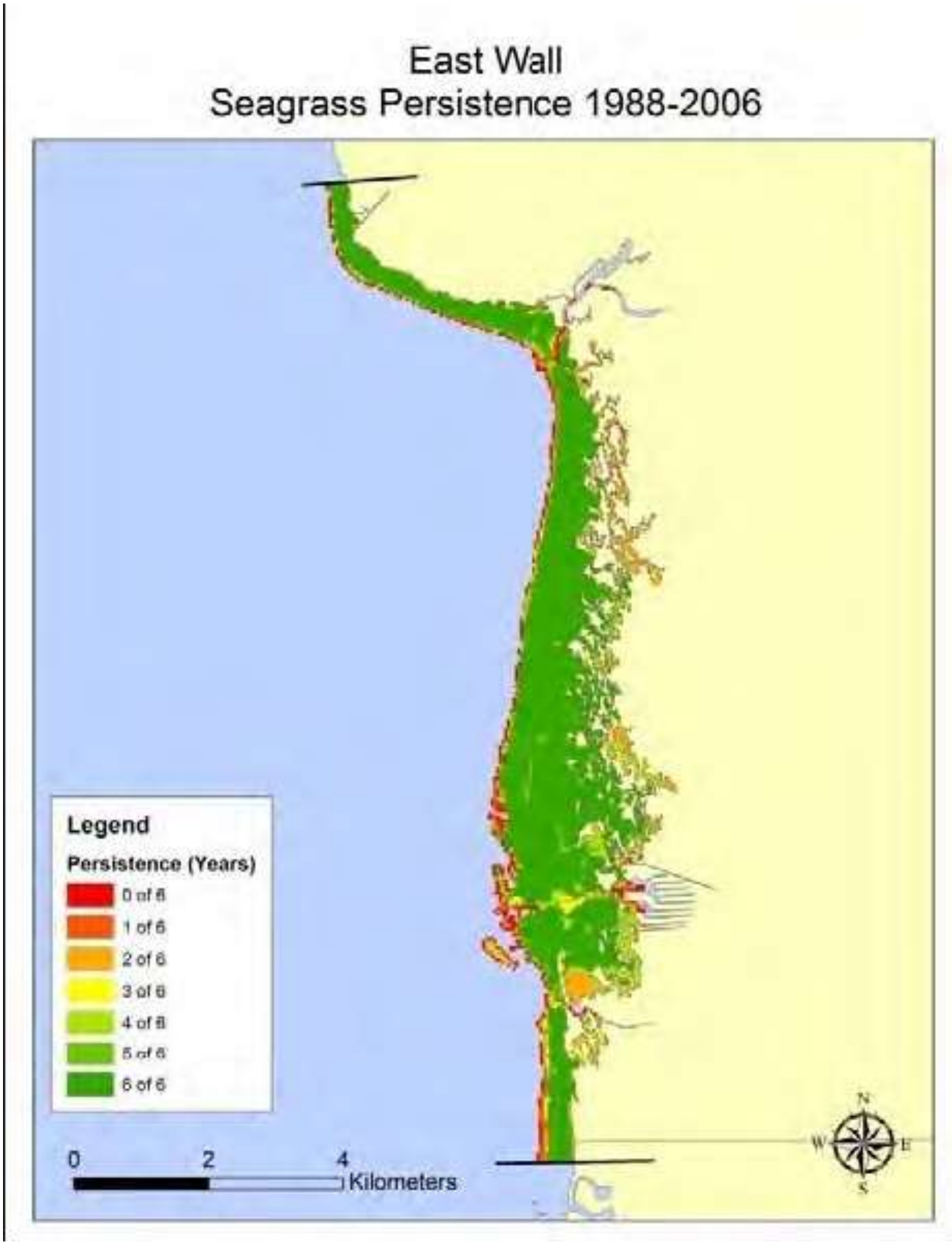


Figure 30: Seagrass persistence in East Wall, 1988-2006

The estimated non-restorable seagrass areas in the vicinity of the City of Punta Gorda include the Tidal Peace River segment and amounts to 64 acres.

Figure 31: Non-Restorable Seagrass Areas in Tidal Peace River

Having determined the extent of the baseline seagrass coverages, recent seagrass coverages, and delineated the non-restorable areas in the CHNEP, potential restoration and protection targets can be calculated.

A number of potential definitions of seagrass restoration and protection targets are presented in Tables 10 and 11. These include:

- maximum annual extent,
- mean annual extent over all recent surveys,
- mean annual extent over the last 3 surveys, and
- most recent annual extent.

The adjusted baseline acreage is the difference between the baseline acreage and the non-restorable acreage in each harbor segment, therefore, correcting the baseline for the areas in which seagrass recovery is unexpected.

The results from Tables 10 and 11 were presented to the seagrass subcommittee on CHNEP May 28, 2009. The discussion focused on the choice of appropriate seagrass restoration and protection targets for each harbor segment. The following definition was developed:

The CHNEP seagrass target for each harbor segment is the greater of either the adjusted baseline acreage or the mean of all recent seagrass surveys.

Application of this definition to the results in Tables 10 and 11 provides the target identified for each harbor segment including the Tidal Peace River. In addition to defining these targets, an appropriate definition of a target range, i.e., the range of acceptable seagrass area, is also desired. It is recommended that this target range be defined by the range between the minimum and maximum areas from the recent seagrass surveys.

Please note that the seagrass restoration targets established are segment-wide acreages and that they do not identify specific locations within each segment which are suitable for restoration.

Baseline, non-restorable and adjusted baseline seagrass extents and potential seagrass targets (acres)		
	Tidal Peace	**CHNEP Total**
Baseline	1,039	61,513
Non-restorable Areas	64	1,737
Adjusted Baseline	975	59,776
Maximum Annual Extent	573	67,415
Mean Annual Extent: all years	384	62,103
Mean Annual Extent: last 3 years	337	63,749
Most Recent Annual Extent	341	65,873

Table 10: Baseline, non-restorable and adjusted baseline seagrass extents and potential seagrass targets (acres)

Draft CHNEP Seagrass Targets in acres						
Harbor Segment	Baseline, adjusted (B)	Mean Annual Extent all years (A)	Protection Target	Restoration Target	Total Target	Target Range
Tidal Peace River	975	384	384	591	975	295-573
TOTAL for CHNEP	59,776	62,103	62,103	3,954	66,057	N/A

Table 11: Draft CHNEP Seagrass Targets in Acres

Upon approval by the Management and Policy committees, these seagrass targets can be used in the refinement of water clarity and quality targets for the waters adjacent to the City of Punta Gorda. There are clear linkages between seagrass growth and reproduction, water quality, and nutrient loading. Specifically, increased nutrient loading can result in elevated chlorophyll concentrations, which in turn affects water clarity. Decreased water clarity reduces the amount of light needed to support seagrass growth and reproduction. Therefore, the results from this task provide the basis for appropriate water quality and nutrient loading targets for the waters of the harbor.

Currently, the most common form of physical destruction to seagrasses is the dredging of plant material (blades as well as roots and rhizomes) by boat propellers and vessel groundings on shallow seagrass beds. This form of seagrass destruction, known as prop scarring, occurs in shallow water areas throughout South Florida. Zieman (1976) estimated that it takes several years for turtle grasses to begin recovery from prop scarring. Sargent *et al.* (1995) indicate that a prop scar within a turtle grass bed averages 3 to 5 years to begin healing. However, a recent study indicates that moderate scarring (*i.e.*, minimal vertical relief in the scar) takes 12 to 15 years to begin recovery (J.W. Kenworthy, NMFS, personal communication 1998). Deeper scars require decades to recover. In Tampa Bay, Lewis and Estevez (1988) indicate complete seagrass scar recovery may take as long as 10 years. This period is probably much longer in areas of poor water quality and where scarring is severe and repetitive; some scarred beds may never recover.

Photograph 9: Close-up example of a propeller scars in a seagrass meadow in Charlotte Harbor This example shows a location where scars from a twin prop vessel cross a scar from a single prop vessel.

Source: FDEP 2009

Another serious form of physical disturbance to seagrasses is from boat wakes. Based on data indicating decreased light penetration associated with weekend boat traffic, Kenworthy *et al.* (1988) found a possible cause-effect relationship between boating activities and increased turbidity. Seagrasses are sensitive to decreased light penetration. Increased boating activity and larger boats have resulted in chronic conditions of resuspended sediments and eroded seagrass beds along the edges of deeper channels, especially in the Upper and Middle Florida Keys (C. Kruer, Florida Keys Environmental Restoration Trust Fund, personal communication 1998). Once seagrasses are lost within an embayment, that system's capacity to stabilize sediments is also lost. A negative cycle is initiated when resuspended sediments reduce the amount of light available for seagrasses to survive and grow, which reduces seagrass coverage, which reduces sediment stabilization, resulting in additional resuspended sediments.

	1993 Acres	2003 Acres	Gains/Losses (Acres)	Gains/Losses (Percent)
Peace River				
Light	210	44	-165	-79%
Moderate	86	23	-64	-74%
Severe	0	0	0	NA
Myakka River				
Light	166	72	-94	-57%
Moderate	26	54	28	108%
Severe	0	4	4	NA
East Wall Charlotte Harbor				
Light	373	0	-373	-100%
Moderate	2,021	2,558	537	27%
Severe	68	19	-49	-72%
Total CHNEP Scarred Habitat	21,817	30,064	8,247	38%

Table 12: Acreages and percents of propeller scarred seagrass habitat by subbasin in the vicinity of the City of Punta Gorda, Charlotte Harbor region (Madley et al. 2009)

Trend analyses indicate that overall the amount of scarred seagrass habitat increased from 52% to 58% for Charlotte County between the years 1993 to 2003. Examinations of prop scar prevalence indicate areas around docks, marinas, channel edges, oyster bars, and mangrove islands are exceptionally susceptible to repeat scarring. These are areas that draw vessels on repeat trips and often over very shallow water. For example, the researchers in this project noticed that the edges of many mangrove islands and oyster bars were heavily scarred from boats using them as navigational aids to maneuver through the estuary. Likewise, channel edges are often locations of severe scarring because a high percentage of boats travel the channels with a minority of them actually missing the deepwater and scaring the channel edges.

Assessing the locations, extents, and severity of scarred habitats is an initial step in the process of conservation measures for these areas. Next, decisions must be made on what, how, and when steps need to proceed for reduction or elimination of the impacts to the seagrass habitat. Management considerations for reducing and restoring the impacts of propeller scarring fall within five categories: boater education, channel markers and other signage, enforcement, limited-motoring zones, and restoration. Discussion of the first four options is included in Florida Seagrass Manager's Toolkit (FWC 2003):

(1) Boater Education

Efforts to educate boaters on the locations of shallow seagrass beds and the importance of seagrasses to estuarine fish and shellfish communities have been undertaken by many local governments, the FWC, FDEP, and the National Estuary Program. "Boaters Guides," which include bathymetric charts showing the locations of shallow seagrass beds and other sensitive aquatic habitats, along with text explaining the importance of those habitats, have been developed for Charlotte Harbor. Many of these guides can be downloaded from the FMRI website (http://www.floridamarine.org/products/products.asp) and are distributed in printed form by a number of organizations in the vicinity of each waterbody. Educational signs, which have been erected at a number of boat ramps, have also been used to provide information on the locations and importance of sensitive aquatic habitats in the vicinity of the ramps.

The Citizens Advisory Committee (CAC) associated with the CHNEP has implemented boater education programs in an effort to reduce boating impacts to seagrass meadows and their inhabitants, including manatees. One focus of these groups has been an effort to identify potential nonregulatory management actions that might be used to provide better protection for existing seagrass beds.

(2) Channel Markers and Other Signage

Efforts to provide more effective marking of navigation channels have been used in many parts of the state to reduce scarring caused by boaters who inadvertently motor onto shallow vegetated flats. Because seagrass beds in shallow waters can also be impacted by the erosive effects of boat wakes and pressure waves, signage designating slow-speed or no-wake zones has also been used as a protective measure in the vicinity of shallow grassbeds. In many cases channel marking and other signage has been used in combination with motor exclusion or caution zones to protect heavily-scarred areas, a multi-pronged approach that is described in more detail below.

(3) Enforcement of Boating Regulations

Experience suggests that many boaters will voluntarily obey regulations designed to protect seagrass resources, particularly if those regulations are developed through an inclusive, consensus-based process that includes an adequate level of public input. The results also suggest, however, that a certain percentage of boaters may tend to overlook, misunderstand or ignore such regulations. Consistent presence of enforcement personnel in areas of heavy boating activity appears to be one of the more effective tools available for reducing the potential impacts of this portion of the boating community on shallow seagrass habitats (Sargent et al. 1995). Sargent et al. (1995) also noted that mapping and monitoring of managed areas are essential for evaluating the effectiveness of management efforts, and suggested that regional or statewide management plans might be needed to provide adequate protection for large areas of seagrass habitat that fall within the jurisdictions of multiple local governments.

(4) Designation of Internal Combustion No-Entry or Slow-Speed Zones

Smith (1998) summarized 11 boating management areas that had been established in Florida prior to 1998 for the purpose of seagrass protection, including No Motor Power Zones in Lee

County;• Pansy Bayou, No Entry Zone, Sarasota County; and J.N. "Ding" Darling National Wildlife Refuge, No Entry Zone, Lee County.

For additional information on how these four management options may be used, please refer to Sargent et al. 1995 and the Florida Seagrass Manager's Toolkit (Florida Fish and Wildlife Conservation Commission 2003). Both of these documents have been provided in digital format to the Charlotte Harbor NEP, as well as being available from the seagrass pages of the FWC website (http://research.myfwc.com/).

(5) Seagrass Bed Restoration

The creation and restoration of seagrass beds is a species specific, site dependent process with limited success. In general the restoration of a sea grass bed upon historic native substrate to a site of prior occupation following restoration or maintenance of good water quality and clarity has enjoyed the greatest success. De novo plantings on unsuitable substratum in areas of poor water quality uniformly fail. In general, it is a waste of resources, propagules and donor beds to plug seagrasses into an impacted habitat without removing the attributes and or entities of impact which destroyed the initial submerged grassbeds onsite, never allowed successful recruitment and maintain the substrate as vacant. Since many conflicting claims of seagrass mitigation success are made, it is valuable to tabulate the various methods, sources and successes of mitigation projects attempted and evaluated to this time. This will not be a comprehensive list and further contributed documentable information would be appreciated.

Thalassia testudinum has been the most frequently planted seagrass species in restoration/creation projects. Mean survival from planting of seedlings using the best methods is 55.3 % from 9 projects and 16.6% for projects that used seeds utilizing the best methods (Beever 1986). *Halodule wrightii* has been planted less frequently in restorations, but often in large acreages. Many consider it to be a founder species in disturbed areas of *T. testudinum*. Mean survival from planting of shoots using the best methods are 39.9 % from 9 projects and 46.1% for projects that used plugs utilizing the best methods (Beever 1986). *Syringodium filiforme* has a 37% mean survival utilizing the best methods.

It should be noted that in all of the above resultant survivorships the parameter measured is simple survival of the initial planting and does not account for areal extent coverage or the actual ratio of area of impact to area of mitigation. What is evident is that all reported planting successes are in restoration of previously or currently vegetated grassbeds. Seagrass bed creations have not been successful. It must be recognized that while restorative plantings can succeed within their own limited bounded criteria a full replacement of vegetative coverage, substrate stability and habitat faunal recruitment has not been demonstrably achieved.
It is valuable to restate the central factors that must be considered in evaluating a sea grass restoration mitigation proposal, in paraphrase from Mike Nagy (1986) following his review of the 1983 Florida Keys Sea Grass Restoration Project.

1) Sea grass restoration remains an experimental process with no guarantee for success. No method exists to accurately predict the degree of success of a sea grass restoration project.

2) Extracting seagrass plantings from donor beds is very destructive. It will take many years for donor beds to recover if they ever do. No documentation of the donor bed recovery has ever been provided by workers in the field.
3) The ecology of sea grass communities is site specific. Research in sea grass restoration in the Florida Keys does not necessarily apply to Charlotte Harbor.
4) So far no one has performed and reported a complete qualitative and quantitative assessment of the overall biological system in a restored grass bed.
5) Sea grass may be growing all over the site, but it is not known that restored grassbeds are as productive for fisheries as a natural sea grass system.
6) Sea grass restoration attempts to date have been very expensive, long term and labor intensive.
7) In summary of the information available it is clear that sea grass bed mitigation should only be attempted when the following criteria among others are met.
    a. It is a restoration of a previously impacted grass bed area following removal of the impacting factor.
    b. The source material is gathered only from "donor" beds which are going to be destroyed in total by permitted project activities.
    c. The methods of planting area those demonstrably effective for that species in that area.
    d. The project is monitored and continued replacement of mortality of plantings continues until at least a 5-year stable target areal coverage is established and maintained.
    e. The target areal coverage should be empirically established by reference to natural grass bed systems in the project site area.
    f. It the project is mitigation then the mitigative plantings should occur prior to commencement of the project construction.
    g. Only public projects where no reasonable siting alternative exists would be allowed to destroy extant natural grass bed areas which would be mitigated for.
    h. The ratio of the areal extent of restoration should be the inverse of the existing survival rates established for that area. For example in Tampa Bay using Tampa Bay plants, *Thalassia testudinum* restorations should be set at a ratio of 1/0.50 or 2 acres restored to 1 acre impacted.

Vulnerability 2: Inadequate Water Supply

A drought is defined as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area." (Glossary of Meteorology 1959). In easier to understand terms, a drought is a period of unusually persistent dry weather that lasts long enough to cause serious problems such as crop damage and/or water supply shortages. The severity of the drought depends upon the degree of moisture deficiency, the duration, and the size of the affected area. There are actually four different ways that drought can be defined. A **meteorological drought** is a measure of departure from normal amounts of precipitation. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought somewhere else. This type of drought generally ranges in duration from a period of months to years. An **agricultural drought** refers to a situation in which the amount of moisture in the soil no longer meets the needs of a particular crop. A **hydrological drought** occurs when surface and subsurface water supplies are below normal. A **socioeconomic drought** refers to the situation that occurs when physical water shortages begin to affect people. No region in North America is immune to periodic droughts; in any given year, at least one region experiences drought conditions (FEMA). Drought is a normal part of virtually every climate on the planet, even rainy ones.

Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks are defined as extreme heat. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Excessively dry and hot conditions can provoke dust storms and low visibility. A heat wave is an extended time interval of abnormally and uncomfortably hot and unusually humid weather. To be a heat wave, such a period should last at least one day, but conventionally it lasts from several days to several weeks (Florida Division of Emergency Management (FDEM)).

A prolonged drought can have serious economic impacts on a community. Increased demand for water and electricity may result in shortages. Moreover, food shortages may occur if agricultural production is damaged or destroyed by a loss of crops or livestock. Heat related illness can be very serious for the elderly, small children, chronic invalids, overweight individuals, and those taking certain medications, drugs, or alcohol.

Impacts on transportation include: aircraft losing lift at high temperatures; highways and roads being damaged by excessive heat; asphalt roads softening; concrete roads "exploding", lifting three- to four- foot pieces of concrete; stress on automobile cooling systems, diesel trucks, and railroad locomotives, leading to an increase in mechanical failures; and train rails developing sun kinks and distortion. Refrigerated goods experience a significantly greater rate of spoilage due to extreme heat (FEMA).

The electric transmission system is impacted when power lines sag in high temperatures. During the summer of 1996, a major west coast power outage impacting four states was blamed in part on extreme high temperatures causing sagging transmission lines to short out. The combination of extreme heat and the added demand for electricity to run air conditioning also causes transmission line temperatures to rise, further stressing the system (FEMA).

The demand for water increases during periods of hot weather. In extreme heat waves, water is used to cool bridges and other metal structures susceptible to heat failure. This causes reduced water supply and pressure in many areas. This can significantly contribute to fire suppression problems for both urban and rural fire departments (FEMA). Potable water for drinking is in higher demand, and more water for irrigation is needed due to higher evapotranspiration rates in the hotter, drier conditions.

The rise in water temperature during heat waves contributes to the degradation of water quality and negatively impacts fish populations. It can also lead to the death of many other organisms in the water ecosystem. High temperatures are also linked to rampant algae growth, causing fish kills in rivers and lakes (FEMA).

Charlotte County is susceptible to drought. This is especially the case during the dry season, January through May. Droughts can lead to agricultural damage, shortage of drinking water, environmental damage, and shortage of water needed for utilities and firefighting. As the climate changes, increased air temperatures will cause increased evaporation, contributing to drought conditions. Droughts can be expected to become more frequent and severe, necessitating the development of water conservation measures as well as alternative sources for potable and irrigation water.

While drought does not cause a direct impact on structures that can be measured in terms of numbers of building or total value, it can impact the county. The risk analysis for drought focuses on the agricultural elements of the County.

According to the National Climactic Data Center of NOAA (2007), no drought events were reported in Charlotte County between January 1, 1950 and September 30, 2004. The drought season in 1998 was severe. It led to conditions were over 100 wildland fires burned over 1,000 acres throughout Charlotte County. The drought provided conditions that enhanced vandal initiated fires.

The impacts of drought are greater than the impacts of any other natural hazard. They are estimated to be between $6 billion and $8 billion annually in the United States and occur primarily in agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

Charlotte County is, always has been, and always will be vulnerable to drought. This is hard to believe since Charlotte County is adjacent to the Gulf of Mexico and has many waterways. However, these are not sources of drinking water and when water levels are low in both the Peace and Myakka Rivers, water treatment plants and sewer treatment plants lose their resource to draw water from. One way to help prevent a drought is to put in place water use restrictions during the dry season in areas most vulnerable to drought. This is already done to some extent through ordinances, however, due to budget and staff constraints, these ordinances are not well enforced except during extreme conditions. In the future, we can expect this problem to become more evident because of the increase in population and therefore a higher demand on water resources.

The assets most at risk to drought in Charlotte County include agricultural interests. The 1995-1996 growing season yielded 5,252,000 million boxes of citrus fruit. This fruit came from 2,695,200 citrus trees on 23,107 acres (11% of total agricultural acreage) of land. There are also 4,000 acres in vegetables (2% of agricultural acreage) consisting of watermelon, potatoes, eggplant, tomatoes, squash, peppers, cabbage and cucumbers. There are 174,000 acres of cattle grazing pastures (87% of agricultural acreage) and 216 farms making up 227,202 acres. (August 1998Charlotte Community CCP profile).

Table 13: Adaptations to Address Inadequate Water Supply and Drought (from public workshops)

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples	Level of Support (%)
Require municipal use of xeriscaping	Inadequate Water Supply		Reduction in the need for irrigation.	Availability of a variety of xeric plant material	City of Punta Gorda Landscape Ordinance; CHNEP: Plant Native Day: February 25, 2006	100
Build xeriscaping into codes and educate homeowners	Inadequate Water Supply		Reduction in the need for irrigation.	Availability of a variety of xeric plant material	CHNEP: Plant Native Day: February 25, 2006, Demonstration Garden showing native grasses of the area by the CHEC Water Resource Center	85
Use native plants in landscaping	Inadequate Water Supply		Reduction in the need for irrigation.	Availability of a variety of native plant material	CHNEP: Plant Native Day: February 25, 2006, Butterfly Gardening with Native Plants, Demonstration Garden showing native grasses of the area by the CHEC Water Resource Center	85
Comprehensive planning	Inadequate Water Supply		The process determines community goals and aspirations in terms of community development over a long-term time horizon.	Florida legislature continues to weaken provisions	FS 9J-5	67.5

Consider climate change in water supply planning	Inadequate Water Supply		Provides a more accurate picture of available future water sources. Does not commit to sources that will not be there.	Uncertainty in future climate change scenarios	CHNEP: Water Planning Alliance Regional System Planning and Engineering Study, Southern Water Use Caution Area (SWUCA) Recovery Strategy	67.5
Improved system of retaining rainwater	Inadequate Water Supply		Reduction in the use of potable water for irrigation.	May require extra physical space for retention		67.5
Cisterns/rain barrels	Inadequate Water Supply		Reduction in the use of potable water for irrigation.	Pest control to reduce or eliminate mosquitoes	Now allowed under 2008 LDRs, CHNEP: Charlotte County Rain Garden, Rain Barrel Workshops with Polk County Schools, Florida Yards and Neighborhood Rain Barrel Workshop	67.5
Drought preparedness planning	Inadequate Water Supply and Fire		Provides a more accurate picture of future water sources. Does not commit to sources that will not be there.	Uncertainty in future climate change scenarios	CHNEP: Water Planning Alliance Regional System Planning and Engineering Study, Water Supply Flow Monitoring Project	67.5
Conservation education	Inadequate Water Supply		Increases water conservation voluntarily	Cost. Changing population continues to need education	CHNEP: Water Conservation Hotel and Motel Program (Water C.H.A.M.P.), Florida Yards and Neighborhoods Water Conservation Workshops	67.5
Minimize impervious surfaces to increase recharge	Inadequate Water Supply	Water Quality Degradation	Reduces runoff	Change in expectations for infrastructure		50

Use of grey water for irrigation	Inadequate Water Supply		Reduction in the use of potable water for irrigation.	Cost of grey water system	CHNEP: Punta Gorda - Reuse Feasibility Study Potential City of Punta Gorda partnership with Charlotte County & SWFWMD to utilize treated water from the County to irrigate US 41 plants rather than the City's potable water.	50
Conservation	Inadequate Water Supply		Reduces demand and allows more water resources for other uses	Conservation benefits can be eliminated by subsequent increase in population that absorbs conservation savings	CHNEP: Water Conservation Hotel and Motel Program (Water C.H.A.M.P.), Florida Yards and Neighborhoods Water Conservation Workshops	37.5
Re-price water on a sliding scale	Inadequate Water Supply		Can provide incentive to use less water	Can negatively impact some businesses that by their nature require high water use		37.5
Reservoir(s)	Inadequate Water Supply		Potential to increase water availability in dry periods by wet season storage	Vulnerable to climate change variability; Cost of land, Cost of construction, costs of maintenance and operation; Impacts to native habitats; Can discourage conservation; Can negatively impact stream flows to meet reservoir	CHNEP: PR/MRWSA Reservoir, Regional Integrated Loop System Phase1A, 2 , 3 Interconnect, Peace River Regional Reservoir Expansion	37.5

				demands		
Use of reclaimed water for irrigation	Inadequate Water Supply		Reduction in the use of potable water for irrigation.	Reclaimed water has higher nutrient levels than well, potable or rain water. Use in irrigation can discharge nutrients to surface waters	CHNEP: Tern Bay Reclaim Water Line, Charlotte County, Charlotte County Regional Reclaimed Water Expansion, US 41 W. Tarpon to Orange Reclaimed Water and Wastewater, Punta Gorda - Reuse Feasibility Study	37.5
Protect groundwater sources	Inadequate Water Supply		Provides higher ground water quality and quantity	Reduces types of land uses and water uses	CHNEP: USGS surface-water and groundwater stations, Polk County - Aquifer Recharge Project to Relieve Flooding & Augment Groundwater Supplies	37.5
Control invasive exotic species	Inadequate Water Supply	Fish and Wildlife Habitat; Fire	Maintains and increases habitat; Reduces negative impacts such as encrusting by Zebra mussels	Cost	CHNEP: Effects of Invasive Exotic Vegetation on Wetland Functions, Tippecanoe East Exotic Species Project, FWC Exotic Freshwater Fishes Poster, Southwest Florida Exotic Species Workshop: December 2006, Invasive exotics: A Homeowners Guide	37.5
Increase tree cover to reduce evaporation from ground	Inadequate Water Supply	Fish and Wildlife Habitat; Fire	Provides improved micro-climate; Reduces water demand; Can reduce energy use	Cost of installation and maintenance	Continuation of City tree planting through donations, grant monies (JPA/LAP money from DOT	37.5

Acquire land for recharge	Inadequate Water Supply	Fish and Wildlife Habitat	Improved green space	Cost of acquisition; It is often hard to leave "empty" land alone without other uses than recharge	CHNEP: CF Industries Aquifer Recharge and Recovery Project (H062), Polk County - Aquifer Recharge Project to Relieve Flooding &Augment Groundwater Supplies	37.5
Increase stormwater management capacity	Inadequate Water Supply	Water Quality Degradation	Reduces runoff and flooding; Can retain water for reuse	Cost to construct; May require significant land area	CHNEP: Recommend basin rule approach and modification of "Stormwater Design Criteria" (Harper Method) Letter to FDEP, Stormwater Management WQ Improvements and Restoration -SFWMD	37.5
Install rainfall sensors to reduce automatic irrigation	Inadequate Water Supply	Water Quality Degradation	Reduces unnecessary water use; Reduces runoff	Cost to install and maintain	City of Punta Gorda Codes require sensors on irrigation	37.5
Create redundancy in water supply	Inadequate Water Supply	Economy	Reduces variability in water supply	Cost		25
Encourage composting and mulching to reduce irrigation	Inadequate Water Supply	Water Quality Degradation	Reduces use of water and fertilizers	Cost of location, operations and transportation if the mulching is centralized		25
Limit development	Inadequate Water Supply and Fire	Water Quality Degradation	Reduces water use demands and costs for water supply planning and development	Contrary to current Florida practices; Discouraged by the current Florida Legislature	City of Sanibel, CHNEP: Do upland drainage alterations contribute to degradation of estuarine creek habitats? Adding water quality analysis as an evaluation tool	25

Identify alternative sources	Inadequate Water Supply		Increases options for water suppliers	Dos not create any new water; Alternative water source may already be needed to satisfy environmental demands	SWFWMD, SFWMD	25
Charge more for certain uses	Inadequate Water Supply		Can reduce the amount of water used for those certain uses	Those who want to use water for those certain uses will object		25
Restore natural accretion processes	Inadequate Water Supply	Water Quality Degradation	Improves hydrology and reduces salt-water intrusion; Protects surficial aquifer	May interfere with other human uses such as damming for reservoirs, deep channels for yacht use, and fast drainage.		25
Reduce runoff into streams	Inadequate Water Supply	Water Quality Degradation	Saves water for reuse; Improves hydroperiod	May be perceived to cause local flooding	CHNEP: Filter Marsh & BMP Maintenance, IFAS BMP Implementation for Flatwoods Citrus (H528), BMP Programs - SFWMD	25
Control sprawl	Inadequate Water Supply and Fire	Water Quality Degradation	Reduces a wide variety of environmental and socioeconomic impacts	Contrary to current Florida practices; Discouraged by the current Florida Legislature	Pre-2050 Sarasota County Comprehensive Plan	25
Look at possibility of desalinization	Inadequate Water Supply		Provides information on costs and benefits of desalination	Desalination should be an option of last resort due to costs and environmental impacts		12.5

Change ordinances that require vegetation such as turf grass	Inadequate Water Supply	Water Quality Degradation	Can reduce water use ; Increase options for public ; More adaptive to climate change	Contrary to old style landscaping practices ; will be opposed by UF IFAS turf scientists and turf industry	City of Punta Gorda is currently monitoring test plots on several varieties of native grasses and artificial sod	12.5
Control fertilizer use	Inadequate Water Supply	Water Quality Degradation	Protects water quality; Reduces algae blooms; Enhances fishery ; Maintains and increases habitat	State regulated with weak preemption; Cost	SWFRPC Resolution(07-01) March 15, 2007, Charlotte County Fertilizer Ordinance 2008-028	12.5
Restrict fertilizer use	Inadequate Water Supply	Water Quality Degradation	Protects water quality; Reduces algae blooms; Enhances fishery ; Maintains and increases habitat	State regulated with weak preemption; Cost	SWFRPC Resolution(07-01) March 15, 2007, Charlotte County Fertilizer Ordinance 2008-028	12.5
All measures to reduce local GHG emissions	Inadequate Water Supply	Flooding	Contributes to reduction of a source of global warming and climate change	Cost; Will be a small subset of a much larger solution		12.5
Reinforce existing infrastructure	Inadequate Water Supply	Fire	Protects against windstorms and climate instability	Cost		12.5
Acquire land for flood/water supply	Inadequate Water Supply	Flooding; Fire	Reduces flooding; Increase water available for water supply uses	Costs of acquisition		12.5
Restriction on uses	Inadequate Water Supply	Fire	Reduction in the use of potable water for irrigation.	Could be contrary to State Burt Harris Act		12.5

Require use of xeriscaping	Inadequate Water Supply		Reduction in the use of potable water for irrigation.	Availability of a variety of xeric plant material		12.5
Water reuse replace irrigation on public land	Inadequate Water Supply		Reduction in the use of potable water for irrigation.	Cost; Reuse water from wastewater treatment can have nutrients that increase surface water pollution		12.5
Charge more for treated water similar to Sarasota	Inadequate Water Supply		Can reduce water use and water demand increasing available supply	Will be opposed by water users		12.5
Minimize use of potable water for irrigation	Inadequate Water Supply		Reduction in the use of potable water for irrigation. Increase in available water supply	Can reduce revenue to water utility		12.5
Desalinization	Inadequate Water Supply		Can provide an apparent "unlimited" supply of water	High costs; Negative environmental impacts from reject discharge, inflow entertainment and alterations in source water and receiving waters hydrology and water chemistry		12.5

Identify conflicting policies between programs	Inadequate Water Supply	Fire	Provides information on institutional and governmental barriers to protecting water supplies	Can reduce intergovernmental coordination when conflicts are exposed; Could engender pre-emption by Federal or State entities that desire to climate conflict in favor of their authority		12.5
Channel water from impervious to pervious areas	Inadequate Water Supply		Reduces run-off; Improves groundwater recharge	Cost of design and construction		12.5
Don't lower drinking water standards	Inadequate Water Supply		Protects public health	May be costly to maintain higher standards		12.5
Agricultural water reuse	Inadequate Water Supply		Conserves water use by largest water user with potential substantial amounts	Can be in conflict with established practices; Much of agricultural activity is exempted by state rules; Needs to be incentivized to obtain voluntary compliance		12.5

Table 14: Adaptations to Inadequate Water Supply and Drought Recommended Against (from the public workshop)

Build xeriscaping into codes	Inadequate Water Supply			Availability of a variety of xeric plant material		Recommended Against
Desalinization *energy requirements*	Inadequate Water Supply					Recommended Against
Stop fertilizer use	Inadequate Water Supply					Recommended Against
Charge impact fees for non-drought-tolerant lawns	Inadequate Water Supply					Recommended Against
Stabilize upland development sites	Inadequate Water Supply					Recommended Against
Change ordinances that require vegetation such as turf grass	Inadequate Water Supply					Recommended Against
Re-price water on a sliding scale	Inadequate Water Supply					Recommended Against
Cap and trade water	Inadequate Water Supply					Recommended Against

ADAPTATION: Florida Friendly Native Landscaping

Florida Friendly Native Landscaping was the most popular adaptation measure proposed to address climate change impacts in the City of Punta Gorda to water supply and drought. Three related topics had the greatest support:

- Require Municipal Use of Xeriscaping
- Build Xeriscaping into Codes and Educate Homeowners
- Use Native Plants in Landscaping.

All three adaptations are geared to reducing the need for irrigation while increasing the drought hardiness of the planted landscape.. The following is a discussion on how this adaptation could be implemented for the City of Punta Gorda.

The concept of xeriscaping was created in Denver Colorado in the late 1970's to develop landscapes that required little to no additional water through irrigation. In Florida, the concept of xeriscaping has been incorporated in the University of Florida Extension Service's "Florida Yards and Neighborhoods" (FYN) Program and less formal "Florida Friendly" landscaping programs of the Water Management Districts. The Southwest Florida Water Management District partners with the university to provide the education outreach by supporting FYN programs through county Extension offices in 11 of its 16 counties, including Charlotte County.

Florida-friendly landscaping can be considered an expansion of xeriscaping. A Florida-friendly yard goes beyond xeriscaping to better fit our unique landscape and climate. It includes best management practices concerning stormwater runoff and living on a waterfront. A properly maintained Florida-friendly yard can help homeowners conserve water and reduce pollution of water resources. . Both FYN and Florida Friendly programs approach to landscaping emphasizes nine interrelated principles including:

- Right plant, right place
- Water efficiently
- Fertilize appropriately
- Mulch
- Attract Wildlife
- Manage yard pests responsible
- Recycle
- Reduce stormwater runoff
- Protect the waterfront.

All nine principals serve to save water and reduce non-climate stresses on the environment. The Charlotte Harbor National Estuary Program (CHNEP) recommends native plants as the ones that are best suited to the local environment, even with a changing climate.

Florida's Nest Native Landscape Plants: 200 Readily Available Species for Homeowners and Professionals by Gil Nelson was prepared with the assistance of the Association of Florida Native Nurseries. This book provides lists of companion plants for each presented. In this way,

where one plant is known to thrive, associated companion plants will thrive as well, with similar irrigation (or lack of irrigation) regimes.
Due in large measure to native plant requirements and their popularity, native plant material is becoming more available.

Though no native nurseries are listed for Charlotte County, these are in neighboring counties:

Deluxe Trees
Charlie or Darlene Foster
6306 SW Carlton Ave
Arcadia, FL 34266
Phone: 863-494-1488
Phone: 561-718-9145
Fax: (863)993-936

Florida Native Plants
Laurel Schiller
730 Myakka Rd
Sarasota, FL 34240
Phone: 941-322-1915
Fax: 941-322-0208
Email: FNPLANTS@mailmt.com
Web: www.floridanativeplants.com

All Native Garden Center & Plant Nursery
John Sibley
300 Center Rd
Fort Myers, FL 33907-1513
Phone: 239-939-9663
Phone: (239)671-9663
Fax: (239)936-8504
Email: nolawn@earthlink.net
Web: www.nolawn.com

Riverland Nursery
Mayer Berg
13005 Palm Beach Blvd
Fort Myers, FL 33905
Phone: 239-693-5555
Phone: 612-760-3675
Fax: 239-693-8080
Email: mayer@riverlandnursery.com
Web: www.riverlandnursery.com

SCCF Native Plant Nursery
Jenny Evans
3333 Sanibel-Captiva Rd
Sanibel, FL 33957-3100
Phone: 239-472-1932
Fax: 239-472-6421
Email: jevans@sccf.org
Web: www.sccf.org

Furthermore, the Florida Native Plant Society is an excellent resource. The Mangrove Chapter serves Punta Gorda and environs (http://mangrove.fnpschapters.org/).

In 2005, the City of Punta Gorda changed its codes which required 100% sod and now have a xeriscaping allowance. The FY05/06 Strategic Budgeting included xeriscaping as a way to reduce Utility costs.

In 2008, the City of updated its Comprehensive plan. The Conservation and Coastal Management Element includes many policies directed to reducing water consumption with landscape choices and increasing the use of native plants. Conservation and Coastal Management Element policies are related to landscaping practices include:

> Policy 2.1.2.12: Punta Gorda will protect native vegetative communities by engaging in the removal of invasive exotic vegetation (e.g., Brazilian pepper), by including native species in the plants allowed under the landscaping ordinance, and by including native plants in public planting areas. *Measurement: Invasive exotic removal activities, landscape plant list, plantings of native plants in public areas.*
>
> Policy 2.1.3.6: The City will continue to promote conservation of individual potable water consumption through implementation of education and outreach programs encouraging water conservation and Florida friendly landscaping. *Measurement: The inclusion of the water conservation provisions and Florida friendly landscaping requirements into the Land Development Regulations.*
>
> Objective 2.3.2: Restore the landscaping of native species and removal of exotics.
>
> Policy 2.3.2.1: Seek matching grant funding opportunities for exotic species removal and native species restoration stands citywide. *Measurement: Number of grants received.*
>
> Policy 2.3.2.2: Implementation and enforcement of land development regulations which require exotic species removal and require native species plantings in conjunction with development projects. *Measurement: Number of Land Development Regulations (LDR) and Code Enforcement Violations.*

The City of Punta Gorda can use provided recommendations (below) to improve the comprehensive plan through the EAR process:

- Include native species in the plants allowed under the landscaping ordinance;
- Including native plants in public planting areas;
- Implement education and outreach programs encouraging Florida friendly landscaping (and native plants).
- Implement and enforce land development regulations which require exotic species removal and require native species plantings in conjunction with development projects.

Vulnerability 3: Flooding

Hurricanes, Tropical Storms and Sub-threshold Coastal Storms

Hurricane season is especially brutal on southwest Florida. No one lives more than 75 miles from the coast. Storms have effects wherever they strike, but they have particularly heavy impacts in coastal areas. Storm surges, wave action, high winds, and heavy rainfall can all combine to produce effects that disrupt normal activities, damage property, and injure people (Florida Sea Grant Coastal Storms website).

South Florida is subject to more hurricanes than any other area of equal size in the United States (Gentry 1974), and receives both Atlantic and Caribbean hurricanes. Of the 38 hurricanes that passed over southwest Florida from 1901 to 1971, 30 occurred in the August to October timeframe (Jordan 1973). Tropical storms strike, on average, once every three years in southern Collier County and once every five years in the northern extents of the Southwest Regional Planning Council area (Bamberg 1980). The three primary climatic effects of hurricanes are high wind, storm surge, and heavy rain. Because wind force increases by the square of the wind speed, a 93 mph wind exerts four times as much force as a 47 mph wind. When hurricane winds attain 249 mph, as in the 1935 Labor Day hurricane, the effects on, for example, forested ecosystems, including tree fall, substrate disturbance, and propagule (cone) distribution, can be considerable. Hydrometerological hazards associated with hurricanes include coastal flooding caused by storm surge; windstorms due to extremely strong winds; riverine flooding caused by heavy rains; and, tornadoes. The low, sea level hugging topography, over-population of the near coastal zone, and limited to inadequate evacuation and shelter systems place southwest Florida in the danger zone for major disasters.

Between 1873 and 1993, Southwest Florida experienced forty-nine tropical cyclones of hurricane intensity. The map below shows the hurricanes that passed by and through the region (Southwest Florida Regional Hurricane Evacuation Study 2005).

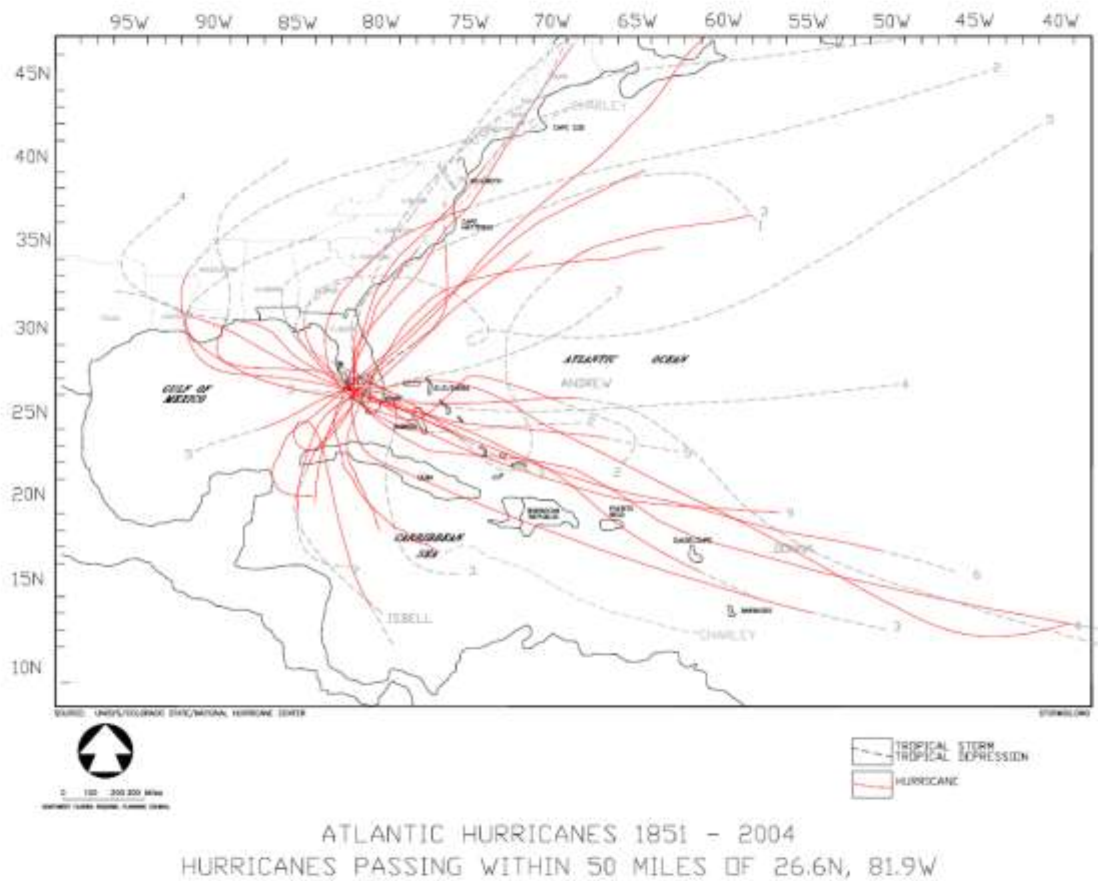


Figure 32: Atlantic hurricanes passing within 50 miles of 26.6 N latitude, 81.9 West longitude

Source: Charlotte County- City of Punta Gorda Local Mitigation Strategy, SWFRPC 2005

In just the ten years between November 13, 1994 and November 30, 2004, the National Climactic Data Center of NOAA (2007) reported a total of 15 hurricane and tropical storm events in Southwest Florida. These events alone resulted in 16 deaths and 833 injuries. An estimated $5.8 billion in property damage and $300.5 million in crop damage was attributed to these events.

While studies have shown that there is no clear, long-term trend in the number of tropical storms (IPCC 2007b; Webster et al. 2005), there have been changes in storm frequency over periods of a few decades. Southwest Florida is currently in an active period (Goldenberg et al. 2001). Also, the power of Atlantic tropical cyclones is rising rather dramatically and the increase is correlated with an increase in the late summer/early fall sea surface temperature over the North Atlantic.

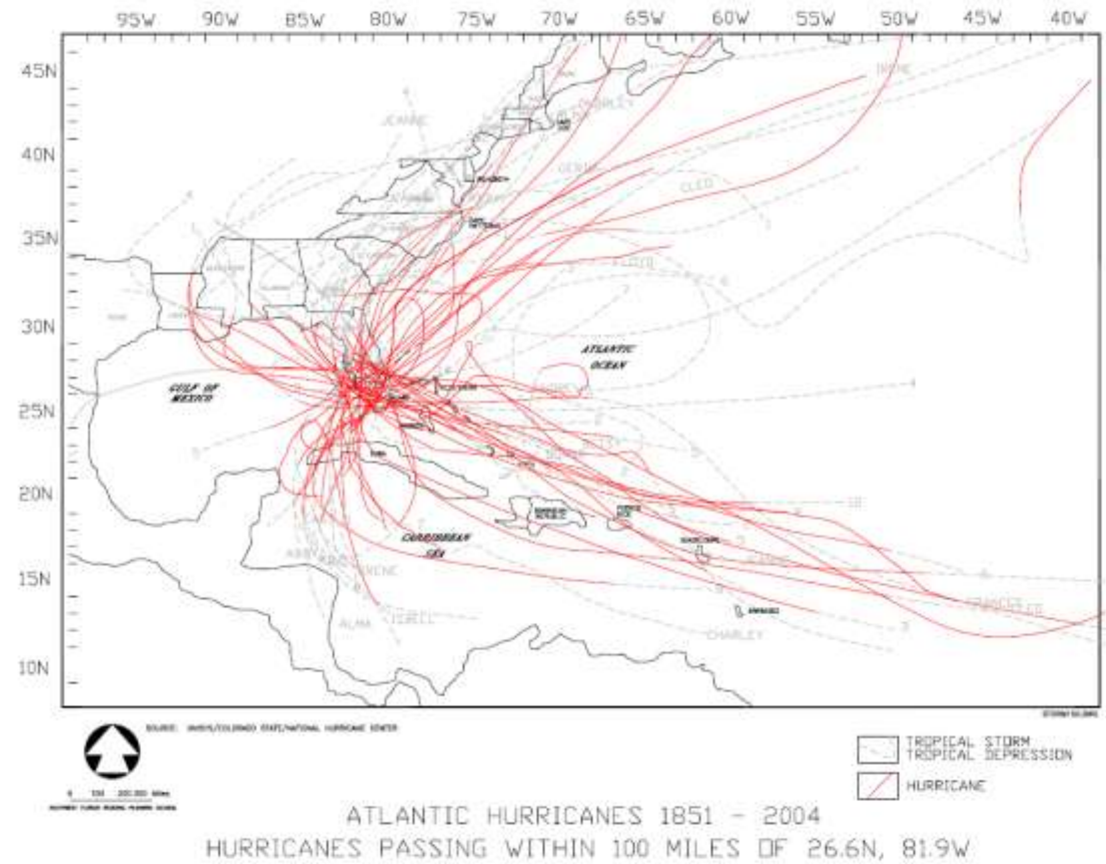


Figure 33: Atlantic hurricanes passing within 100 miles of 26.6 N latitude, 81.9 West longitude

Source: Charlotte County- City of Punta Gorda Local Mitigation Strategy, SWFRPC 2005

Potential Impacts

Climate change is likely to worsen hurricanes, but precise effects are uncertain. Higher water temperatures in the Gulf of Mexico and Atlantic Ocean may cause more intense hurricanes, which will cause more damage to coastal and inland habitations, infrastructure and human economy (Elsner 2006; Peterson et al. 2007; USNOAA 2008; USEPA CRE 2008). Damage will multiply as the effects from more intense hurricanes are added to more severe storm surges resulting from higher sea levels.

The following analysis of vulnerability including the dollar estimates depends in whole or in part on the *Local Mitigation Strategy for Charlotte County/ City of Punta Gorda 2005,* approved by FEMA on April 28. 2005 with the data analyzed and report produced by the Southwest Florida Regional Planning Council. This data is expressed in 2005 dollars. This has not been adjusted since significant renewal and construction has occurred in the City of Punta Gorda with major public and private investments in infrastructure and a simple inflation conversion would not account for the changes and major infrastructure investments that have occurred in the City, particularly in the downtown and historic district.

All of Punta Gorda's structures fall into a storm zone. The majority of these structures are located in the Category 2 storm zone (67.0%). The majority of the total value is also located in the Category 2 storm zone (58.0%). The tropical storm and Category 1 storm zones contain the next highest number of structures and total value (Table 15 and associated figures below).

It is important to remember that when a storm hits, the impacts of that storm may be felt beyond the boundaries of that storm zone. For example, a Category 3 hurricane will impact properties in the Category 2, Category1, and tropical storm zones as well the properties in the Category 3 storm zone.

Estimated Values for Structures in Punta Gorda by Storm Zone					
Storm Zone	**No. of Buildings**	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
TS	1,442	$276,089,430	$211,214,748	$28,270,334	$515,574,512
1	1,416	$254,127,450	$179,478,880	$49,660,447	$483,266,777
2	6,621	$992,129,339	$553,539,240	$34,112,191	$1,579,780,770
3	274	$41,658,997	$24,165,934	$1,954,230	$67,779,161
4 or 5	233	$28,906,624	$14,849,081	$1,574,800	$45,330,505
Not in Zone	0	$0	$0	$0	$0
Total	**9,986**	**$1,592,911,840**	**$983,247,882**	**$115,572,002**	**$2,691,731,724**

Table 15: Estimated Values for Structures in Punta Gorda by Storm Zone

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

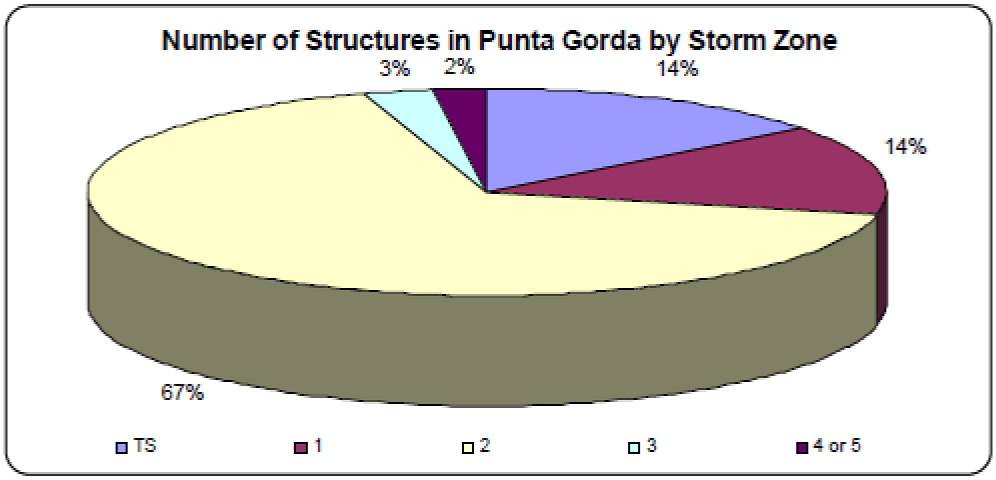


Figure 34: Number of Structures in Punta Gorda by Storm Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

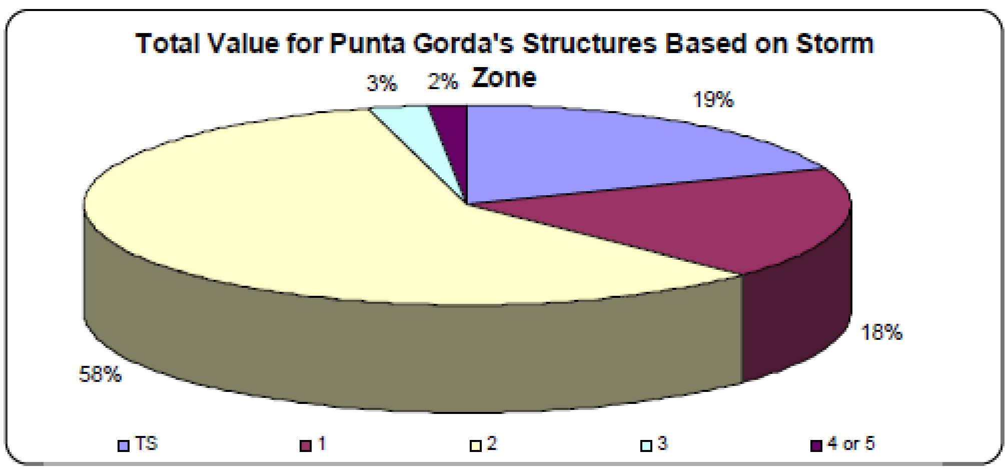


Figure 35: Total Value for Punta Gorda's Structures Based on Storm Category 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

Historic Structures

Approximately 89.0% of the historic structures in Punta Gorda fall in the Category 2 storm zone. This storm zone category also contains approximately 95.0% of the total value.

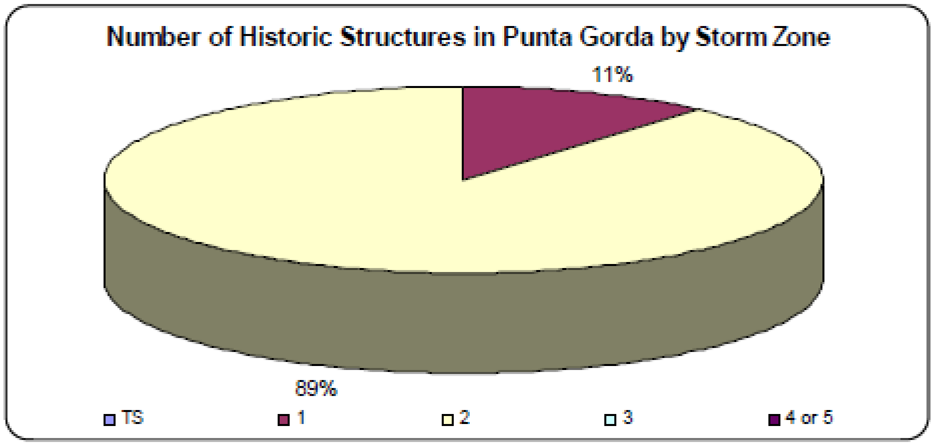


Figure 36: Number of Historic Structures in Punta Gorda by Storm Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

Top Employers

Table 16 shows the breakdown of top employer-owned structures by storm zone. The Category 2 storm zone contains the most structures, but the tropical storm zone, which has the second highest number of structures, contains the highest amount of total value. This storm zone category has 174 structures worth approximately $302 million (Table 16).

Estimated Values for Structures Owned by Top Employers Located in Punta Gorda by Storm Zone					
Storm Zone	**No. of Buildings**	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
TS	67	$67,042,435	$78,162,684	$8,614,050	$153,819,169
1	11	$18,207,004	$18,204,060	$2,733,570	$39,144,634
2	96	$51,508,947	$52,755,551	$4,838,520	$109,103,018
3	0	$0	$0	$0	$0
4 or 5	0	$0	$0	$0	$0
Not in Zone	0	$0	$0	$0	$0
Total	**174**	**$136,758,386**	**$149,122,294**	**$16,186,140**	**$302,066,820**

Table 16: Estimated Values for Structures Owned by Top Employers Located in Punta Gorda by Storm Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

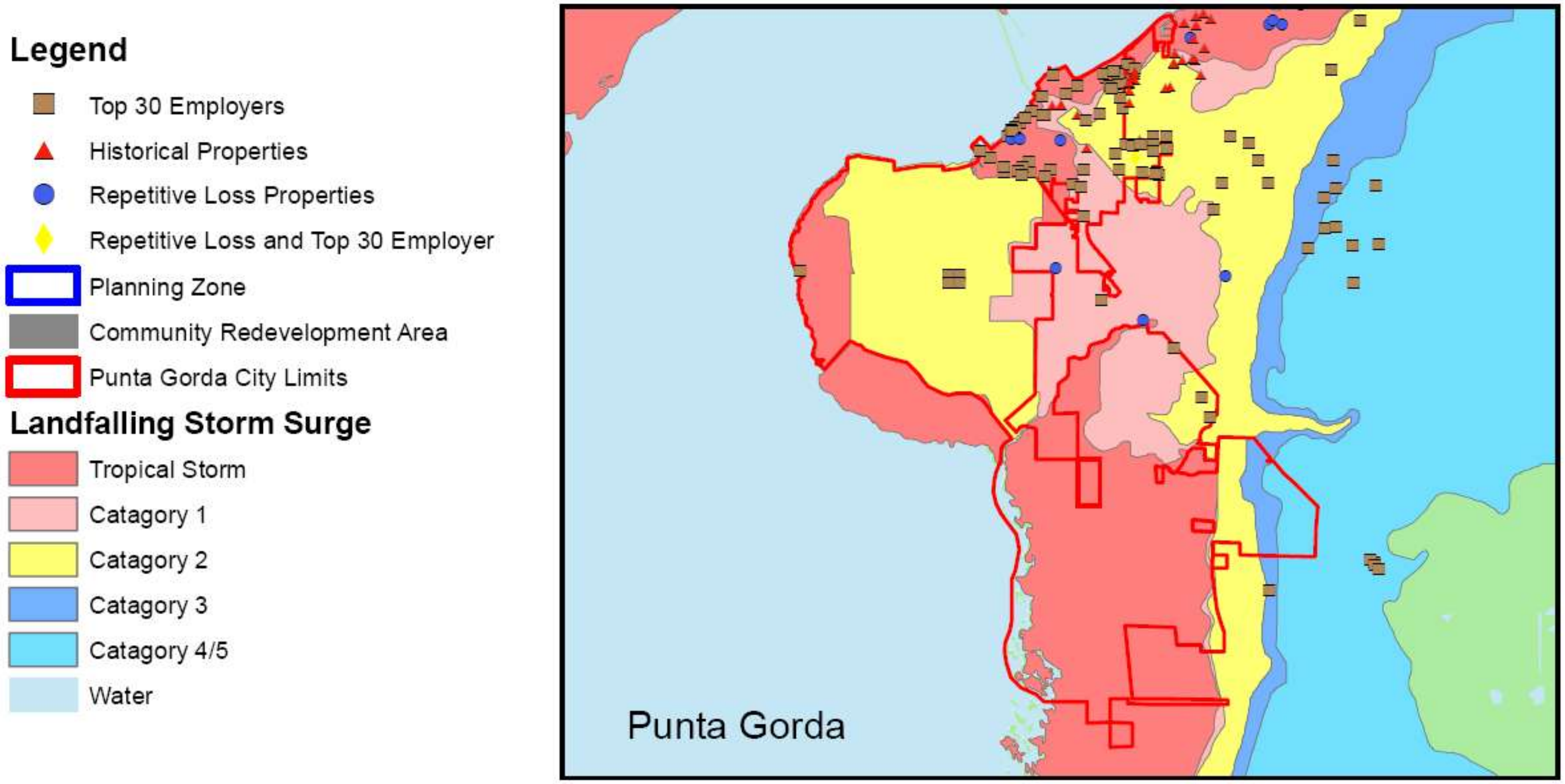
Repetitive Loss Structures

There are four repetitive loss structures located in Punta Gorda. All four of these are also located in the tropical storm zone. They have a building value of $503,016 and a total value of $754,524 (Table 17).

ESTIMATED VALUES FOR REPETITIVE LOSS STRUCTURES LOCATED IN PUNTA GORDA BY STORM ZONE					
Storm Zone	**No. of Buildings**	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
TS	4	$503,016	$251,508	$0	$754,524
1	0	$0	$0	$0	$0
2	0	$0	$0	$0	$0
3	0	$0	$0	$0	$0
4 or 5	0	$0	$0	$0	$0
Not in Zone	0	$0	$0	$0	$0
Total	**4**	**$503,016**	**$251,508**	**$0**	**$754,524**

Table 17: Estimated Values for Repetitive Loss Structures Located in Punta Gorda by Storm Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council



37: Charlotte County Storm Surge and Planning Zones with Top Employers, Historical and Repetitive Loss Properties

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

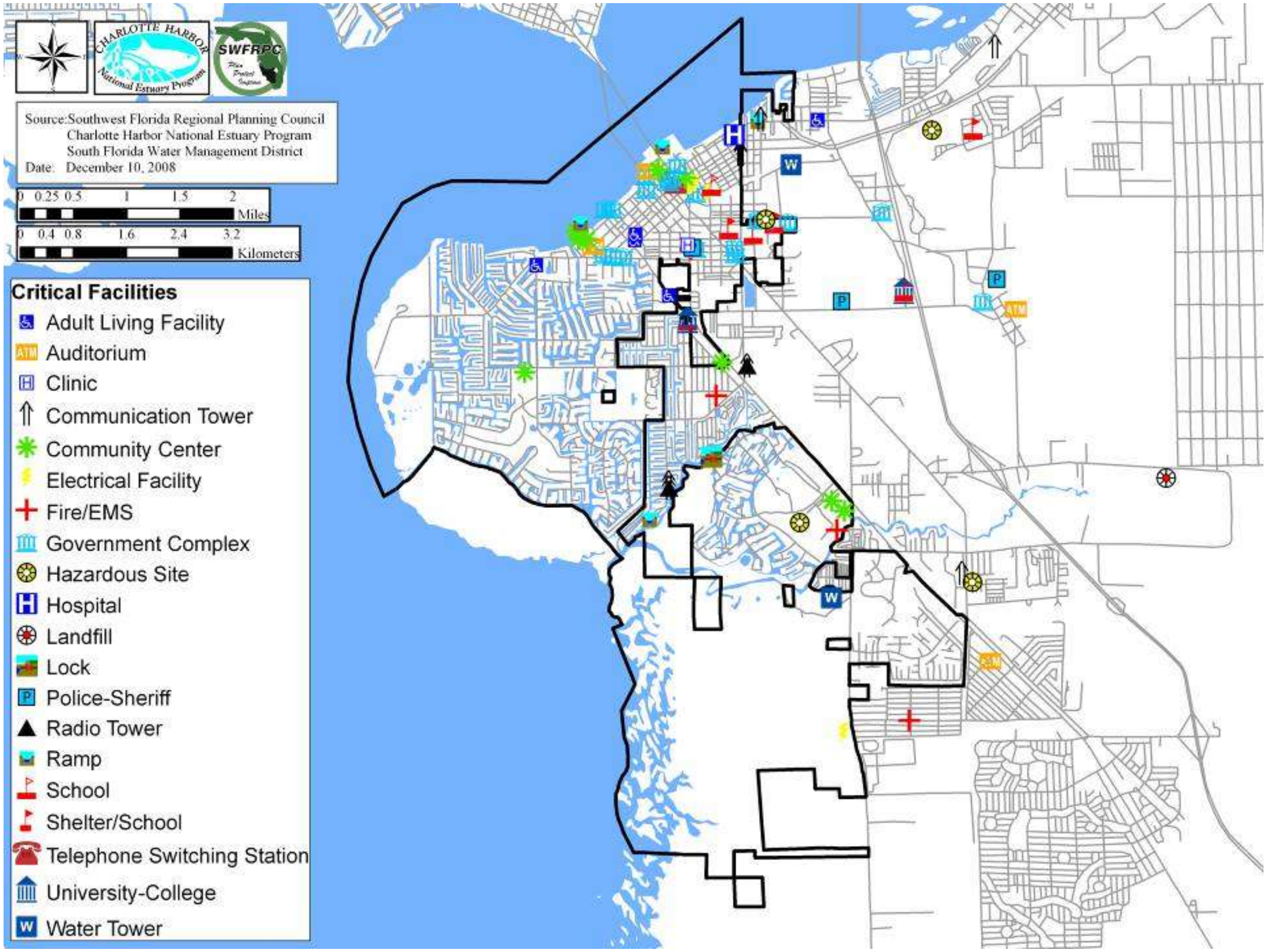


Figure 38: City of Punta Gorda Critical Facilities

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Critical facilities

All of the 147 critical structures in Punta Gorda are located in a storm zone. The Category 2 storm zone has the most structures (70.0%) followed by the Category 1 storm zone (20.0%), and the tropical storm zone (9.0%). The Category 3 storm zone contains the least critical facility structures and no critical facility structures in Punta Gorda are located in the Category 4 and 5 storm zone (Table 17 and associated figures).

ESTIMATED VALUES FOR CRITICAL FACILITIES IN PUNTA GORDA BASED ON STORM ZONES					
Storm Zone	**No. of Buildings**	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
TS	13	$37,067,312	$38,974,173	$1,026,570	$77,068,055
1	29	$16,382,070	$16,621,187	$7,904,418	$40,907,675
2	104	$58,267,412	$58,220,312	$9,917,640	$126,405,364
3	1	$106,038	$53,019	$0	$159,057
4+	0	$0	$0	$0	$0
Not in Zone	0	$0	$0	$0	$0
Total	**147**	**$111,822,832**	**$113,868,691**	**$18,848,628**	**$244,540,151**

Table 18: Estimated Values for Critical Facilities in Punta Gorda Based on Storm Zones 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

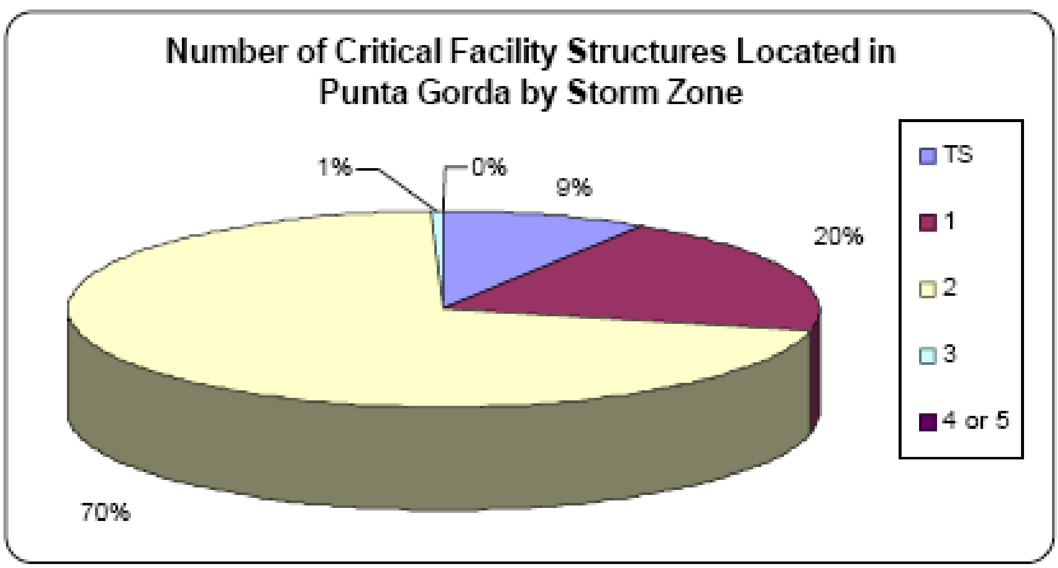
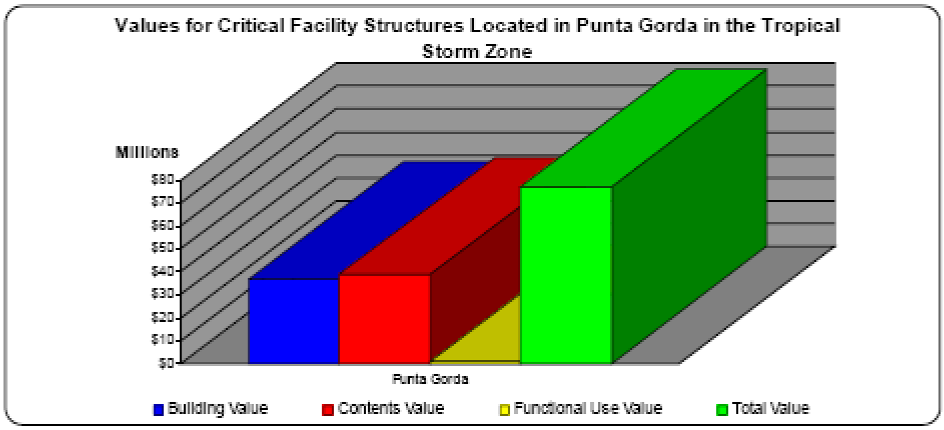
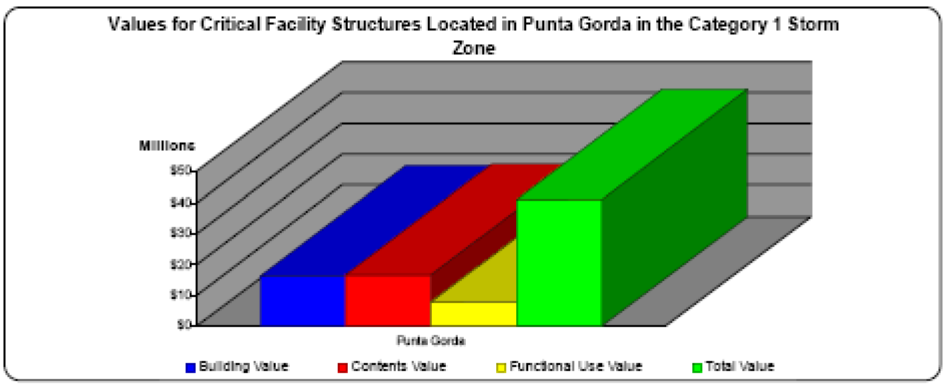
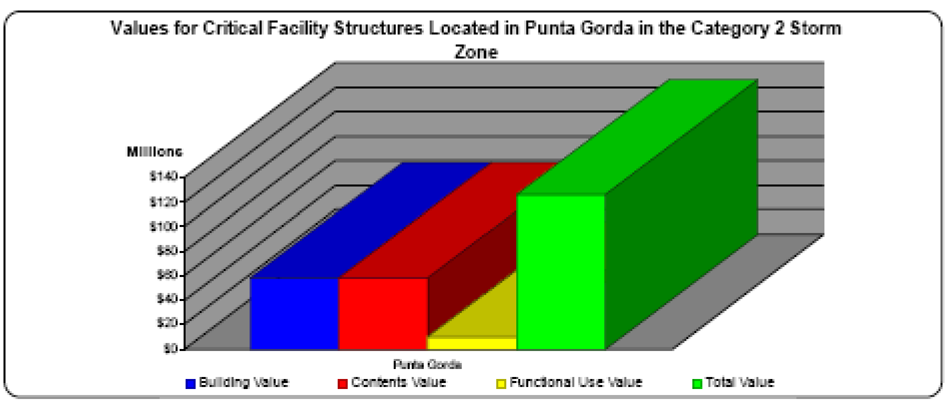


Figure 39: Number of Critical Facilities Located in Punta Gorda by Storm Zone 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

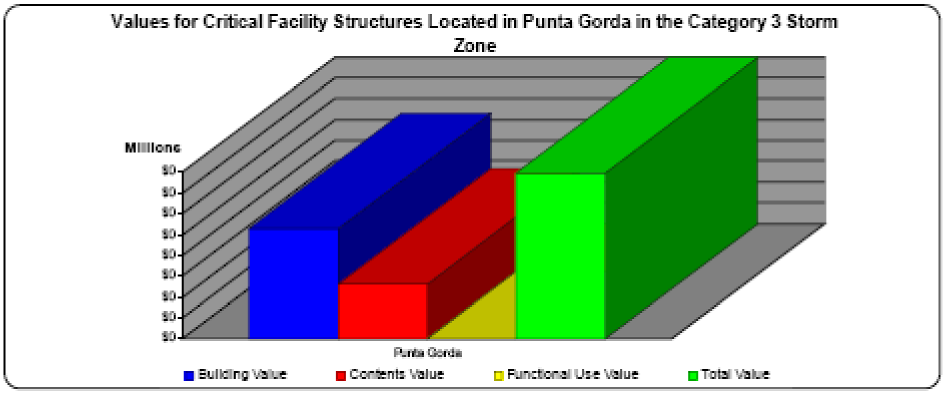


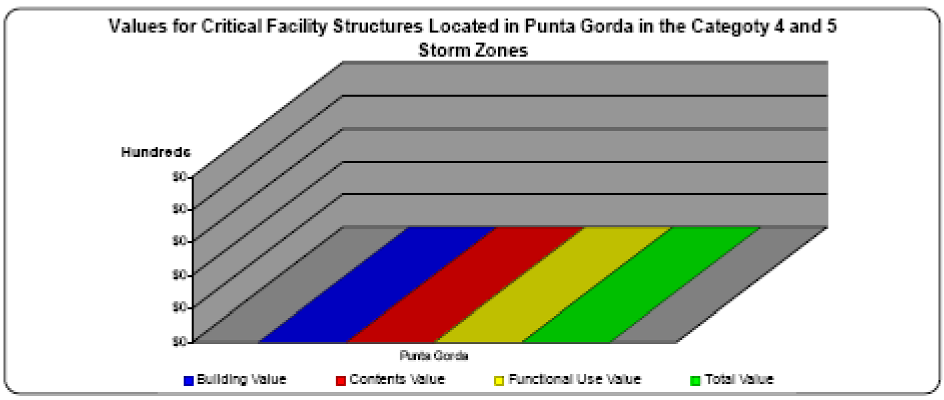




Figures 40-42-35: Values for Critical Facility Structures in Tropical Storm, Category 1, and Category 2 Storm Zones 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy





Figures 43 & 44: Values for Critical Facility Structures in Category 3, 4 & 5 Storm Zones 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

POTENTIAL MINIMUM COASTAL STORM SURGE LOSSES FOR CRITICAL FACILITY STRUCTURES IN PUNTA GORDA				
Storm Zone	**Minimum Building Loss**	**Minimum Contents Loss**	**Minimum Functional Use Loss**	**Minimum Total Loss**
TS	$462,894	$694,342	$143,102	$1,300,339
1	$727,406	$1,091,108	$224,875	$2,043,389
2	$4,905,414	$7,019,914	$1,697,714	$13,623,043
3	$21,478,067	$31,797,050	$4,228,849	$57,503,966
4 or 5	$40,580,738	$60,711,982	$5,620,650	$106,913,370

Table 19: Potential Minimum Coastal Storm Surge Losses for Critical Facility Structures in Punta Gorda 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

POTENTIAL MAXIMUM COASTAL STORM SURGE LOSSES FOR CRITICAL FACILITY STRUCTURES IN PUNTA GORDA				
Storm Zone	**Maximum Building Loss**	**Maximum Contents Loss**	**Maximum Functional Use Loss**	**Maximum Total Loss**
TS	$1,810,483	$2,202,582	$728,351	$4,741,415
1	$2,270,744	$3,126,221	$748,794	$6,145,759
2	$26,583,586	$39,566,095	$4,841,487	$70,991,168
3	$47,396,667	$71,362,593	$5,654,588	$124,413,848
4 or 5	$48,297,639	$72,559,479	$5,654,588	$126,511,707

Table 20: Potential Maximum Coastal Storm Surge Losses for Critical Facility Structures in Punta Gorda 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Tropical Storm Impacts

For a tropical storm event, Punta Gorda can expect $1.3 million in building losses and $2.7 million in total losses under the minimum surge scenario. Under the maximum surge scenario, $47.0 million in building losses and $90.2 million in total losses can be expected (see Tables 21 and Figure 45 below).

POTENTIAL COASTAL STORM SURGE LOSSES FOR PUNTA GORDA FROM A TROPICAL STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$1,307,654	$1,224,109	$143,102	$2,674,865
Maximum	$46,993,755	$40,767,466	$2,461,311	$90,222,532

Table 21: Potential Coastal Storm Surge Losses for Punta Gorda from a Tropical Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

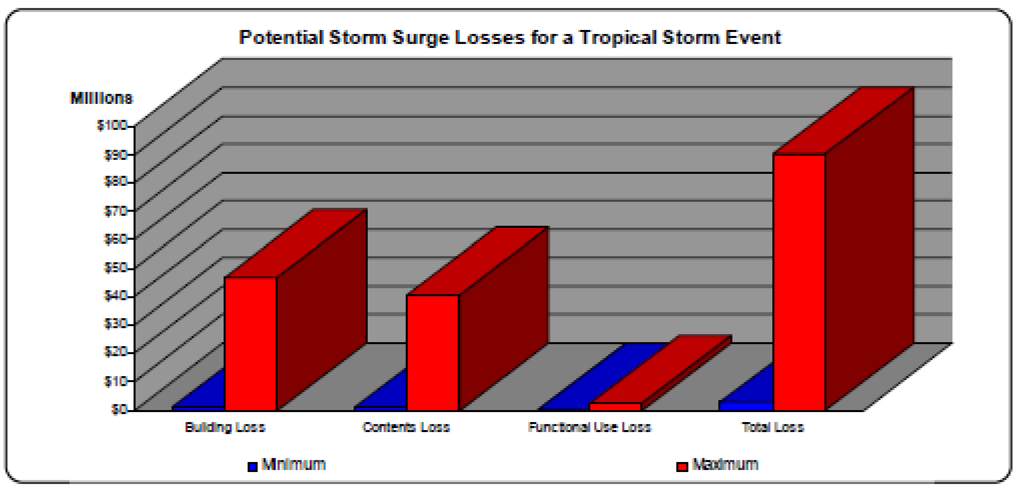


Figure 45: Potential Storm Surge Losses for a Tropical Storm Event 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Tropical storm effects on historic structures

For a tropical storm event, the historic structures in Punta Gorda can expect $40,044 in building losses and $122,082 in total losses under the maximum surge scenario (Table 22 and 46 below).

POTENTIAL COASTAL STORM SURGE LOSSES FOR HISTORIC STRUCTURES IN PUNTA GORDA FROM A TROPICAL STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$0	$0	$0	$0
Maximum	$40,044	$60,066	$21,973	$122,082

Table 22: Potential Coastal Storm Surge Losses for Historic Structures in Punta Gorda from a Tropical Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

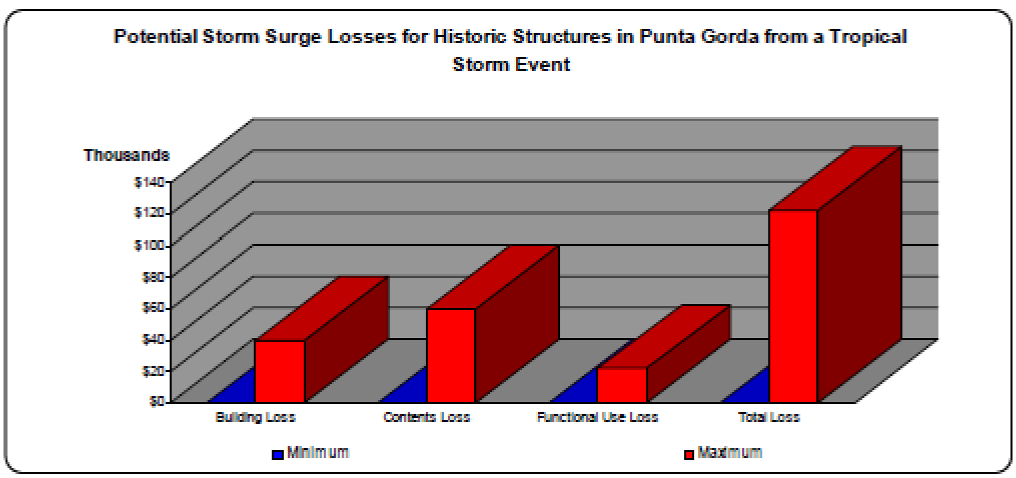


Figure 46: Potential Storm Surge Losses for Historic Structures from a Tropical Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Tropical storm effects on top employers

Charlotte County's top employers with structures located in Punta Gorda can expect $101,497 in building losses and $105,495 in total losses under the minimum surge scenario from a tropical storm event. Under the maximum surge scenario, $3.1 million in building losses and $8.7 million in total losses can be expected (Table 23 and Figure 47).

POTENTIAL COASTAL STORM SURGE LOSSES FOR STRUCTURES OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS IN PUNTA GORDA FROM A TROPICAL STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$101,497	$3,998	$0	$105,495
Maximum	$3,080,109	$5,074,793	$564,426	$8,719,327

Table 23: Potential Coastal Storm Surge Losses for Structures Owned By Punta Gorda's Top Employers from a Tropical Storm 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

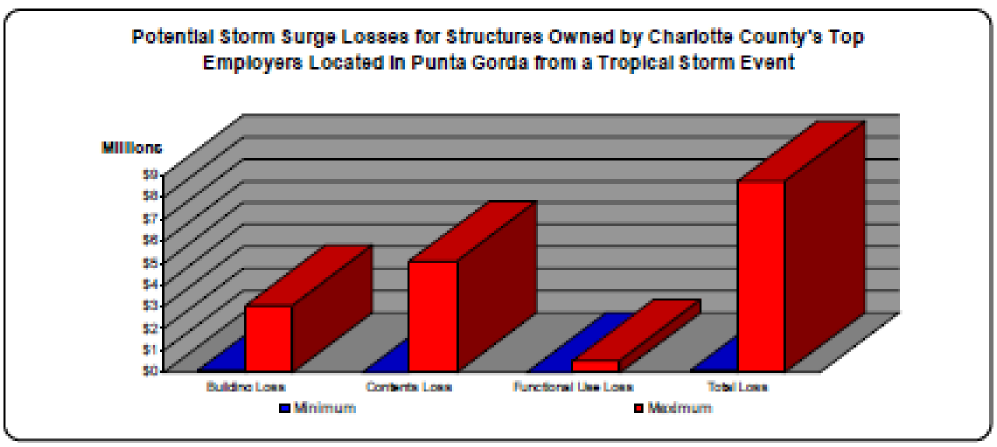


Figure 47: Potential Storm Surge Losses for Structures Owned by Punta Gorda's Top Employers from a Tropical Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Tropical storm effects on repetitive loss structures

Repetitive loss structures located in Punta Gorda can expect $3,762 in building losses and $6,584 in total losses under the maximum surge scenario from a tropical storm event (Table 24 and Figure 48).

POTENTIAL COASTAL STORM SURGE LOSSES FOR REPETITIVE LOSS STRUCTURES IN PUNTA GORDA FROM A TROPICAL STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$0	$0	$0	$0
Maximum	$3,762	$2,822	$0	$6,584

Table 24: Potential Coastal Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Tropical Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

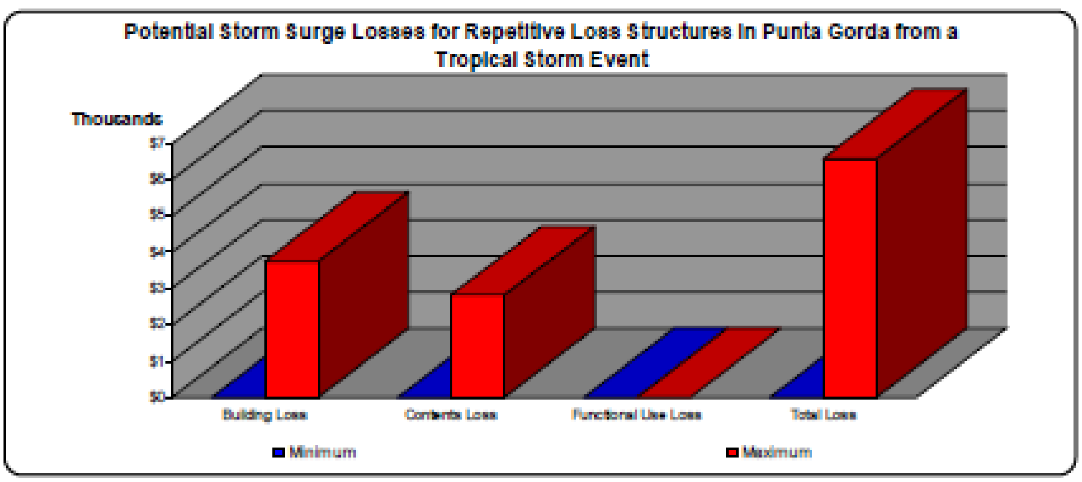


Figure 48: Potential Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Tropical Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Tropical storm effects on critical facilities

A tropical storm event has the potential to create a total building loss ranging from approximately $463,000 to $1.8 million and a total loss of $1.3 to $4.7 million dollars (Tables 25and 26 and Figure 49).

POTENTIAL MINIMUM COASTAL STORM SURGE LOSSES FOR CRITICAL FACILITY STRUCTURES IN PUNTA GORDA				
Storm Zone	**Minimum Building Loss**	**Minimum Contents Loss**	**Minimum Functional Use Loss**	**Minimum Total Loss**
TS	$462,894	$694,342	$143,102	$1,300,339
1	$727,406	$1,091,108	$224,875	$2,043,389
2	$4,905,414	$7,019,914	$1,697,714	$13,623,043
3	$21,478,067	$31,797,050	$4,228,849	$57,503,966
4 or 5	$40,580,738	$60,711,982	$5,620,650	$106,913,370

Table 25: Potential Minimum Coastal Storm Surge Losses for Critical Facility Structures in Punta Gorda 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

POTENTIAL MAXIMUM COASTAL STORM SURGE LOSSES FOR CRITICAL FACILITY STRUCTURES IN PUNTA GORDA				
Storm Zone	**Maximum Building Loss**	**Maximum Contents Loss**	**Maximum Functional Use Loss**	**Maximum Total Loss**
TS	$1,810,483	$2,202,582	$728,351	$4,741,415
1	$2,270,744	$3,126,221	$748,794	$6,145,759
2	$26,583,586	$39,566,095	$4,841,487	$70,991,168
3	$47,396,667	$71,362,593	$5,654,588	$124,413,848
4 or 5	$48,297,639	$72,559,479	$5,654,588	$126,511,707

Table 26: Potential Maximum Coastal Storm Surge Losses for Critical Facility Structures in Punta Gorda

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

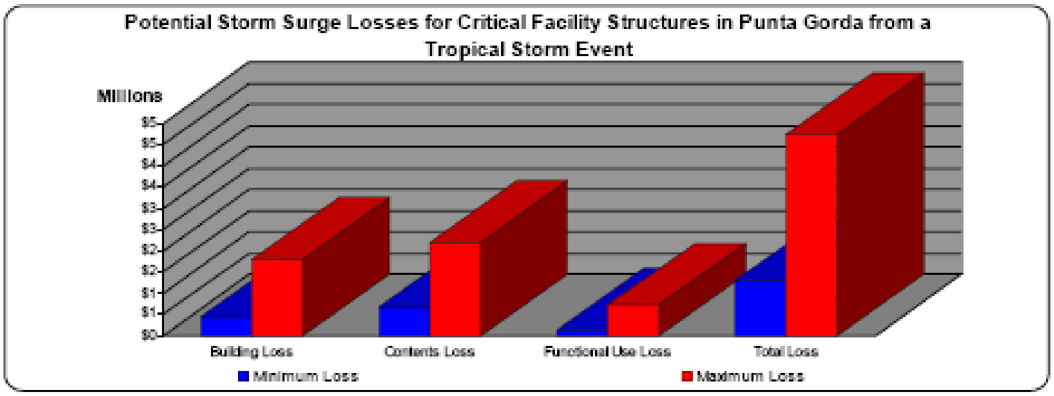


Figure 49: Potential Storm Surge Losses for Critical Facilities in Punta Gorda from a Tropical Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Category 1 Event

For a Category 1 storm event, Punta Gorda can expect $14.9 million in building losses and $26.6 million in total losses under the minimum surge scenario. Under the maximum surge scenario, $69.0 million in building losses and $142.3 million in total losses can be expected (Table 27 and Figure 50).

POTENTIAL COASTAL STORM SURGE LOSSES FOR PUNTA GORDA FROM A CATEGORY 1 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$14,924,875	$11,356,256	$287,337	$26,568,468
Maximum	$69,052,467	$61,846,589	$11,380,462	$142,279,517

Table 27: Potential Coastal Storm Surge Losses for Punta Gorda from a Category 1 Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

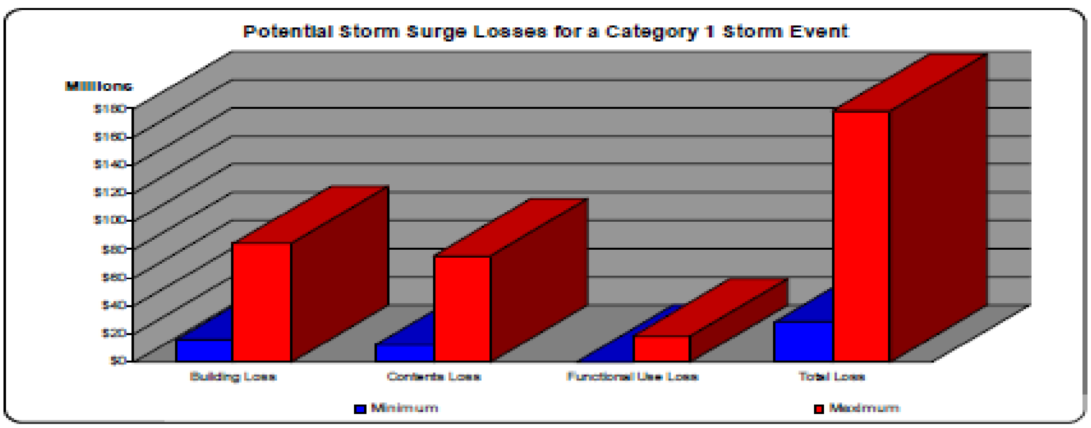


Figure 50: Potential Storm Surge Losses for a Category 1 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 1 storm on historic structures

For a Category 1 storm event, the historic structures in Punta Gorda can expect approximately $86,249 in building losses and $245,675 in total losses under the maximum surge scenario (Table 28 and Figure 51).

POTENTIAL COASTAL STORM SURGE LOSSES FOR HISTORIC STRUCTURES IN PUNTA GORDA FROM A CATEGORY 1 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$0	$0	$0	$0
Maximum	$86,249	$129,373	$30,054	$245,675

Table 28: Potential Coastal Storm Surge Losses for Historic Structures in Punta Gorda from a Category 1 Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

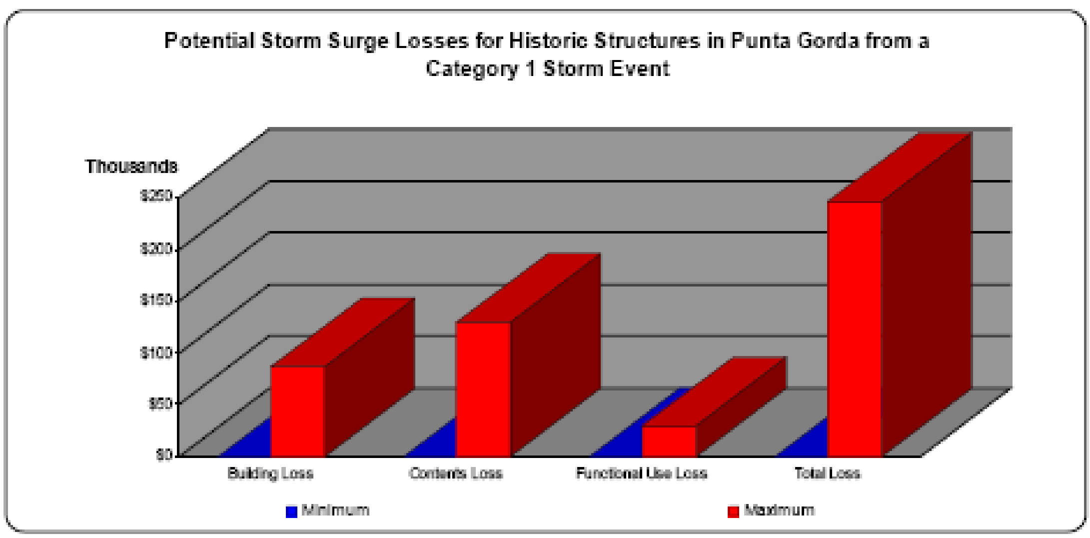


Figure 51: Potential Storm Surge Losses for Historic Structures in Punta Gorda from a Category 1 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 1 storm on top employers

Charlotte County's top employers with structures located in Punta Gorda can expect $101,578 in building losses and $105,636 in total losses under the minimum surge scenario from a Category 1 storm event. Under the maximum surge scenario, $4.7 million in building losses and $13.7 million in total losses can be expected (Table 29 and Figure 52).

POTENTIAL COASTAL STORM SURGE LOSSES FOR STRUCTURES OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS IN PUNTA GORDA FROM A CATEGORY 1 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$101,578	$4,059	$0	$105,636
Maximum	$4,743,737	$8,246,033	$737,060	$13,726,830

Table 29: Potential Coastal Storm Surge Losses for Structures Owned by Charlotte County's Top Employers in Punta Gorda from a Category 1 Storm Event 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

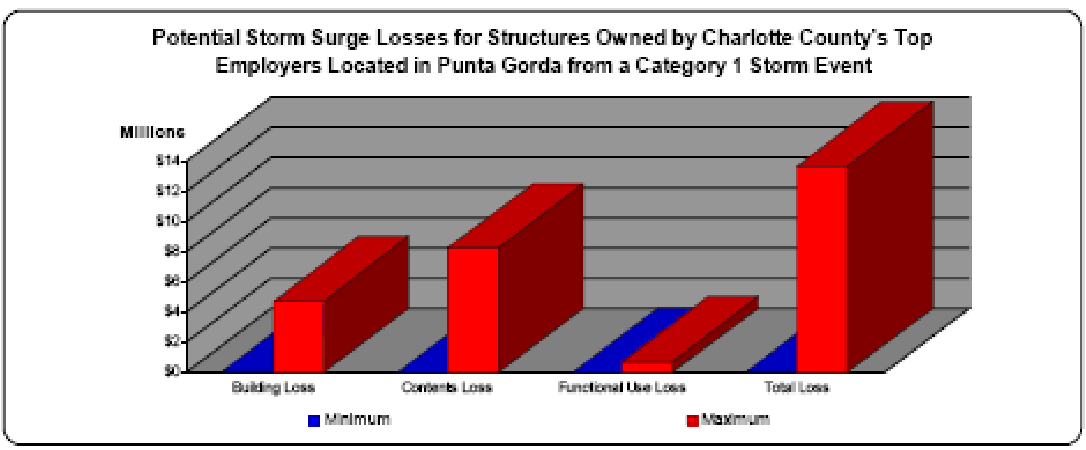


Figure 52: Potential Storm Surge Losses for Structures Owned by Punta Gorda's Top Employers 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 1 storm on repetitive loss structures

Repetitive loss structures located in Punta Gorda can expect $14,424 in building losses and $25,241 in total losses under the maximum surge scenario from a Category 1 storm event (Table 30 and Figure 52).

POTENTIAL COASTAL STORM SURGE LOSSES FOR REPETITIVE LOSS STRUCTURES IN PUNTA GORDA FROM A CATEGORY 1 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$0	$0	$0	$0
Maximum	$14,424	$10,818	$0	$25,241

Table 30: Potential Coastal Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 1 Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

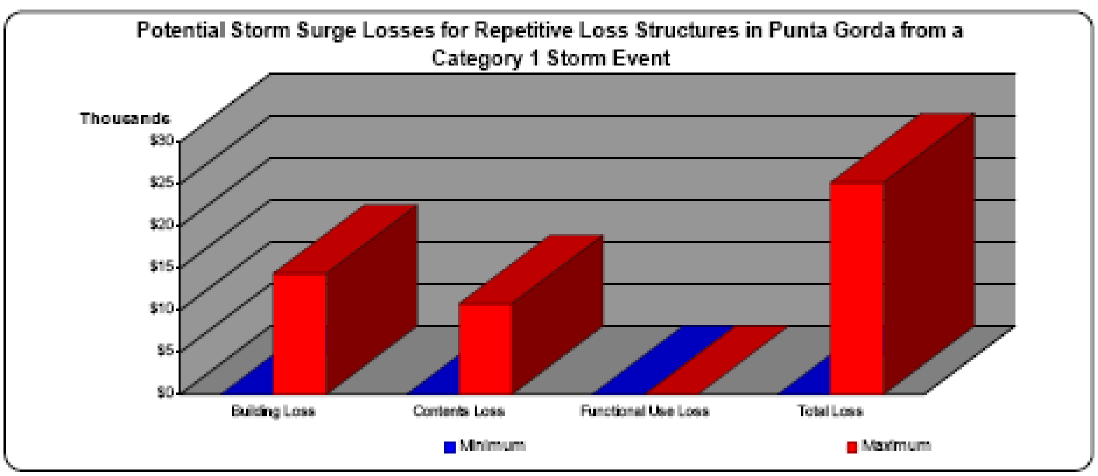


Figure 53: Potential Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 1 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 1 storm on critical facilities

A Category 1 storm event has the potential to create a total building loss ranging from $727,000 to $2.3 million and a total loss of $2.0 to $6.1 million dollars.

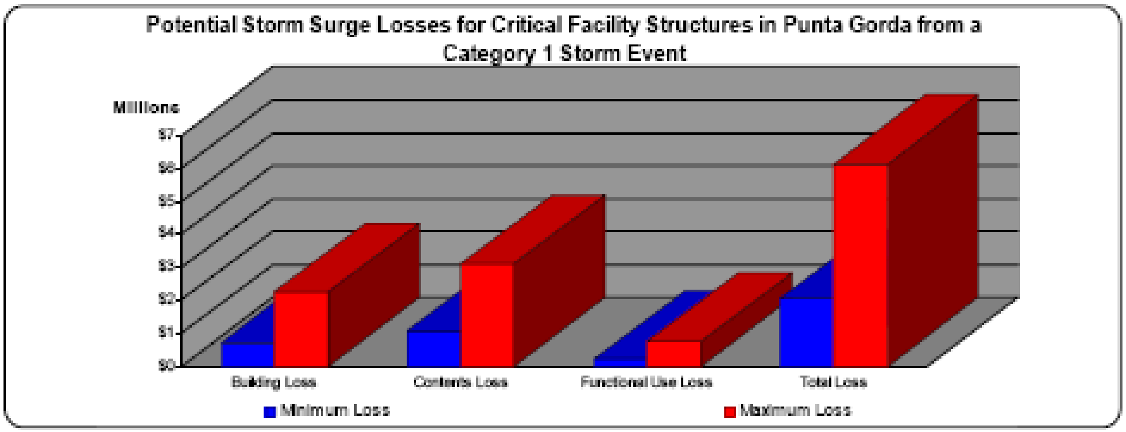


Figure 54: Potential Storm Surge Losses for Critical Facilities in Punta Gorda from a Category 1 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Category 2 Event

Under the minimum surge scenario, a Category 2 storm event is projected to cause Punta Gorda $108.0 million in building losses and $220.2 million in total losses. Under the maximum surge scenario, $403.7 million in building losses and $811.2 million in total losses can be expected (Table 31 and Figure 55).

POTENTIAL COASTAL STORM SURGE LOSSES FOR PUNTA GORDA FROM A CATEGORY 2 STORM EVENT				
	Building Loss	Contents Loss	Functional Use Loss	Total Loss
Minimum	$108,003,566	$102,053,900	$10,162,140	$220,219,605
Maximum	$403,745,384	$373,596,705	$33,823,968	$811,166,056

Table 32: Potential Coastal Storm Surge Losses for Punta Gorda from a Category 2 Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

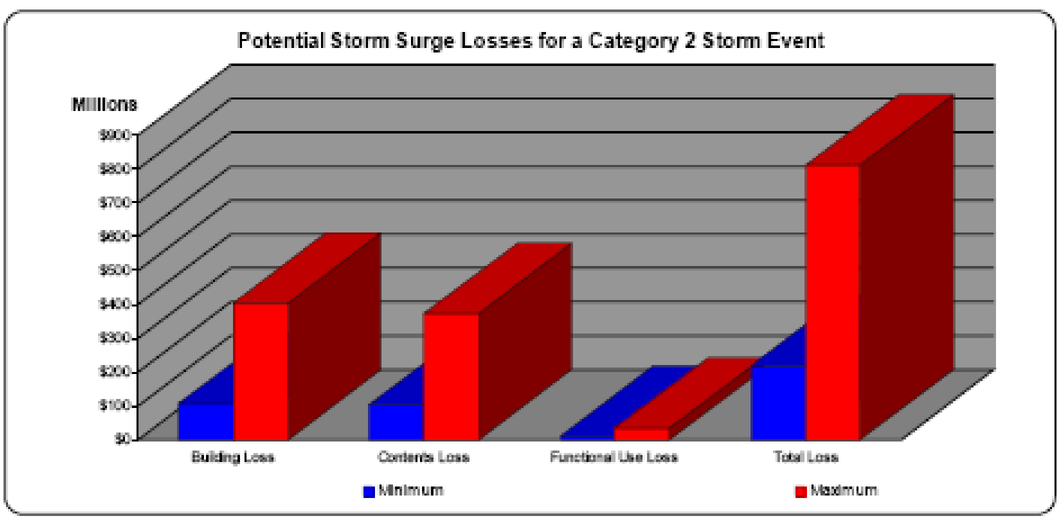


Figure 55: Potential Storm Surge Losses for a Category 2 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy 2005

Effects of a Category 2 storm on historic structures

For a Category 2 storm event, the historic structures in Punta Gorda can expect approximately $170,945 in building losses and $509,157 in total losses under the minimum surge scenario. Under the maximum surge scenario, building losses are estimated at $4.1 million and total losses are estimated at $10.4 million (Table 33 and Figure 56).

POTENTIAL COASTAL STORM SURGE LOSSES FOR HISTORIC STRUCTURES IN PUNTA GORDA FROM A CATEGORY 2 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$170,945	$256,418	$81,794	$509,157
Maximum	$4,107,431	$6,161,147	$120,540	$10,389,118

Table 33: Potential Coastal Storm Surge Losses for Historic Structures in Punta Gorda from a Category 2 Storm 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

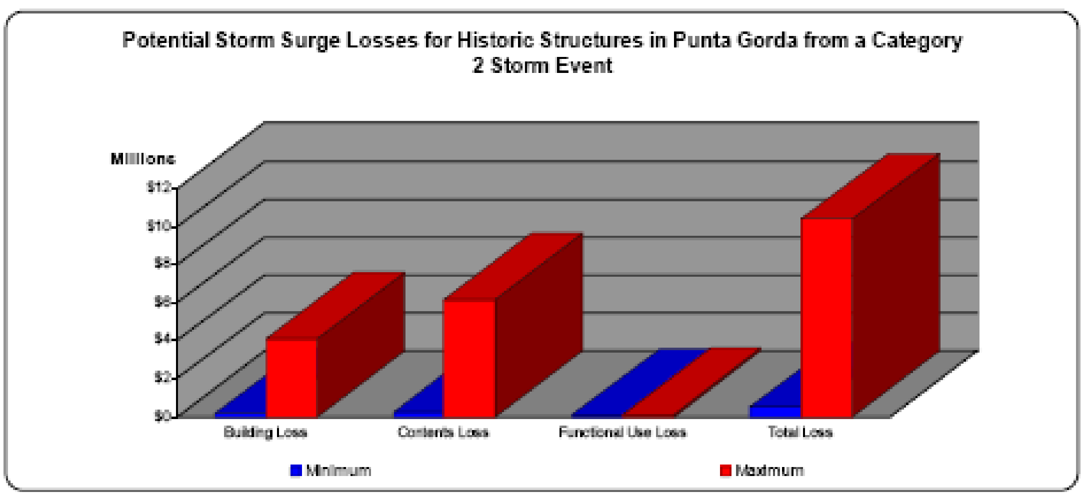


Figure 56: Potential Storm Surge Losses for Historic Structures in Punta Gorda from a Category 2 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 2 storm on top employers

Charlotte County's top employers with structures located in Punta Gorda can expect $9.4 million in building losses and $26.8 million in total losses under the minimum surge scenario from a Category 2 storm event. Under the maximum surge scenario, $32.3 million in building losses and $88.5 million in total losses can be expected (Table 34 and Figure 57).

POTENTIAL COASTAL STORM SURGE LOSSES FOR STRUCTURES OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS IN PUNTA GORDA FROM A CATEGORY 2 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$9,378,913	$15,826,567	$1,599,783	$26,805,263
Maximum	$32,374,489	$52,088,763	$4,023,176	$88,486,427

Table 34: Potential Coastal Storm Surge Losses for Structures Owned by Charlotte County's Top Employers in Punta Gorda from a Category 2 Storm Event 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

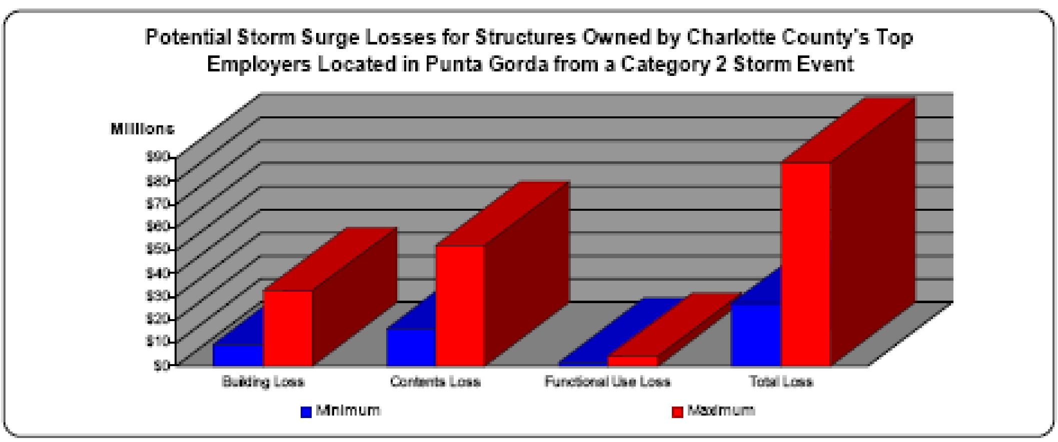


Figure 57: Potential Storm Surge Losses for Structures Owned by Punta Gorda's Top Employers from a Category 2 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 2 storm on repetitive loss structures

Repetitive loss structures located in Punta Gorda can expect $28,486 in building losses and $49,850 in total losses under the minimum surge scenario from a Category 2 storm event. Under the maximum surge scenario, $69,203 in building losses and $121,106 in total losses can be expected (Table 35 and Figure 58).

POTENTIAL COASTAL STORM SURGE LOSSES FOR REPETITIVE LOSS STRUCTURES IN PUNTA GORDA FROM A CATEGORY 2 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$28,486	$21,364	$0	$49,850
Maximum	$69,203	$51,903	$0	$121,106

Table 35: Potential Coastal Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 2 Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

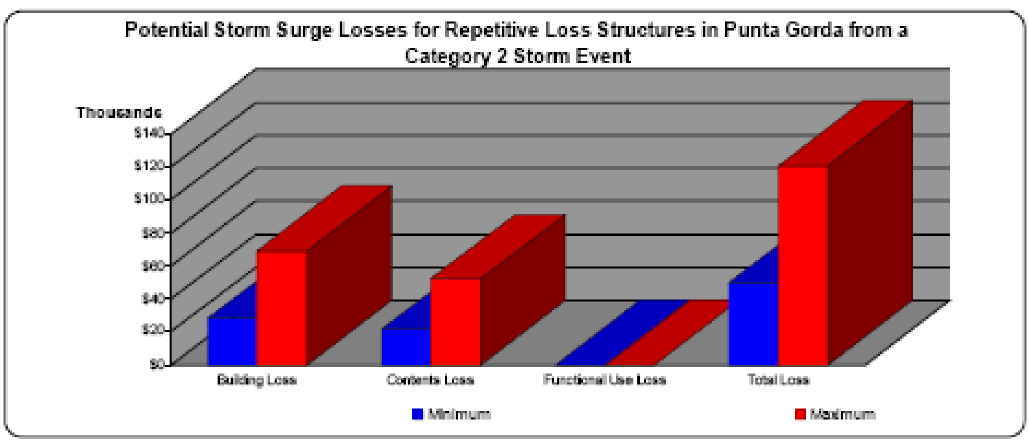


Figure 58: Potential Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 2 storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 2 storm on critical facilities

A Category 2 storm event has the potential to create a total building loss ranging from $4.9 to $26.6 million and a total loss of $13.6 to $71.0 million dollars

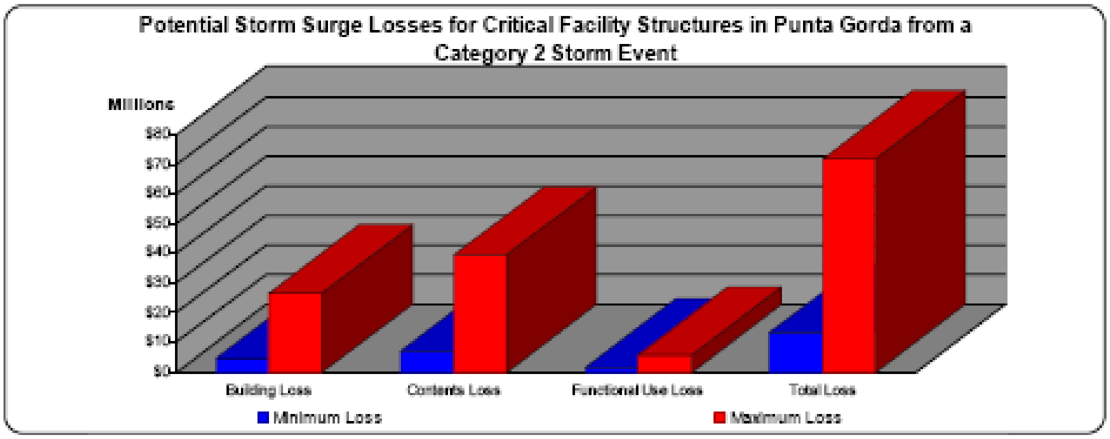


Figure 59: Potential Storm Surge Losses for Critical Facilities in Punta Gorda from a Category 2 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Category 3 Event

Under the minimum surge scenario, a Category 3 storm event is projected to cause Punta Gorda $332.6 million in building losses and $668.2 million in total losses. Under the maximum surge scenario, $1.18 billion in building losses and $1.86 billion in total losses can be expected (Table 36 and Figure 60).

POTENTIAL COASTAL STORM SURGE LOSSES FOR PUNTA GORDA FROM A CATEGORY 3 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$332,621,535	$309,073,210	$26,525,833	$668,220,578
Maximum	$1,183,776,730	$644,322,637	$34,545,617	$1,862,644,984

Table 36: Potential Coastal Storm Surge Losses for Punta Gorda from a Category 3 Storm Event 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

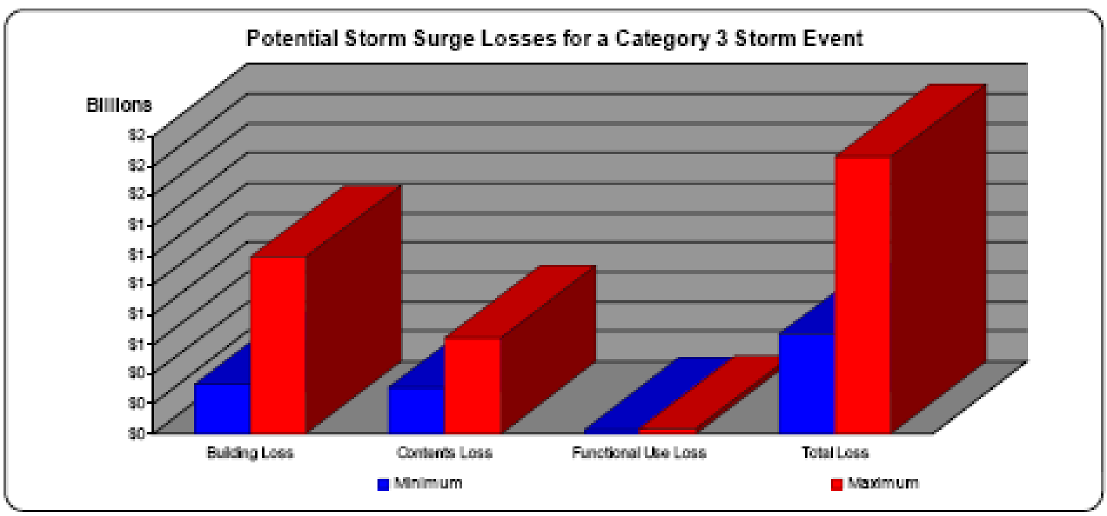


Figure 60: Potential Storm Surge Losses for a Category 3 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 3 storm on historic structures

For a Category 3 storm event, the historic structures in Punta Gorda can expect approximately $2.9 million in building losses and $7.6 million in total losses under the minimum surge scenario. Under the maximum surge scenario, building losses are estimated at $8.4 million and total losses are estimated at $21.1 million (Table 37 and Figure 61).

POTENTIAL COASTAL STORM SURGE LOSSES FOR HISTORIC STRUCTURES IN PUNTA GORDA FROM A CATEGORY 3 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$2,981,888	$4,472,833	$118,689	$7,573,410
Maximum	$8,413,024	$12,619,536	$127,944	$21,160,504

Table 37: Potential Coastal Storm Surge Losses for Historic Structures in Punta Gorda from a Category 3 Storm 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

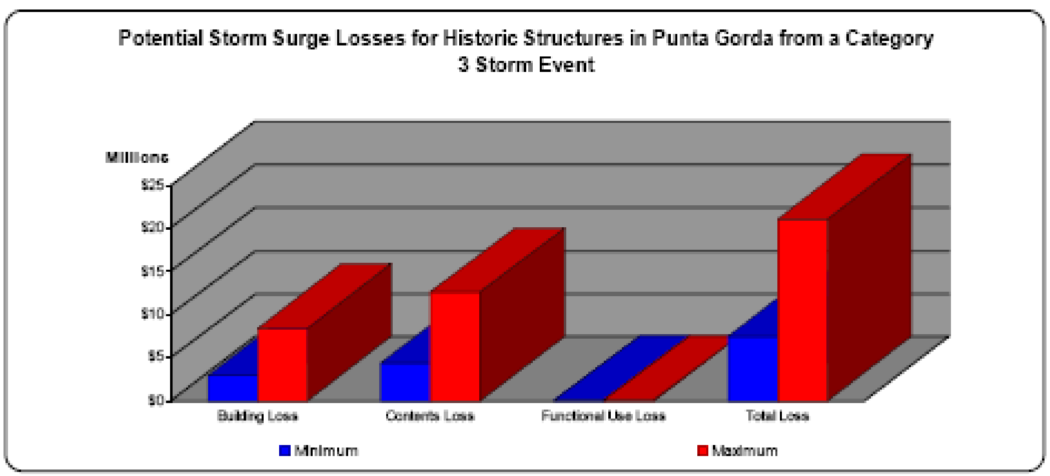


Figure 61: Potential Storm Surge Losses for Historic Structures in Punta Gorda from a Category 3 Storm2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 3 storm on top employers

Charlotte County's top employers with structures located in Punta Gorda can expect $27.2 million in building losses and $74.7 million in total losses under the minimum surge scenario from a Category 3 storm event. Under the maximum surge scenario, $56.2 million in building losses and $151.5 million in total losses can be expected (Table 38 and Figure 62).

POTENTIAL COASTAL STORM SURGE LOSSES FOR OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS IN PUNTA GORDA FROM A CATEGORY 3 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$27,249,496	$43,929,417	$3,503,259	$74,682,172
Maximum	$56,155,679	$90,479,435	$4,855,842	$151,490,956

Table 38: Potential Coastal Storm Surge Losses for Structures Owned by Charlotte County's Top Employers in Punta Gorda from a Category 3 Storm Event

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

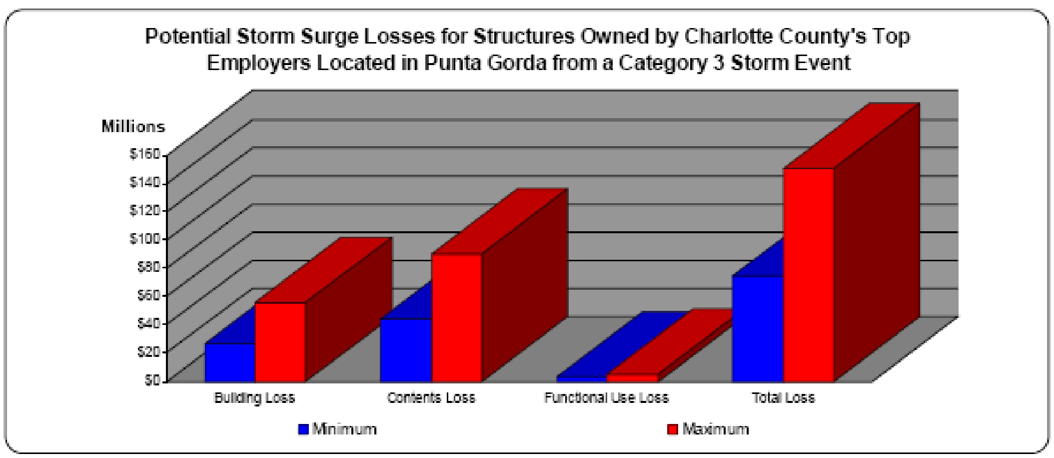


Figure 62: Potential Storm Surge Losses for Structures Owned by Punta Gorda's Top Employers from a Category 3 Storm

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 3 storm on repetitive loss structures

Repetitive loss structures located in Punta Gorda can expect $42,059 in building losses and $73,604 in total losses under the minimum surge scenario from a Category 3 storm event, Under the maximum surge scenario, $170,500 in building losses and $298,376 in total losses can be expected (Table 39 and Figure 63).

POTENTIAL COASTAL STORM SURGE LOSSES FOR REPETITIVE LOSS STRUCTURES IN PUNTA GORDA FROM A CATEGORY 3 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$42,059	$31,544	$0	$73,604
Maximum	$170,500	$127,875	$0	$298,376

Table 39: Potential Coastal Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 3 Storm Event

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

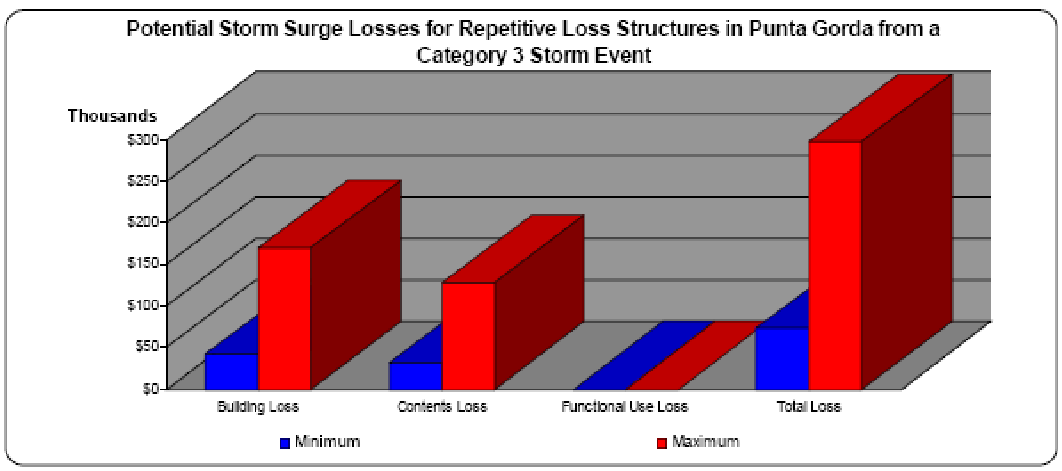


Figure 63: Potential Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 3 Storm

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 3 storm on critical facilities

A Category 3 storm event has the potential to create a total building loss ranging from $21.5 to $47.4 million and a total loss of $57.5 to $124.4 million dollars.

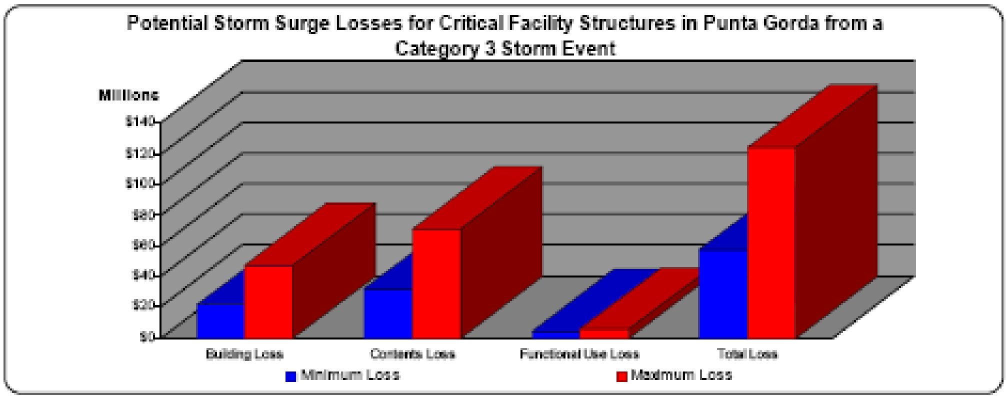


Figure 64: Potential Storm Surge Losses for Critical Facilities in Punta Gorda from a Category 3 Storm

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Category 4/5 Event

For a Category 4/5 storm event, the historic structures in Punta Gorda can expect approximately $629 million in building losses and $1.2 billion in total losses under the minimum surge scenario. Under the maximum surge scenario, building losses are estimated at $745 million and total losses are estimated at $1.5 billion (Table 40 and Figure 65).

POTENTIAL COASTAL STORM SURGE LOSSES FOR PUNTA GORDA FROM A CATEGORY 4/5 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$629,086,317	$580,946,721	$33,895,800	$1,243,928,838
Maximum	$744,952,775	$682,759,788	$34,671,601	$1,462,384,163

Table 40: Potential Coastal Storm Surge Losses for Punta Gorda from a Category 4/5 Storm Event

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

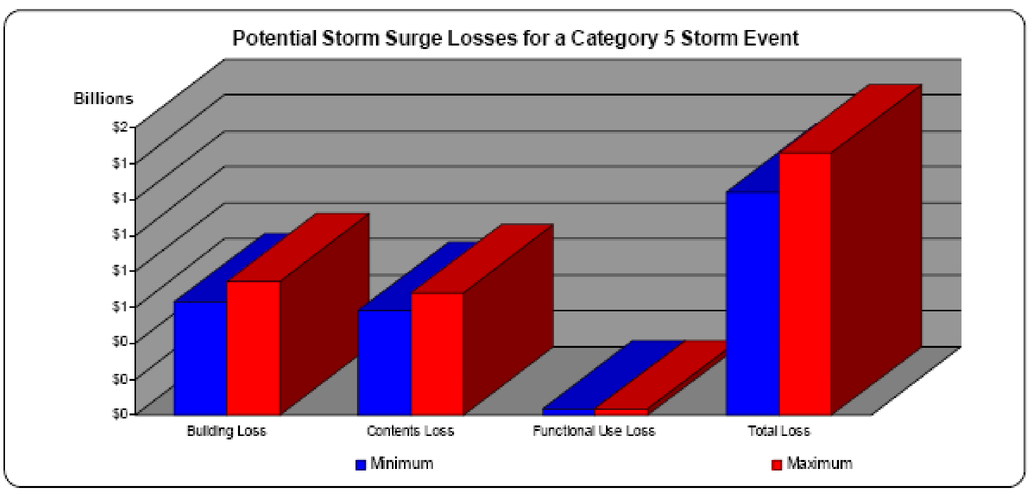


Figure 65: Potential Storm Surge Losses for a Category 5 Storm

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 4/5 storm on historic structures

For a Category 4/5 storm event, the historic structures in Punta Gorda can expect approximately$6.5 million in building losses and $16.4 million in total losses under the minimum surge scenario. Under the maximum surge scenario, building losses are estimated at $8.4 million and total losses are estimated at $21.1 million (Table 41 and Figure 66).

POTENTIAL COASTAL STORM SURGE LOSSES FOR HISTORIC STRUCTURES IN PUNTA GORDA FROM A CATEGORY 4/5 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$6,497,142	$9,749,269	$127,944	$16,374,356
Maximum	$8,413,024	$12,619,536	$127,944	$21,160,504

Table 41: Potential Coastal Storm Surge Losses for Historic Structures in Punta Gorda from a Category 4/5 Storm

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

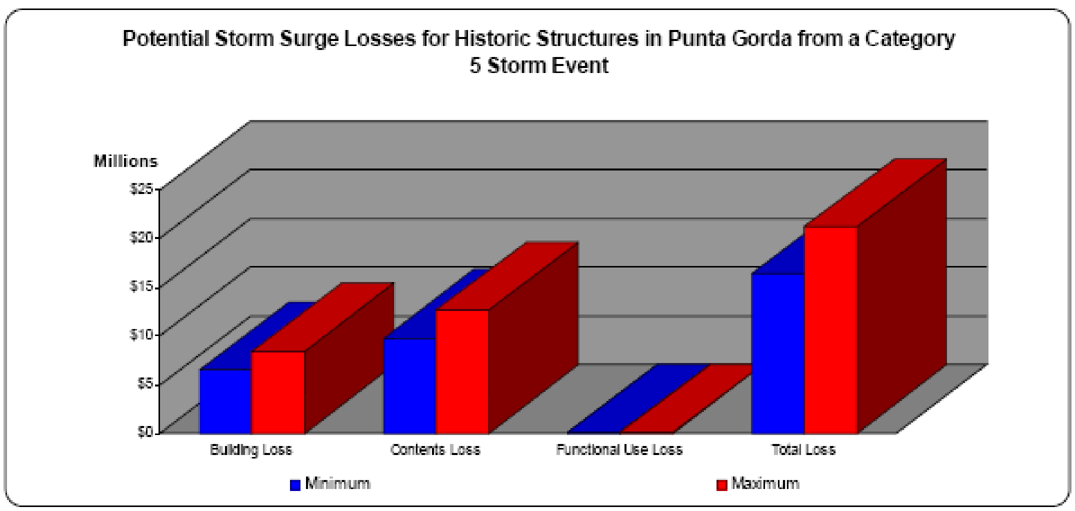


Figure 66: Potential Storm Surge Losses for Historic Structures in Punta Gorda from a Category 5 Storm

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 4/5 storm on top employers

Charlotte County's top employers with structures located in Punta Gorda can expect $49 million in building losses and $134 million in total losses under the minimum surge scenario from a Category 5 storm event. Under the maximum surge scenario, $56.8 million in building losses and $153 million in total losses can be expected (Table 42 and Figure 67).

POTENTIAL COASTAL STORM SURGE LOSSES FOR OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS IN PUNTA GORDA FROM A CATEGORY 4/5 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$49,384,333	$79,766,183	$4,821,904	$133,972,420
Maximum	$56,886,783	$91,546,765	$4,855,842	$153,289,390

Table 42: Potential Storm Surge Losses for Structures Owned by Charlotte County's Top Employers in Punta Gorda from A Category 4/5 Storm Event

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

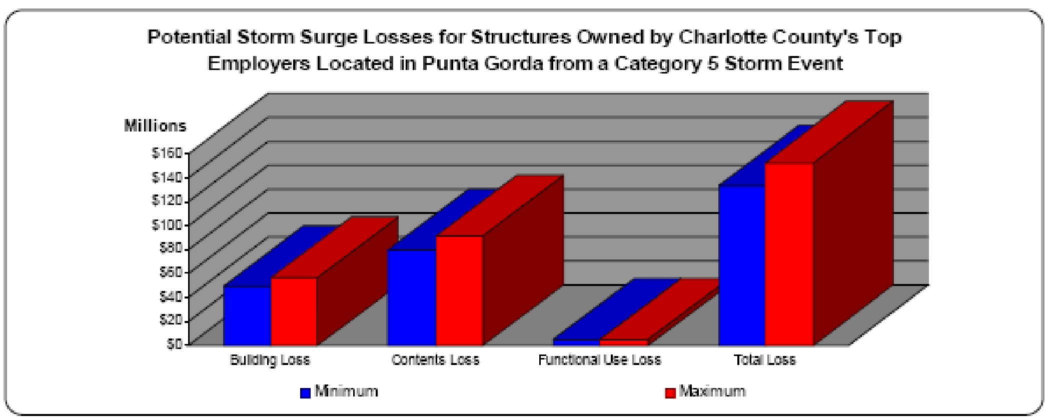


Figure 67: Potential Storm Surge Losses for Structures Owned by Punta Gorda's Top Employers from a category 5 Storm

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 4/5 storm on repetitive loss structures
Repetitive loss structures located in Punta Gorda can expect $143,957 in building losses and$232,138 in total losses under the minimum surge scenario from a Category 5 storm event. Under the maximum surge scenario, $201,348 in building losses and $352,359 in total losses can be expected (Table 43 and Figure 68).

POTENTIAL COASTAL STORM SURGE LOSSES FOR REPETITIVE LOSS STRUCTURES IN PUNTA GORDA FROM A CATEGORY 4/5 STORM EVENT				
	Building Loss	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Minimum	$143,957	$108,180	$0	$252,138
Maximum	$201,348	$151,011	$0	$352,359

Table 43: Potential Coastal Storm Surge Losses for Repetitive Loss Structures in Punta Gorda from a Category 4/5 Storm 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

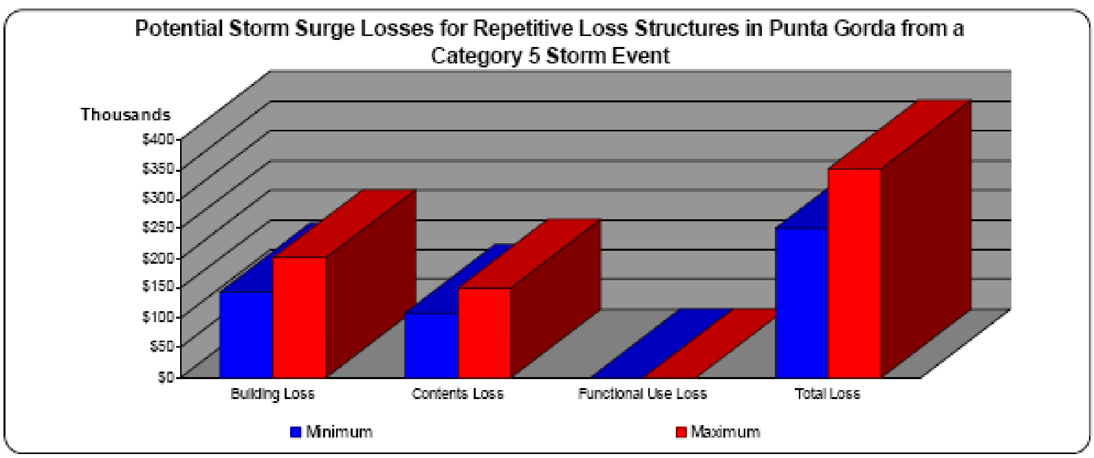


Figure 68: Potential Storm Surge Losses from a Category 4/5 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of a Category 4 or 5 storm event on critical facilities

A Category 4 or 5 storm event has the potential to create a total building loss ranging from $40.6 to $48.3 million and a total loss of $106.9 to $126.5 million dollars.

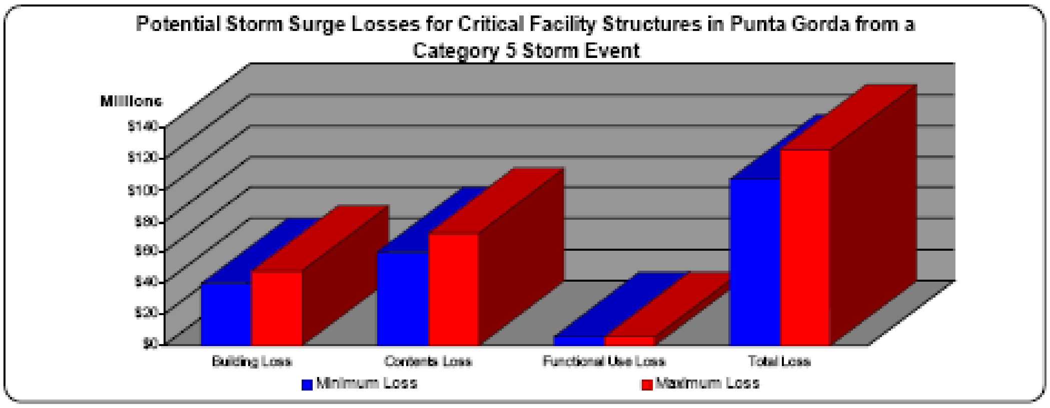


Figure 69: Potential Storm Surge Losses for Critical Facilities in Punta Gorda from a Category 5 Storm 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Floods

Floods are the most common and widespread of all natural disasters--except fire. Most communities in the United States have experienced some kind of flooding, after spring rains, heavy thunderstorms, or winter snow thaws.

A flood, as defined by the National Flood Insurance Program is: "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is your property) from: overflow of inland or tidal waters, unusual and rapid accumulation or runoff of surface waters from any source, or a mudflow" (FEMA hazard website). Flooding occurs when climate (or weather patterns), geology, and hydrology combine to create conditions where water flows outside of its usual course (Clakamas County Natural Hazard Mitigation Plan). Floods can be slow or fast rising but generally develop over a period of days. Floods can come in the form of “flash floods,” which usually result from intense storms dropping large amounts of rain within a brief period. Flash floods occur with little or no warning and can reach full peak in only a few minutes (IFAS Disaster Handbook). Other floods are more gradual, as with a large those resulting from a storm front, a tropical storm, or a hurricane washing ashore (FEMA).

Flood waters can be extremely dangerous. The force of six inches of swiftly moving water can knock people off their feet. Flash flood waters move at very fast speeds and can roll boulders, tear out trees, destroy buildings, and obliterate bridges. Walls of water can reach heights of 10 to 20 feet and generally are accompanied by a deadly cargo of debris. Cars can be easily swept away in just two feet of moving water (FEMA).

Flooding has already been demonstrated as being a problem in Punta Gorda and has been the cause for great expenditures of effort and funding by the public and private sectors. Flooding from hurricanes has been severe, as with Hurricane Charley on the barrier islands of the CHNEP, but flooding associated with climate change can be expected to make those conditions occur more frequently. As high tides become higher, and rain events become more intense, flooding can be expected to become a regular occurrence, especially in the lower areas, including downtown.

The 100 year floodplain is an important factor that influences many parcels of property and people throughout Punta Gorda. Almost all (93.4%) of the structures in Punta Gorda are located within the 100 Year Floodplain. These structures make up 94.7% of the total value for Punta Gorda (Table 44).

ESTIMATED VALUES FOR STRUCTURES WITHIN PUNTA GORDA BASED ON THE 100 YEAR FLOODPLAIN					
	No. of Buildings	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
Inside 100 Year Floodplain	9,328	$1,502,477,972	$934,065,737	$112,042,972	$2,548,586,681
Outside 100 Year Floodplain	658	$90,433,868	$48,949,138	$3,529,030	$142,912,036
Total	**9,986**	**$1,592,911,840**	**$983,014,875**	**$115,572,002**	**$2,691,498,717**

Table 44: Estimated Values for Structures within Punta Gorda Based on the 100 Year Floodplain 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

Historic structures in the 100 year floodplain

All of Punta Gorda's structures that are classified as historic are located in the 100 year floodplain. These 44 structures have a building value of $21.9 million and a total value of$44.3 million (Table 45).

ESTIMATED VALUES FOR HISTORIC STRUCTURES WITHIN PUNTA GORDA BASED ON THE 100 YEAR FLOODPLAIN					
	No. of Buildings	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
Inside 100 Year Floodplain	44	$21,914,968	$21,914,968	$426,480	$44,256,416
Outside 100 Year Floodplain	0	$0	$0	$0	$0
Total	**44**	**$21,914,968**	**$21,914,968**	**$426,480**	**$44,256,416**

Table 45: Estimated Values for Historic Structures within Punta Gorda Based on the 100 Year Floodplain 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

Top employers in the 100 year floodplain

All of the structures owned by Charlotte County's top employers that are located in Punta Gorda are located in the 100 year floodplain. These 174 structures have a building value of $136.8 million and a total value of $302 million (Table 46).

ESTIMATED VALUES FOR STRUCTURES OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS LOCATED WITHIN PUNTA GORDA BASED ON THE 100 YEAR FLOODPLAIN					
	No. of Buildings	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
Inside 100 Year Floodplain	174	$136,758,386	$149,122,294	$16,186,140	$302,066,820
Outside 100 Year Floodplain	0	$0	$0	$0	$0
Total	**174**	**$136,758,386**	**$149,122,294**	**$16,186,140**	**$302,066,820**

Table 46: Estimated Values for Structures Owned by Charlotte County's Top Employers Located within Punta Gorda Based on the 100 Year Floodplain 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

Repetitive loss structures in the 100 year floodplain

All four of the repetitive loss structures that are located in Punta Gorda are located in the 100 year floodplain. These 4 structures have a building value of $503,016 and a total value of $754,524 (Table 47).

ESTIMATED VALUES FOR REPETITIVE LOSS STRUCTURES WITHIN PUNTA GORDA BASED ON THE 100 YEAR FLOODPLAIN					
	No. of Buildings	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
Inside 100 Year Floodplain	4	$503,016	$251,508	$0	$754,524
Outside 100 Year Floodplain	0	$0	$0	$0	$0
Total	**4**	**$503,016**	**$251,508**	**$0**	**$754,524**

Table 47: Estimated Values for Repetitive Loss Structures within Punta Gorda Based On the 100 Year Floodplain 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

In most cases, the damage from any single flood event is less than the total area of the City susceptible to flooding. The following calculations are the damages expected from a single 100 year flood event based upon the planning zones identified in the Local Mitigation Strategy for the City of Punta Gorda. Punta Gorda faces a potential building loss of $13.6 million and a potential total loss of $39million from a flood event. This represents 13.2% of the total building value and 15.7% of the total value for all the structures in the floodplain in Punta Gorda (Table 48 and Figure 70).

POTENTIAL LOSSES FOR STRUCTURES IN PUNTA GORDA FROM A 100 YEAR FLOOD EVENT BASED ON PLANNING ZONE					
	No. of Buildings	**Building Loss**	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Punta Gorda	174	$13,570,789	$23,167,778	$2,297,562	$39,036,129
Total	**174**	**$13,570,789**	**$23,167,778**	**$2,297,562**	**$39,036,129**

Table 48: Potential Losses for Structures in Punta Gorda from a 100 Year Flood Event Based On Planning Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

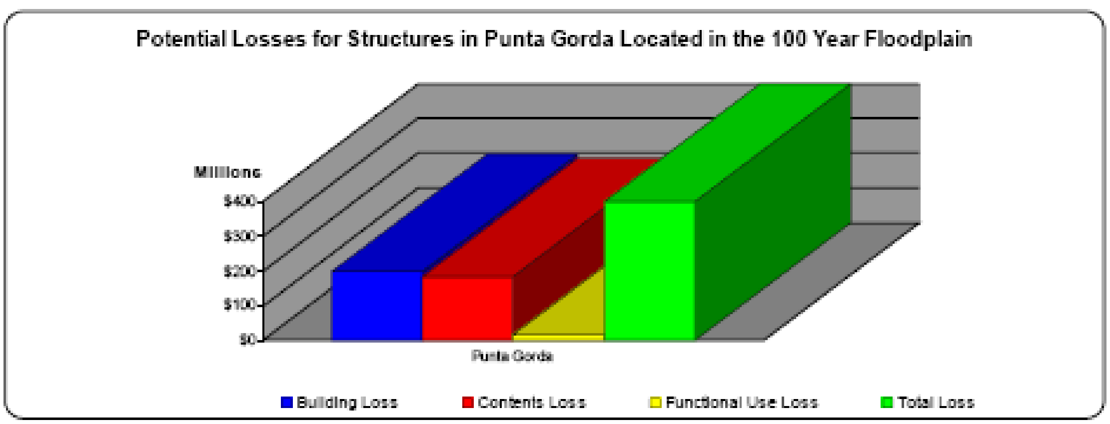


Figure 70: Potential Losses for Structures in Punta Gorda Located in the 100 Year Floodplain 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of flooding on historic properties

The 44 historic structures located in Punta Gorda face a potential loss from a flooding event of $697,330. This represents 1.58% of their total value (Table 49 and Figure 71).

POTENTIAL LOSSES FOR HISTORIC STRUCTURES IN PUNTA GORDA FROM A 100 YEAR FLOOD EVENT BASED ON PLANNING ZONE					
	No. of Buildings	**Building Loss**	**Contents Loss**	**Functional Use Loss**	**Total Loss**
Punta Gorda	44	$238,566	$357,849	$100,915	$697,330
Total	**44**	**$238,566**	**$357,849**	**$100,915**	**$697,330**

Table 49: Potential Losses for Historic Structures in Punta Gorda from a 100 Year Flood Event Based on Planning Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

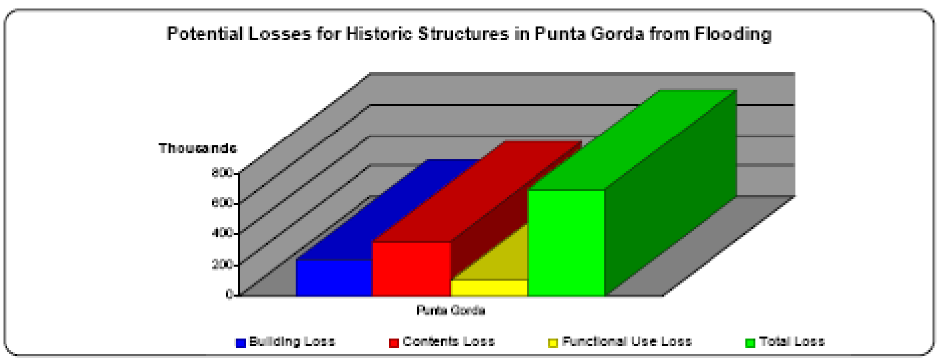


Figure 71: Potential Losses for Historic Structures in Punta Gorda from Flooding 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of flooding on top employers

The 174 structures owned by Charlotte County's top employers that are located in Punta Gorda face a potential loss from a flooding event of $39 million. This represents 12.9% of their total value (Table 50 and 72).

POTENTIAL LOSSES FOR STRUCTURES OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS LOCATED IN PUNTA GORDA FROM A 100 YEAR FLOOD EVENT BASED ON PLANNING ZONE					
	No. of Buildings	Building Loss	Contents Loss	Functional Use Loss	Total Loss
Punta Gorda	174	$13,570,789	$23,167,778	$2,297,562	$39,036,129
Total	**174**	**$13,570,789**	**$23,167,778**	**$2,297,562**	**$39,036,129**

Table 50: Potential Losses for Structures Owned by Charlotte County's Top Employers Located in Punta Gorda from a 100 Year Flood Event Based on Planning Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

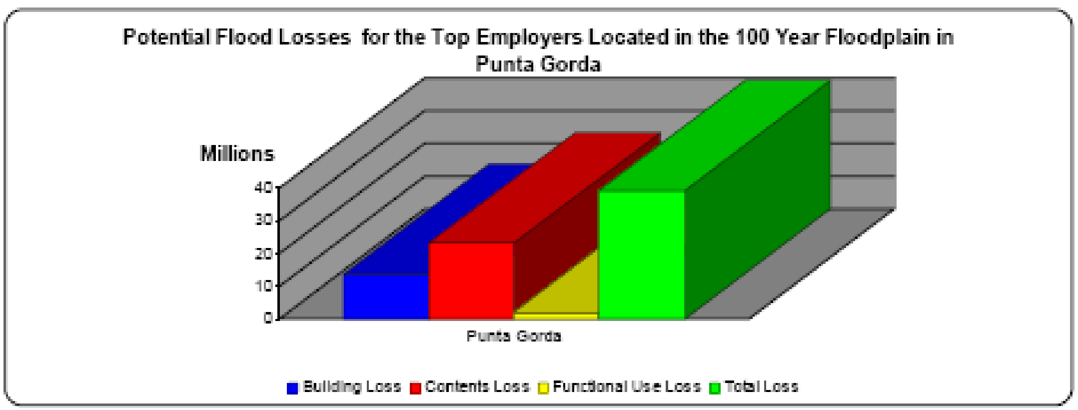


Figure 72: Potential Losses for the Top Employers Located in the 100 Year Floodplain in Punta Gorda from flooding 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Effects of flooding on repetitive loss structures

The four repetitive loss structures that are located in Punta Gorda face a potential loss from a flooding event of $96,498. This represents 12.8% of their total value (Table 51 and Figure 73).

POTENTIAL LOSSES FOR STRUCTURES OWNED BY CHARLOTTE COUNTY'S TOP EMPLOYERS LOCATED IN PUNTA GORDA FROM A 100 YEAR FLOOD EVENT BASED ON PLANNING ZONE					
	No. of Buildings	Building Loss	Contents Loss	Functional Use Loss	Total Loss
Punta Gorda	4	$55,141	$41,356	$0	$96,498
Total	**4**	**$55,141**	**$41,356**	**$0**	**$96,498**

Table 51: Potential Losses for Structures Owned by Charlotte County's Top Employers Located in Punta Gorda from a 100 Year Flood Event Based on Planning Zone 2005

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

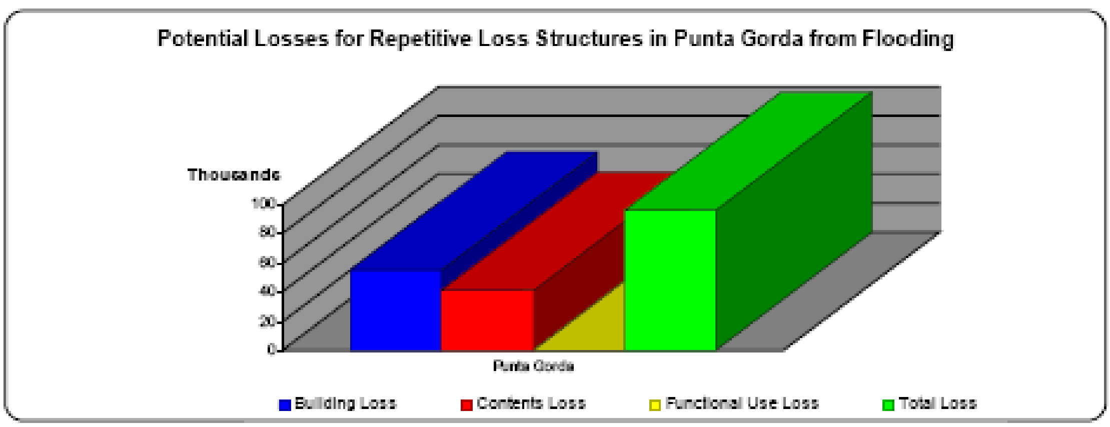


Figure 74: Potential Losses for Repetitive Loss Structures in Punta Gorda from Flooding 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Charlotte County possesses many low-lying areas that are subject to periodic freshwater flooding. Such flooding can accompany tropical storms or hurricane, but it can also be the result of sustained periods of heavy rainfall that cause surface sediments to become saturated. Charlotte County contains numerous rivers/creeks and wetlands. These natural drainage systems can overflow into their adjacent floodplains creating sheet flow type flooding, which occasionally cause property, structural, and/or agricultural damage and sometimes loss of life (2001 Hurricane Study). As long as development occurs in the floodplain, there is risk of flood damage.

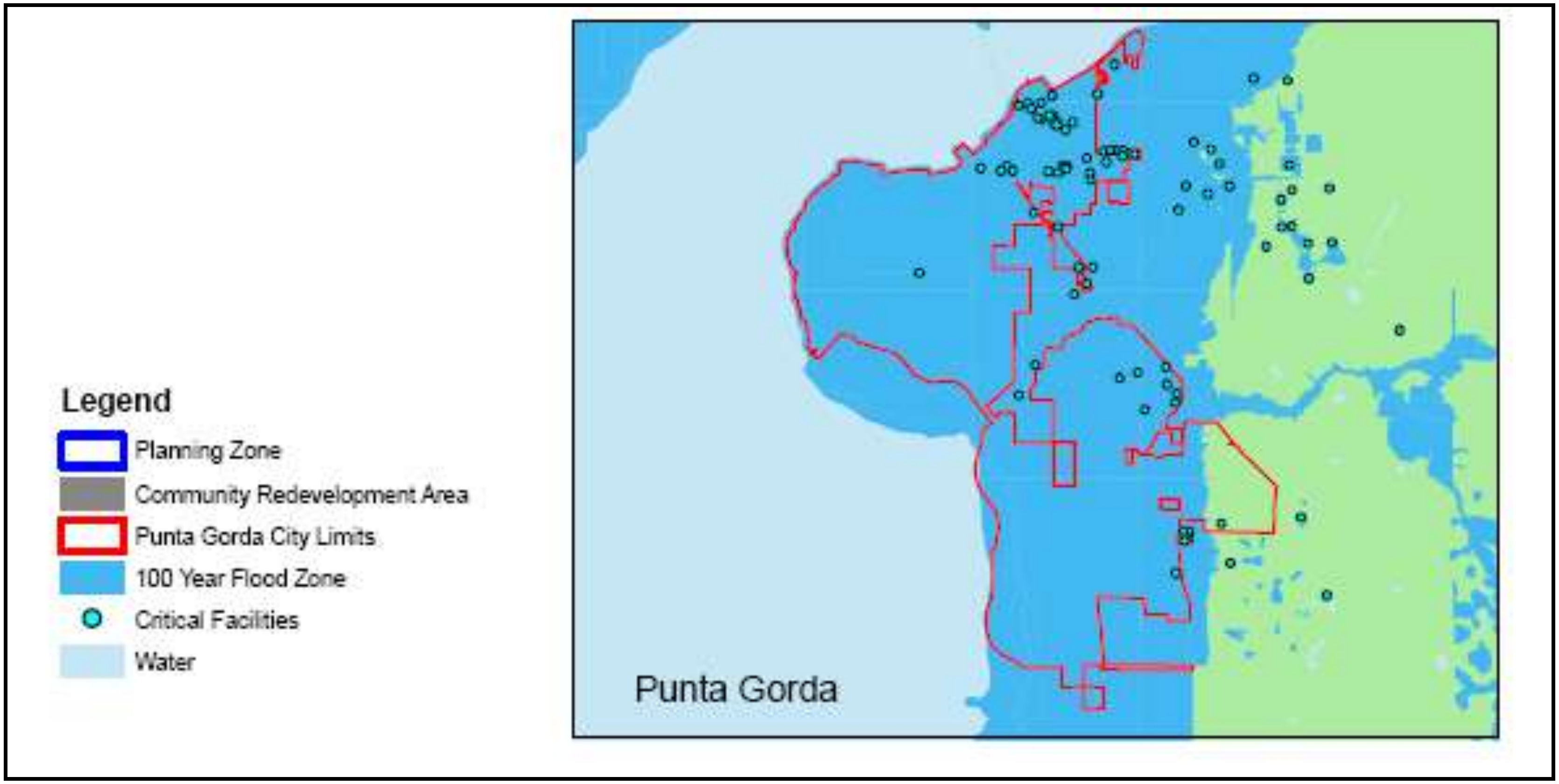


Figure 75: Critical Facilities and the 100 Year Floodplain in Punta Gorda 2005

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

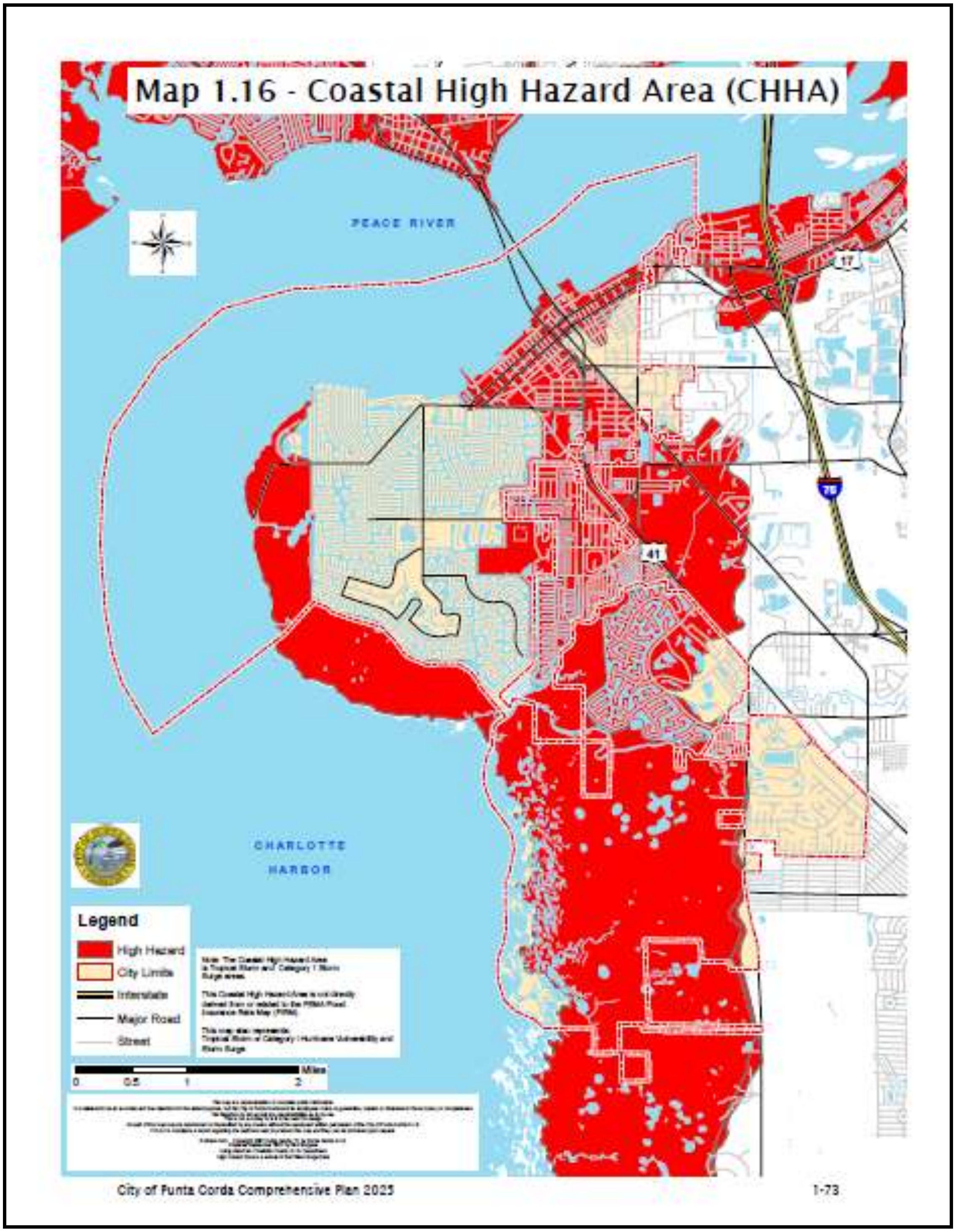


Figure 76: The Coastal High Hazard Area in Punta Gorda

Source: City of Punta Gorda Comprehensive Plan 2025

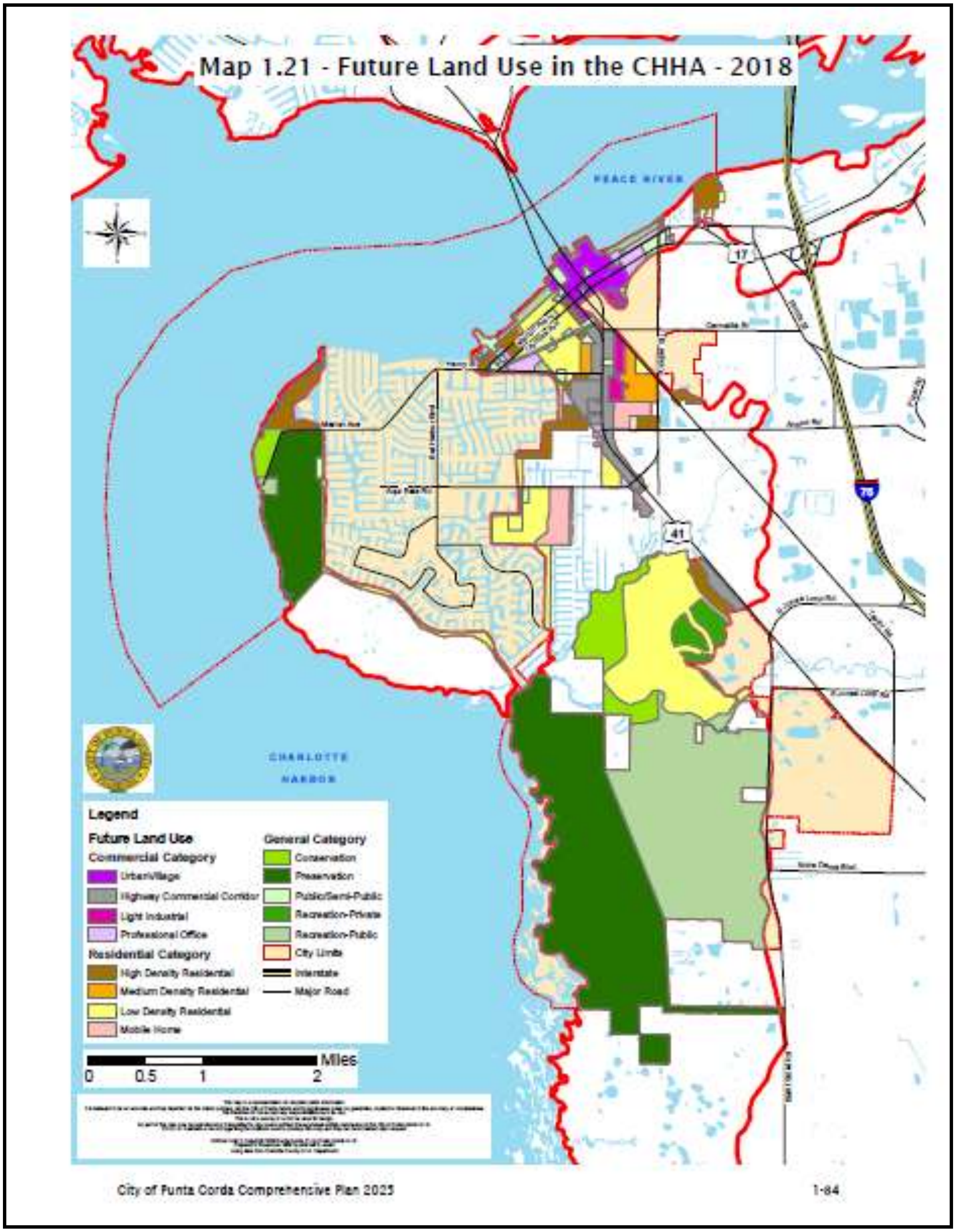


Figure 77: Future Land Use (2018) in the Coastal High Hazard Area of Punta Gorda

Source: City of Punta Gorda Comprehensive Plan 2025

Table 52: Adaptations for Coastal Erosion, Sea Level Rise, and Storm Surge Flooding (from the public workshop)

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples	Level of Support (%)
Explicitly indicate in local master plans which areas will retain natural shorelines	Flooding	Fish and Wildlife Habitat	Reduces infrastructure exposure to hazards, Decreases variable risk; Maintains and increases habitat; Enhances fishery	Not a lot of natural shoreline is present on the Peace River	City of Punta Gorda Comprehensive Plan Conservation Land Use Category	50
Build roads and sidewalks of porous materials	Flooding	Water Quality	Reduces stormwater runoff; can prevent pooling floods and reduce time of flooding	Some of these materials are not as durable; Some of these material need regular maintenance		37.5
Incorporate wetland protection into infrastructure planning	Flooding	Fish and Wildlife Habitat	Reduces wetland and habitat loss; Absorbs runoff and maintains water tables; Maintains and increases habitat; Enhances fishery	Takes time and some cost to plan; reduces buildable footprint	Deer Island, Boston, MA	37.5

Complete downtown flooding study	Flooding	Economy	Reduces infrastructure exposure to hazards, Decreases variable risk	Cost; Study may recommend more costs		37.5
Improved flood plain management/regulation	Flooding	Economy	Reduces infrastructure exposure to hazards, Decreases variable risk	Costs of management and regulation		25
Increase stormwater capacity	Flooding	Economy	Reduced flooding of infrastructure	Increased capacity may require additional physical space		25
Modify stormwater conveyance systems and control elevation	Flooding	Economy	Reduced flooding of infrastructure	Cost; Disruption during construction		25
Improve building codes	Flooding	Economy	Reduces infrastructure exposure to hazards, Decreases variable risk	Cost of new construction and retrofit		25
Constrain location of certain infrastructure such as landfills, hazardous waste, sewer	Flooding	Unchecked Growth	Reduces infrastructure exposure to hazards, Decreases variable risk	Reduces siting options; May increase costs		25

Remove hard protection or other barriers to shoreline retreat and protections	Flooding	Fish and Wildlife Habitat	Maintains and increases habitat; Enhances fishery	Cost; temporary water quality impacts during construction and re-stabilization; Alternatives of bulkhead construction can be more expensive and more difficult to obtain permits for novel designs	Maine, Massachusetts	25
Retreat	Flooding	Fish and Wildlife Habitat	Reduced flooding of infrastructure; Maintains and increases habitat; Enhances fishery; Maintains species habitats; maintains protection for inland ecosystems	In highly developed areas, there is often no land available for wetlands to migrate; Cost	Buzzards Bay, MASS	25
Establish no-rebuild zones	Flooding	Fish and Wildlife Habitat; Unchecked Growth	Reduces infrastructure exposure to hazards, Decreases variable risk; Maintains and increases habitat; Enhances fishery			25

Land acquisition for retreat/relocation	Flooding	Fish and Wildlife Habitat; Unchecked Growth	Maintains and increases habitat; Enhances fishery	In highly developed areas, there is often no land available for retreat/relocation; Cost		25
Increase shoreline setbacks and exchange/purchase/acquisition	Flooding	Fish and Wildlife Habitat	Reduces infrastructure exposure to hazards, Decreases variable risk; Maintains and increases habitat; Enhances fishery			25
Construct stormwater infrastructure improvements	Flooding	Economy	Reduced flooding of infrastructure			12.5
Increase vegetation	Flooding	Water Quality	Maintains and increases habitat; Enhances fishery			12.5
Raise elevation of streets	Flooding	Economy	Reduced flooding of street infrastructure	Cost; Elevated street can flood adjacent un-elevated land		12.5
Adaptive stormwater management	Flooding	Economy	Reduces infrastructure exposure to hazards, Decreases variable risk			12.5

Regulate pumping near shorelines	Flooding					12.5
Improved roof drainage capacity	Flooding	Economy				12.5
Replace shoreline armoring with living shoreline	Flooding	Fish and Wildlife Habitat	Maintains and increases habitat; Enhances fishery			12.5
Allow coastal wetlands to migrate inland in areas explicitly indicated	Flooding	Fish and Wildlife Habitat	Maintains and increases habitat; Enhances fishery			12.5
Increase bridge clearances	Flooding	Economy				12.5
Undertake a long-term study of the need to raise infrastructure	Flooding	Economy; Unchecked Growth				12.5
Design new coastal drainage systems	Flooding	Economy	Reduced flooding of infrastructure		Vancouver, Canada (planned – CitiesPLUS 100-year plan)	12.5
Restrict/prohibit development in erosion/flood/damage prone areas	Flooding	Fish and Wildlife Habitat	Reduces infrastructure exposure to hazards, Decreases variable risk			12.5
Limit development	Flooding	Water Quality	Reduces infrastructure exposure to hazards, Decreases variable risk			12.5

Improve weather response plans	Flooding					12.5
Build "deconstructable" buildings which can be taken apart and easily moved to higher ground	Flooding					12.5
Establish rolling easements	Flooding	Fish and Wildlife Habitat; Water Quality				12.5
All measures to reduce local GHG emissions	Flooding	Economy				12.5

Table 53: Adaptations for Coastal Erosion, Sea Level Rise, and Storm Surge Flooding Recommended Against (from the public workshop)

Shoreline hardening	Flooding					
Fortify dikes	Flooding				Tyrell County, NC (dikes primarily used to protect agricultural land); Thames River Barrier, London, England (built during the 1970s)	25
Raise elevation of buildings	Flooding					12.5
Relocate structures	Flooding					12.5
Retreat	Flooding					12.5

ADAPTATION: Explicitly indicate in local master plans, (Comprehensive Plans), which areas will retain natural shorelines.

"Explicitly indicate in local master plans, (Comprehensive Plans), which areas will retain natural shorelines" was the most popular adaptation measure proposed to address flooding impacts due to climate change in the City of Punta Gorda. This adaptation fits with the City of Punta Gorda's EAR review for the Comprehensive Plan.

This policy would reduce infrastructure exposure to several flooding hazards including short-term, intense rain storms, tropical and hurricane storm surge flooding, and long term inundation from a rising sea level, decreasing the amount of variable risk the City would experience in regard to disaster recovery and costs of clean up. In undeveloped areas, this practice will maintain existing habitats and increase habitat for fish and wildlife, enhancing sport and commercial fisheries and other recreational and conservation uses.

The majority of wetlands in the City of Punta Gorda are part of 3,600 acres of public/private open space in the form of conservation, preservation and public park lands, comprising approximately 47.24% of the total area of the City. Much of this protected land provides a significant natural buffer between the urban development and the estuarine system of Charlotte Harbor. Approximately two-thirds of the City's shoreline remains in its natural condition - either mangrove forest or inter-tidal swamp. These areas are generally inaccessible to the inexperienced public and are nearly 100% are State-jurisdictional wetlands.

Development in these private conservation and preservation areas would require permits from a number of state and federal regulatory agencies, including but not limited to, the Florida Department of Environmental Protection, Southwest Florida Water Management District, and the U. S. Army Corps of Engineers. The City's current Land Development Regulations (LDR) encourage shifting development activity from these properties to less sensitive upland areas and require an applicant to provide appropriate permit authorization from the regulatory agencies prior to issuance of any development permits from the City. However, there always exists the potential for these lands to be subject to development given reduced state and federal protection of wetlands, especially when coupled with off-site mitigation mechanisms that allow valuable urban coastal waterfronts to be developed. Mitigation, creation, restoration or enhancement off-sets at less economically lucrative, distant public conservation lands is often used to substitute for impacted coastal wetlands. The City supports the purchase of privately held environmentally sensitive lands by governmental or non-profit organizations for the purposes of permanent protection.

The more than 4,000 acres of land within the Conservation, Preservation, and Public-Recreation future land use designations have considerable environmental significance. The City continues to acquire land along the waterfront, and such acquisitions will continue where possible and when funding is available. The fact that the City has 47.24% of its total land area in conservation should be applauded. This area will remain in conservation and will assist in the protection of the adjacent development.

Adaptations for Coastal Erosion and Sea Level Rise

The following discussion depends significantly on the contributions of and Titus (1998), Trescott and Walker (2009): Volk (2008a).

Coastal erosion is responsible for hundreds of millions of dollars of property damage each year; the threat of erosion, that is, merely being located in an erosion-prone area, significantly lowers property values as well. Both beach nourishment (the addition of sand to the eroded shore) and shoreline stabilization (in the form of seawalls, riprap, revetments and other structures) can help waterfront property owners protect the sales value of individual properties. However, when analyzed at the scale of a community, the implications of the two approaches are quite different. Completed beach nourishment increases property values for both waterfront properties and for non-waterfront properties a few rows inland. Thus the total benefits to the community may be substantially greater than estimated for waterfront properties alone, as is typically the case. In contrast, shoreline stabilization appears to lower property values a few rows inland. Thus, while it is beneficial for each individual waterfront property owner to stabilize his own shoreline, non-waterfront property owners lose value as a result of the actions of their waterfront neighbors. Moreover, as more and more waterfront property owners rely on shoreline stabilization, waterfront property values eventually decline as well. The first few property owners to stabilize their shoreline achieve significant benefits, but as more and more of their neighbors follow suit, property values drop to about where they started (Kriesel and Friedman 2002).

Many adaptation options that maintain sediment transport are reactionary, in that they seek to reverse changes that have already occurred or changes that will continue to occur. Because sediment transport is based on a constant cycle of gains and losses, all of these options require maintenance. However, when combined with other actions, these adaptation options may work to prevent loss of coastal habitats and enable marshes to accrete at a rate consistent with sea level rise (Martinich 2008).

Adaptation options to maintain sediment transport include either trapping sediment that would otherwise migrate or reintroducing sediment into systems. Constructing groin structures traps sand and prevents it from traveling down shore. Adding sand to beaches with beach nourishment projects that extend the shoreline or create dunes, and replacing sand in water bodies following storms allows for sediment transport to continue and reverses losses due to erosion (Martinich 2008).

Possible responses to sea level rise include building walls to hold back the sea, allowing the sea to advance while adapting to it, and raising the land and/or structures (e.g., by replenishing beach sand and/or elevating houses and infrastructure). Each of these responses is costly, either in out-of-pocket expenses or in lost land and structures. For example, the cumulative cost of enough sand replenishment to protect Florida’s coast from a 20-inch rise in sea level by 2100 is estimated at $1.7 to $8.8 billion (USEPA 1997).

The effects of sea level rise in the City of Punta Gorda will be to increase the level of risk and expense borne by property owners, particularly if property owners choose to remain in place utilizing the expensive strategy of armoring the shoreline and filling land to keep up with storm surge and the increasing average tide height. The likelihood that the City will respond in a way that reduces these effects is complicated by factors including City population increases, coastal property values, increased density in coastal development, the value of coastal tourism, demand for individual coastal access, and the level of insurance subsidization.

The three primary options for development responses to sea level rise and storm surge effects are ***protection*** (armoring, filling, diking), ***managed retreat*** which is better described as **planned relocation**, and structural ***accommodation*** adaptations (such as elevation of infrastructure). Each method possesses advantages and disadvantages (TCRPC 2005). To date, the City of Punta Gorda has employed all three methods to address shoreline and flooding issues.

One of the major problems in evaluating the different options to address flooding from storm surges, sea level rise and the combination of the two is that the names utilized to describe the activities have psychologically loaded contexts. The term **"protection"** that can represent expensive and complex engineering solutions has a heroic and active context of man vs. nature, triumph over adversity. In contrast the terms **managed retreat** and **accommodation** have passive and negative connotations associated with defeat, particularly for those that seek active, physically tangible solutions to problems.

It was the determination of the study *Summary of Research on Strategies for Adaptation to Sea Level Rise in Florida* by Michael Volk of the University of Florida, that a variety of strategies will be necessary for adaptation, particularly along protected shorelines. These strategies may be categorized based on the existing and projected land use and on the natural coastal ecology. Volk's (2008) strategies are broken down based on high or low energy shorelines, and developed or undeveloped land use. The general recommendation from that study was for **managed retreat** from the shoreline.

Volk's conclusions are that ecologically and financially sustainable shoreline **protection** is probably not possible, particularly on high energy shorelines. **Protection** of any shoreline will only be feasible up to a certain amount of sea level rise, after which the financial costs will be too great to justify **protection**. As an alternative to shoreline **protection**, **managed retreat** policies could be implemented and shorelines could generally be allowed to **retreat** naturally. There may however be cases where shoreline **protection** is deemed appropriate, such as in the case of historic downtown Punta Gorda.

Protection

Protection refers to shoreline stabilizing or hardening techniques, such as seawalls and beach nourishment, that attempt to maintain a static shoreline position. It also includes diking and filling to keep pace with sea level. ***Protection*** may be financially sustainable in the short term because it does not require **relocation** or discontinuation of property use. If the structural method is a relatively small proportion of the total infrastructure investment both in terms of effort and costs, including maintenance, then it is more easily selected. However, in the long term ***protection*** is likely to prove to be financially unsustainable. Recurrent property damage will likely increase due to the effects of sea level rise coupled with more severe storms and storm surges. Protective structure maintenance and construction costs will increase. The concentration of public resources on **protection** of shoreline infrastructure will require an unbalanced use of public funding sources repetitively on the same parcels. Armoring, filling and diking all damage the recreational and fisheries values of coastlines by causing shoreline ecosystem loss. ***Protection*** will likely be ecologically unsustainable because it tends to damage coastal ecosystems, alter shoreline processes such as sediment flows, and prohibit ecosystem translocation (Titus 1991 et al.).

Under some circumstances, where shorelines are well-developed, shoreline armoring and other ***protection*** measures may be necessary. The historic downtown district of Punta Gorda is an example of an area where some passive ***protection*** strategies could be employed. Buildings can be raised either by lifting them with jacks and adding fill beneath, or by filling in ground-level floors and adding additional stories at the top. Raising a building by just one eight to ten foot store would compensate for the maximum amount of sea level rise predicted to occur by 2200. New structures could be designed to have the additional height in the initial design. Currently several newer businesses in the downtown area of Punta Gorda have elevated as part of their design.

While adverse impacts should first be avoided and then minimized, sometimes some loss of ecological function and/or public access to the shoreline is unavoidable. Mitigation can be required to compensate for these lost uses and functional values. Depending on the type of loss, mitigation can take the form of restoring another impaired shoreline, preserving a shoreline of significant ecological value, or enhancing or creating another public access site. Similar to established wetland mitigation banks, shoreline mitigation banks could also be created to facilitate selection and prioritization of mitigation projects. Property owners could pay into a mitigation bank which is then used to fund regional shoreline restoration and beach renourishment efforts.

In highly developed areas where a hardened structure is already present and is the only feasible alternative, mitigation allows for positive environmental/societal benefits to be gained to offset any adverse environmental or public access impacts that occur at the site.

However, mitigated systems are rarely as good as the unaltered natural systems they are meant to replace. Good scientific data and project monitoring is needed to ensure that the mitigation will be comparable to the functions and uses lost. Mitigation may not be environmentally or socially relevant if the mitigation project is geographically removed from the project area (NOAA 2009).

Strategies for shoreline **protection** were examined for high and low energy developed shorelines as well as for critical conservation lands by Volk (2008). It was determined that ecologically and financially sustainable **protection** of high energy developed shorelines is not possible, due to the dynamic nature of shoreline processes.

Seawalls or other hard stabilizing structures along these shorelines will destroy shoreline ecosystems, require continued maintenance, and will cease to be feasible after some level of rise (15 feet for example). Beach nourishment used along shorelines will also have negative ecological effects, and will likely become more financially unsustainable as sea levels rise.

Sustainable **protection** of low energy developed shorelines was determined to have a higher level of feasibility than **protection** of high energy shorelines due to decreased wave and erosive energy. It may be possible to maintain functional shoreline ecosystems while still maintaining a 'static' protected shoreline. For this to happen, ecosystems must still be allowed to **retreat** upland from rising seas. Ecosystem **retreat** inland from the existing shoreline is likely not possible if the existing shoreline position is to be maintained.

A second option is to establish ecosystems seaward of the existing shoreline, which can **retreat** up to the existing shoreline position. With this option, shoreline ecosystems may exist while maintaining an essentially static shoreline. The goals of a strategy such as this would be to maintain the same level of **protection** as would be gained through construction of a traditional protective structure such as a dike, to reestablish, maintain, and facilitate the adaptation of functional shoreline ecosystems, and to spread shoreline **protection** costs spread over a long period of time in keeping with rate of sea level rise. Several important issues created by this strategy, which could preclude its use, are sediment sources, takings of sovereign submerged lands, source of funding, and upland drainage. It should be noted that drainage of uplands will be an issue with any strategy protecting lands lower than the mean high tide.

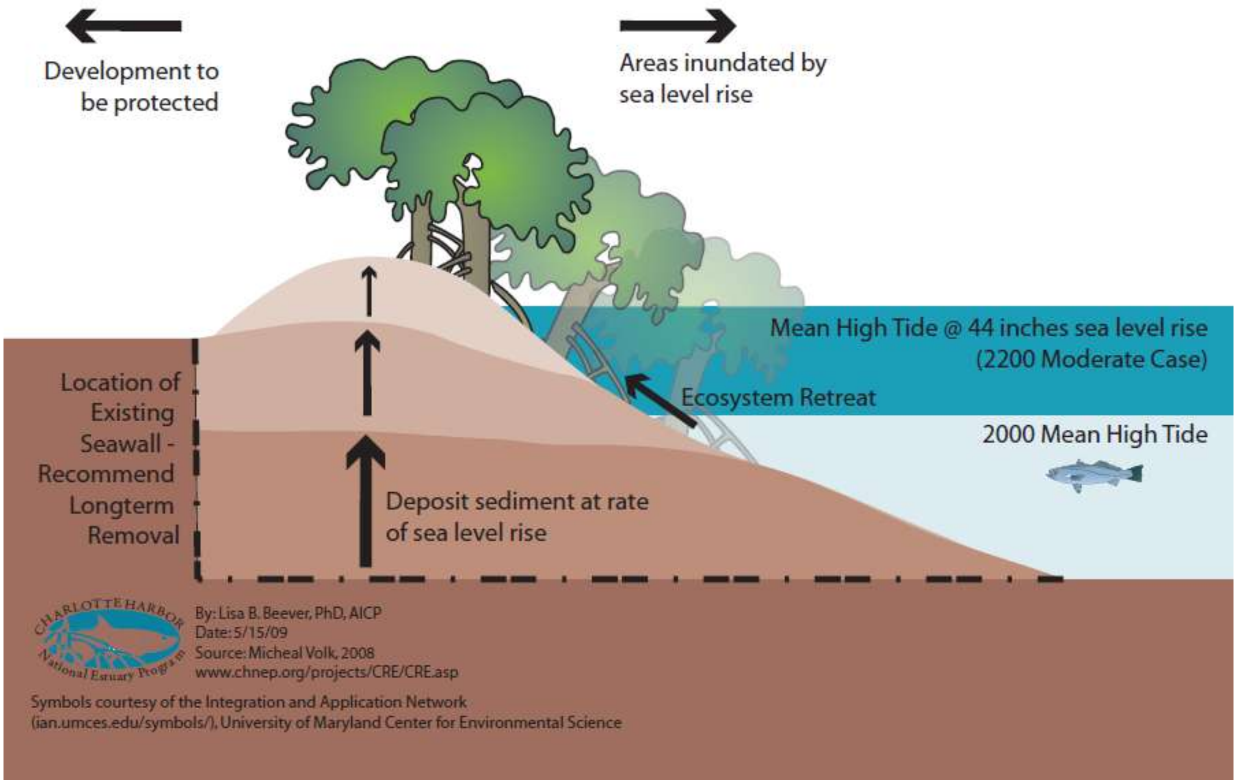


Figure 78: A method of gradual filling of areas in front of shoreline protection to keep pace with sea level rise.

Based upon Volk 2008.

Managed retreat

Managed retreat or **planned relocation** refers to moving development and infrastructure out of harm's way in a planned and controlled manner over time using techniques such as long-range infrastructure planning, property abandonment, structure **relocation**, and hazard avoidance. **Planned relocation** is ecologically sustainable because it allows natural ecosystem processes and shoreline **relocation** to occur while protecting the public financial and infrastructure investment. It is financially sustainable because it avoids the long-term costs associated with ***protection***, particularly if it is based on long-range planning. There are however a number of issues related to ***planned relocation*** including dry land property loss, in-migration land use conflicts, the possibility of 'takings' arguments and litigation, the ability to overcome existing external financial incentives for coastal development, potential tourism and tax base impacts, and the potential short-term costs.

Protection of conservation lands is not generally recommended (Volk 2008; Titus 1991 et al., SWFRPC 2005). Rather, facilitation of ecosystem adaptation and migration should occur. However, there may be cases where the criticality of conservation lands is such that it justifies short term **protection**. Figure 78 illustrates conceptually how this could occur. Water flow and disturbance of the existing tidal ecosystems are issues created by this strategy.

The primary elements of a ***planned relocation*** strategy could be as follows.

First, the City of Punta Gorda would conduct comprehensive shoreline assessments to determine the unique characteristics of the specific shoreline, suitability analyses to determine which lands should be protected or where shoreline **retreat** should be allowed, and hazard projections to determine the area first in line to be inundated based on erosion, sea level rise, and storm surge estimates.

Second, rolling easements or similar policies that allow shoreline **retreat** and disallow coastal **protection** or hardening could be implemented. Rolling easements are a special type of easement purchased from property owners along the shoreline to prevent them from holding back the sea but which allow any other type of use and activity on the land. As the sea advances, the easement automatically moves or "rolls" landward. Because shoreline stabilization structures cannot be erected, sediment transport remains undisturbed and wetlands and other important tidal habitat can migrate naturally. Similarly, there will always be dry or intertidal land for the public to walk along, preserving lateral public access to the shore. This step does not need to be implemented all at the same time and easements could be acquired in order of priority related to level and timing of exposure to coastal flooding.

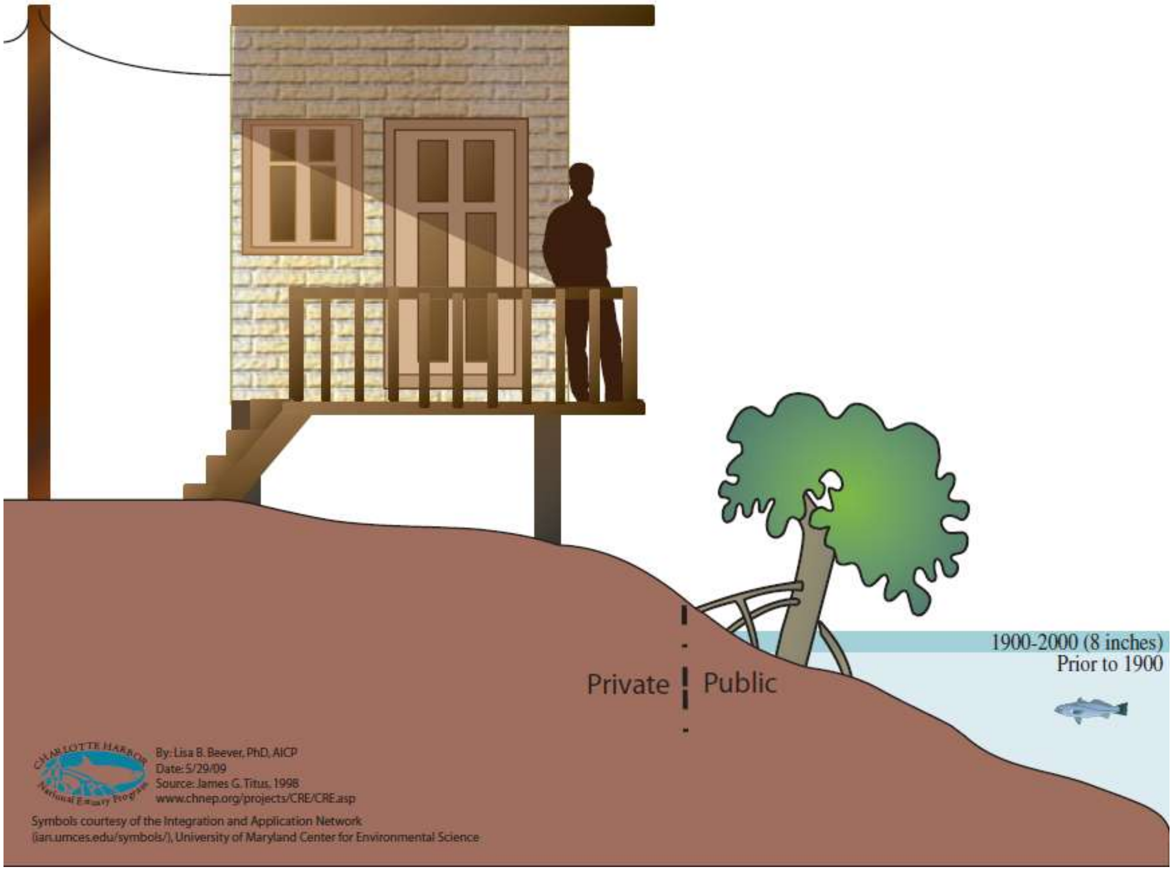


Figure 79: Rolling easement step 1 Year 2010. Easement established at current shoreline. Source: CHNEP 2009 Based on Titus 1998.

Unlike setbacks, which prohibit development near the shore and can often result in "takings" claims if a property is deemed undevelopable due to the setback line, rolling easements place no restrictions on development. They allow the landowner to build anywhere on their property with the understanding that they will not be able to prevent shoreline erosion by armoring the shore, or the public from walking along the shore—no matter how close the shoreline gets to their structure. If erosion threatens the structure, the owner will have to relocate the building or allow it to succumb to the encroaching sea.

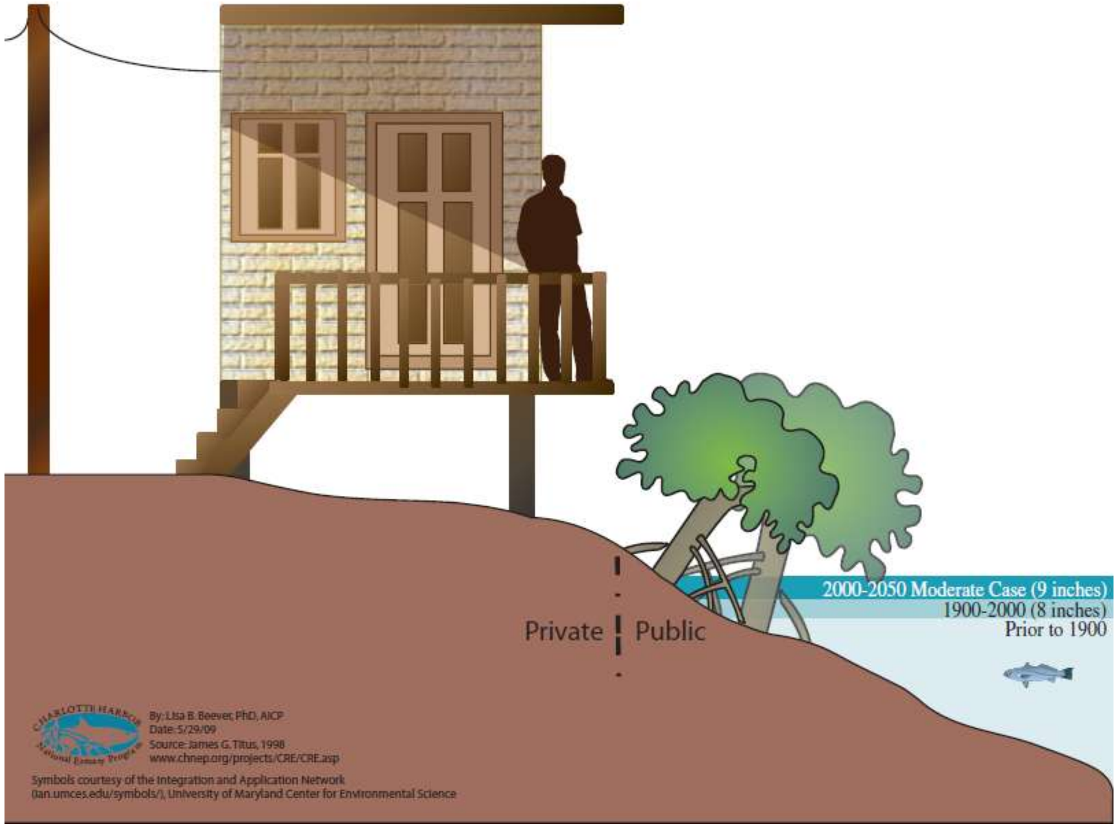


Figure 80: Rolling easement step 2 Year 2050. Moderate case 9 inches sea level rise. Mangroves and marsh move inland. Former mangroves become inundated.

Source: CHNEP 2009 Based on Titus 2008.

Under the Public Trust Doctrine, the public has the right to access tidal lands for fishing and recreation. Therefore, for most states, tidal land is public land. Even for "low-tide" states where private ownership is permitted up to the low-tide line, the public still has the right to access the intertidal zone. For the purposes of a rolling easement, eventually, as the shore continues to erode, the structure that was once on private property, will be sitting on public land. At this point, the private owner could decide to relocate the structure inland. Alternately, the property owner could allow the structure to remain until it becomes unsafe and pay rent to the state for use of public land.

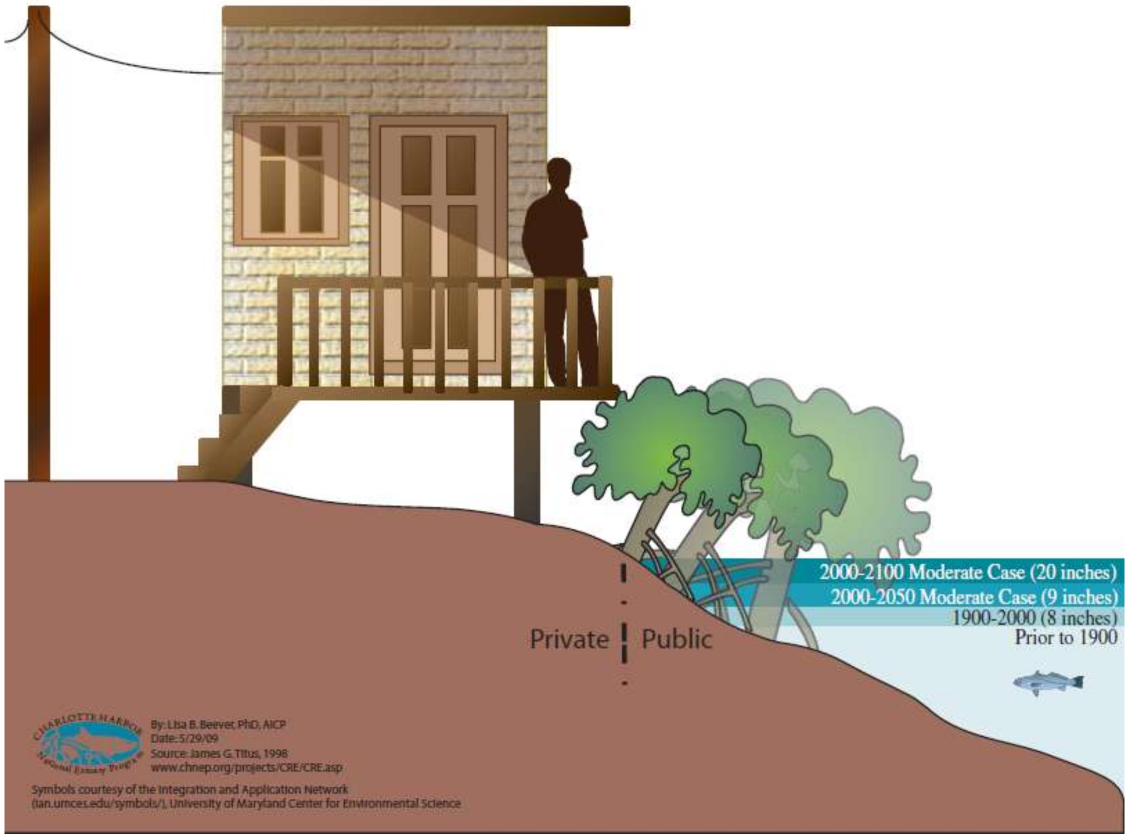


Figure 81: Rolling easement step 3 Year 2100. Moderate case 20 inches sea level rise. Mangroves and marsh move inland. Former mangroves become inundated.

Source: CHNEP 2009 Based on Titus 2008.

Because there are no restrictions to land use, rolling easements have minimal impacts on property values, usually reducing property values by one percent or less (Titus 1998). "Takings" claims are also limited because it could be decades or more before erosion impacts are felt. In the meantime, the landowner would have full use of their property. To circumvent any potential "takings" claim, the government could purchase the easement from the property owner. More detailed examples about the cost advantages and disadvantages of rolling easements can be found in Titus (1998).

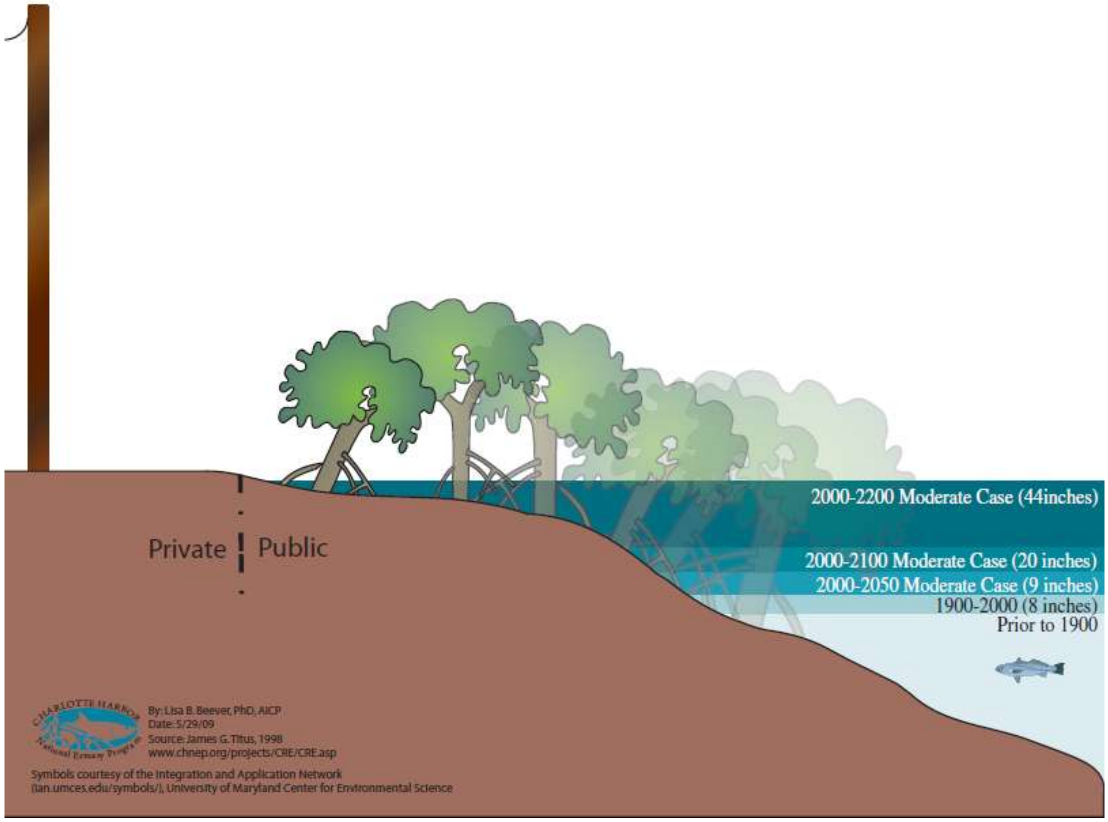


Figure 82: Rolling easement step 4 Year 2200. Moderate case 20 inches sea level rise. Mangroves and marsh move inland. Former mangroves become inundated. Residence moved to new location or abandoned and removed.

Source: CHNEP 2009 Based on Titus 2008.

In addition, because landowners are aware that their structure may one day need to be relocated, rolling easements can encourage the building of smaller, and more mobile structures that can be relocated easily.

Rolling easements can even be used where the shoreline is hardened to allow for continued lateral public access to the shore. As the beach disappears at the base of the hard stabilization structure, the rolling easement steps over the structure, enabling the public to walk along the landward side of the armored shore—an area that used to be private property. Without a rolling easement to enable public access, once the sea advances to the toe of the bulkhead or riprap, the public would be barred from walking along the shore since the dry upland falls into private ownership. The rising water levels would have drowned all access to tidal beach on public trust land.

Although rolling easements, like erosion control easements, can be useful shoreline management tools by themselves, and an effective way to implement managed **retreat** policies they are typically more effective if used in coordination with other approaches including setbacks and other building along the shore.

Among the benefits of rolling easements is that they help minimize activities that could enhance erosion problems without prohibiting development altogether. Often property owners can receive tax benefits for placing a conservation easement on their property. Rolling easements can help maintain natural shoreline processes. There are minimal "takings" issues as compared to setbacks. Rolling easements do not require as much scientific data as some other shoreline management approaches such as setbacks. Rolling easements are typically less costly than setbacks as well.

Among the drawbacks of rolling easements is that they are not as effective for shorelines that are already significantly developed. Property owners may be hesitant to place easements on their property because the restrictions may decrease or be perceived to decrease the resale value of their property. Property boundaries typically do not align with drift cell boundaries or other environmentally relevant scales. Therefore, placing an easement along the shoreline to prohibit shoreline armoring or limit development in one area but not for another site in the same drift cell could exacerbate erosion rates down drift from the hardened/developed shoreline, negating any benefits a conservation easement could have. Enforcing rolling easements could be difficult.

Third, the City may designate a special overlay district in areas likely to be inundated based on hazard projections. Unique design guidelines should be implemented in these areas. Public financing in these areas should be minimized, particularly for new infrastructure. Within this area likely to be inundated, the City should create an along-shore buffer or easement for ecosystem retreat, management, and restoration. Property purchases, purchase of development rights, setbacks or deed restrictions, development disincentives, and sale incentives are some ways to create this easement. The City will need to plan for removal of inundated structures, infrastructure, and identify strategies for mitigation of hazards related to inundated structures. Creative reuse will be essential; for example, the reuse of building foundations as marine habitat could be appropriate.

Finally, the City will need to continue to integrate good waterfront design principles, and adapt existing useable infrastructure for new evolving waterfront. Communities that allow **retreat** must realize that the waterfront will be constantly evolving, and must allow for this change within land-use plans and waterfront projects.

Accommodation

Accommodation or in-place **adaptation** refers to strategies that allow for the use of vulnerable lands to continue, but that do not attempt to prevent flooding or inundation with shoreline **protection**. Examples include **relocation** friendly construction, short-term land uses, and inundation friendly uses. **Accommodation** adaptations, if not part of a long-range plan for **planned relocation**, can have the same negative financial and ecological impacts as ***protection***.

Strategies for **accommodation** are addressed in Volk (2008) through draft guidelines for construction and land use in areas likely to be inundated. **Accommodation** is recommended as part of an overall **managed retreat** strategy, and would occur in areas likely to be inundated where **retreat** is ultimately planned. It is important to adopt special guidelines for these areas first because suitable land uses within these areas will be better able to respond and adapt to coastal hazards, minimizing financial loss and hazards to coastal populations. These guidelines must be adopted for the use of areas likely to be inundated in order to minimize negative ecological effects and hazards to development, and proactive human action will likely be necessary to facilitate ecosystem adaptation to sea level rise. Two of the most important elements to this are discontinuing coastal hardening and providing lands for ecosystem **retreat.**

Second, suitable land use within these areas may help to facilitate ecosystem adaptation and maintain functional shoreline ecology. The key concepts behind the guidelines discussed by Volk (2008) are the support of land uses that are water dependent, temporary, adaptable, or evolve as sea levels rise, that are financially sustainable investments with consideration of sea level rise, that allow natural shoreline and ecosystem processes to continue, and that integrate good waterfront design principles.

In Punta Gorda, the largely undeveloped area west of Burnt Store Road, which forms the east wall of Charlotte Harbor, is a good example of a place where **planned relocation** is the best strategy. In this area, ecosystem retreat would enable the migration of the extensive mangrove forests and salt marshes, which form an important protective barrier against storm surge and tropical storm-related winds.

Ecosystem retreat inland from the existing shoreline is likely not possible if the existing shoreline position is to be maintained. A second option is to establish ecosystems seaward of the existing shoreline, which can retreat up to the existing shoreline position. With this option, shoreline ecosystems may exist while maintaining an essentially static shoreline. The goals of a strategy such as this would be to maintain the same level of protection as would be gained through construction of a traditional protective structure such as a dike, to reestablish, maintain, and facilitate the adaptation of functional shoreline ecosystems, and to spread shoreline protection costs spread over a long period of time in keeping with rate of sea level rise. Several important issues created by this strategy, which could preclude its use, include sediment sources, takings of sovereign submerged lands, source of funding, and upland drainage. It should be noted that drainage of uplands will be an issue with any strategy protecting lands lower than the mean high tide. Protection from inundation of conservation lands is not generally recommended (Titus 1991 et al.). Rather, facilitation of ecosystem adaptation should occur. However, there may be cases where the criticality of historical or conservation lands is such that it justifies short-term protection. Water flow and disturbance of the existing tidal ecosystems are issues created by this strategy.

Strategies for **accommodation** are addressed in the TCRPC study through draft guidelines for construction and land use in areas likely to be inundated. Accommodation is recommended as part of an overall managed retreat strategy, and would occur in areas likely to be inundated where retreat is ultimately planned. It is important to adopt special guidelines for these areas first because suitable land uses within these areas will be better able to respond and adapt to coastal hazards, minimizing financial loss and hazards to coastal populations. Second, suitable land use within these areas may help to facilitate ecosystem adaptation and maintain functional shoreline ecology. The key concepts behind the guidelines discussed are the support of land uses that are water dependent, temporary, adaptable, or evolve as sea levels rise; that are financially sustainable investments give consideration of sea level rise; that allow natural shoreline and ecosystem processes to continue; and that integrate good waterfront design principles.

The conclusions of the TCRPC (2008) study are that ecologically and financially sustainable shoreline protection is probably not possible, particularly on high energy shorelines. Protection of any shoreline will only be feasible up to a certain amount of sea level rise, after which the financial costs will be too great to justify protection. As an alternative to shoreline protection, managed retreat policies should be implemented and shorelines should generally be allowed to retreat naturally. There may however be cases where shoreline protection is deemed appropriate, such as in the case of historic St. Augustine, Florida. Accommodation, if used, should be part of a greater strategy for retreat. Guidelines must be adopted for the use of areas likely to be inundated in order to minimize negative ecological effects and hazards to development, and proactive human action will likely be necessary to facilitate ecosystem adaptation to sea level rise. Two of the most important elements to this are discontinuing coastal hardening and providing lands for ecosystem retreat.

Although the southwest Florida region does not have an explicit sea level rise response policy, policies designed to address other issues with similar consequences define an implicit response for many parts of the region. Trends in land use, construction practices, economic growth, environmental sensibilities, and consumer preferences also contribute to the momentum that defines the region's likely response to sea level rise (Titus 1991 et al.).

Federal Policies and Programs

The federal government has several major policies that directly and indirectly affect the likelihood that shores will be protected from erosion, inundation, and increased flooding as sea level rises. We will first examine some policies that encourage retreat, and that encourage shore protection.

Federal Policies that Encourage Shore Protection

The federal wetland program explicitly allows shoreline armoring, while having no explicit policies to *prevent* shoreline armoring. The federal government has long provided subsidies for jetties that stabilize harbor entrances, and beach nourishment along intensely developed shores. In areas like Miami Beach, seawalls did—and probably still would—protect development from eroding shores, so the subsidy for beach nourishment fundamentally influences the type of shore protection. Along more moderately developed shores in this region, the absence of shore protection would probably result in seawalls designed for a modest storm; but a major storm would destroy the seawall, and permanently erode the shore 50 to 100 feet inland. In these areas, the availability of federal beach nourishment funds enables the shore to continue to be protected.

Numerous federal policies appear to encourage or enable relatively dense development in the coastal zone. Federal flood insurance decreases the risk to the owner of coastal construction. Improved building codes resulting from flood insurance regulations enable homes to continue standing in the waters of the Gulf of Mexico after storm-generated erosion, making retreat unnecessary, provided that the beach returns (either naturally or from a beach nourishment project). Federal subsidies for sewage treatment plants make it possible to more densely develop coastal areas where a proliferation of septic tanks would severely pollute coastal bays.

Federal Policies that Encourage a Retreat from the Shore

The federal government influences shore protection as a landowner, a regulator, and a subsidizer (Titus 2000). As a coastal land owner, the federal government has made several very large parcels of land in southwest Florida unavailable to development by acquisition for conservation purposes. Because undeveloped lands are much less likely to be protected than developed areas, federal ownership itself often makes shore protection unlikely, even where there is no specific policy on whether to protect the shore or retreat. Several conservation-oriented landowning agencies consciously allow wetlands and beaches to migrate inland. Everglades National Park and Big Cypress National Preserve all follow the National Park Service general policy of allowing natural processes to work their will. The most noteworthy example of the National Park Service's commitment to allowing shores to retreat was the recent relocation of Hatteras Light in North Carolina, which was moved over one thousand feet inland on a special-purpose railroad track at a cost of over $10 million. National Wildlife Refuges generally allow wetlands to migrate inland within their boundaries, which would apply to the refuges at Ding Darling on Sanibel Island, Matlacha Pass, Pine Island, and Caloosahatchee National Wildlife Refuges all in Lee County.

Even agencies that regularly protect some shores may foster shore retreat to some extent. Military bases armor shores to protect buildings and naval port facilities; but military bases often have substantial undeveloped buffer areas where natural shores are preserved.

The federal government does not generally regulate the use of privately owned uplands; so it does not directly discourage development in the coastal zone. However, Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act require landowners to obtain permits to fill wetlands. Regulations interpreting the requirements of these statutes often discourage or prohibit fill and other beach nourishment activities along bay shores. Although bulkheads and stone revetments are generally allowed in this region, they are technically fill and require a permit if below mean high water. Although these structures can be built inland of mean high water, eventually they sit within the ebb and flow of the tides as sea levels rise and shores erode; therefore replacement or repair might require filling in the "waters of the United States" and hence require a permit.

The Coastal Barrier Resources Act (CoBRA) prohibits federal subsidies and flood insurance to specific designated portions of barrier islands, barrier spits, and other coastal areas (Titus 2000). In this region, the designated coastal barriers are in Charlotte and Lee Counties, including parts of Don Padre Island, parts of Cayo Costa and North Captiva Islands (state parks) and in Collier County, parts of Keewaydin and Cape Romano Islands. The second designation of "other coastal areas" includes numerous undeveloped unbridged islands within the bays of the region.

In this region, the main impact of CoBRA has been that the lack of bridge access made development relatively unattractive, leading other areas to be developed first and keeping land prices on these portions of the coast relatively low. As a result, state and local land acquisition programs have acquired parcels on some of these islands. Cayo Costa State Park is a good example of how CoBRA has worked, where the presence of thousands of platted lots with vested development rights has discouraged development, giving time for a voluntary state land acquisition program to acquire about 97% of this state park from private land owners.

In other parts of the state, CoBRA areas with easier access have been developed, but the unavailability of federal subsidies makes beach nourishment unlikely. Lack of federal subsidies for sewage treatment has limited the density in still other areas. The unavailability of flood insurance and federally backed mortgages also discourages development.

Even though the other parts of the Federal Flood Insurance Program encourage shore protection, the program does have a component that also encourages retreat. Specifically, the repetitive loss program (a repetitive loss consists of two flood insurance claims on the subject property) offers a 50/50 federal/local match to buy the parcel for preservation. Otherwise a repetitive loss owner can match 50% of the cost to raise the structure to prevent further flooding which is a form of encouraging shore protection.

Florida State Policies and Programs

Similar to the federal policies, no state policies specifically address the issue of sea level rise, but many policies are already in place to deal with consequences. These policies are included in the Coastal Construction Control Line Program, the Beach Erosion Control Program, the Coastal Building Zone, Strategic Beach Management Plans and Environmental Resource Permits.

Florida Policies that Encourage Shore Protection

The Florida Beach and Shore Preservation Act was enacted by Florida’s legislature to preserve and protect Florida’s beach and dune system. Beaches and dunes are the first line of defense against storms, acting as a buffer between the sea and coastal development. One of the programs authorized by the Beach and Shore Preservation Act to be an essential element in the protection effort is the Coastal Construction Control Line (CCCL) Program (Beach and Shore Preservation Act, Florida Statutes Chapter 161).

The CCCL Program was designed to protect Florida’s beach and dune system from irresponsible construction that could weaken, damage, or destroy the health of the dune system. Structures that are built too close to the sea can inhibit the beach and dune system from its natural recovery processes and can cause localized erosion. Improperly constructed structures are a threat to other nearby coastal structures, should they be destroyed by storms. The CCCL Program gives the state the jurisdiction to apply stringent siting and design criteria to construction projects seaward of the control line. The CCCL is not a setback line, but is rather a demarcation line of the state’s authority.

The CCCL is marked at the landward limit of coastal areas that are subject to the effects of a 100-year storm surge. While wind and flooding may intrude further inland than the 100-year storm surge area, effects landward of the CCCL are considerably less than seaward of it. Seaward of the CCCL, the State prohibits the construction or siting of structures that would cause a significant adverse impact to the beach and dune system, result in the destabilization of the system or would destroy marine turtle habitat. To meet these requirements, structures are required to be located a sufficient distance from the beach and frontal dune and must also be sited in a way that does not remove or destroy natural vegetation. The CCCL also requires all structures to be constructed to withstand the wind and water effects of a 100-year storm surge event. This involves creating structures that meet the American Society of Civil Engineering 7-88 Section 6 wind design standard for 110 mph winds (115 mph for the Florida Keys). Water design standards include a foundation engineered to withstand a 100-year storm event, including the effects of surge, waves and scouring. There is no prohibition of rebuilding under the CCCL Program. Due to the effects of erosion, the CCCL Program discourages the construction of rigid coastal armoring (seawalls) and instead encourages property owners' use of other protection methods, such as foundation modification, structure relocation and dune restoration.

Another similar endeavor to regulate coastal construction is the Coastal Building Zone (CBZ). The CBZ was established as part of the Coastal Protection Act of 1985 to protect coastal areas and to protect life and property. The CBZ is similar to the Coastal Construction Control Line program in that it is a regulatory jurisdiction, rather than a setback line. The CBZ envelopes land from the seasonal high water line to 1500 feet landward of the CCCL. In those areas fronting on the ocean but not included within an established CCCL, the Coastal Building Zone includes the land area seaward of the most landward V-Zone line, as established by the National Flood Insurance Program's (NFIP) flood maps. The V-Zone is an area likely to experience a wave greater than three feet high with storm surge, or areas within the 100-year storm event used by the CCCL program. Local governments, rather than the state, enforce the Coastal Building Zone as a part of their building codes.

Within the CBZ, new construction is required to meet the Standard Building Code 1997 wind design standard of 110 mph (115 mph for the Florida Keys). As for water standards, structures are required to meet NFIP requirements or local flood ordinance requirements, whichever are stricter. Foundations must also be designed to withstand a 100-year storm surge. CBZ construction standards are less stringent than CCCL standards. This is due to the fact that NFIP flood maps have lower base flood elevations for 100-year storm events than do CCCL studies.

Another State effort to protect Florida's beaches, authorized by the Beach and Shore Preservation Act, is the Beach Erosion Control Program (BCEP). The BECP is the primary program that implements the Florida Department of Environmental Protection's beach management recommendations. The BCEP was created to coordinate the efforts of local, state, and federal governments in protecting, preserving and restoring Florida's coastal resources. One of the activities of this program is the offering of financial assistance to counties, local governments and other special districts for shore protection and preservation efforts. The BECP will provide up to 50 percent of project costs. The mix between federal, state and local funds is different for each project.

Beach management activities eligible for funding from the BECP include beach restoration and nourishment activities, project design and engineering studies, environmental studies and monitoring, inlet management planning, inlet sand transfer, dune restoration and protection activities, and other beach erosion prevention related activities.

Another endeavor of the BECP is the development and maintenance of a Strategic Beach Management Plan (SMBP) for Florida. The SBMP is a multiyear repair and maintenance strategy to carry out the proper state responsibilities of a comprehensive, long-range, statewide program of beach erosion control; beach preservation, restoration, and nourishment; and storm and hurricane protection. The SBMP is divided into specific beach management plans for Florida's coastal regions.

Like the Federal Wetland Program, a State of Florida Environmental Resource Permit is authorized by Part IV of Chapter 373, Florida Statutes, to regulate activities involving the alteration of surface water flows. This includes new activities in uplands that generate stormwater runoff from upland construction, as well as dredging and filling in wetlands and other surface waters. Environmental Resource Permit applications are processed by either the Department of Environmental Protection or one of the state's water management districts. The South and Southwest Florida Water Management Districts cover parts of this region.

State Policies that Encourage a Retreat from the Shore

Florida also has one of the largest land and water (including wetlands) acquisition programs in the country, called "Florida Forever" (FF). The funding from this program is used for restoration, conservation, recreation, water resource development, historical preservation, and capital improvements on acquired conservation lands. Land acquisition through this program is almost exclusively voluntary, as the state wishes to avoid using its power of eminent domain. The funding for this program comes from $3 billion in bond issues over a 10-year period, which is being paid back from an excise tax. Florida Forever funds are distributed annually to various governmental agencies for land and water acquisition: Department of Environmental Protection (38%), Water Management Districts (35%), Florida Communities Trust (24%), Department of Agriculture/Forestry (1.5%), and the Fish and Wildlife Conservation Commission (1.5%). Since the program began in 1999, Florida Forever funds have been used to protect over 270,000 acres of natural floodplains, nearly 500,000 acres of significant water bodies, over 24,000 acres of fragile coastline, and over 520,000 acres of functional wetlands (FNAI 2008).

Similar to and developed at about the time as the first federal CoBRA designations, the Florida Legislature passed the Coastal Infrastructure Policy law in Chapter 380.27(1 & 2), F.S. that states the following:

(1) No state funds shall be used for the purpose of constructing bridges or causeways to coastal barrier islands, as defined in s. 161.54(2), which are not accessible by bridges or causeways on October 1, 1985.

(2) After a local government has an approved coastal management element pursuant to s. 163.3178, no state funds which are un-obligated at the time the element is approved shall be expended for the purpose of planning, designing, excavating for, preparing foundations for, or constructing projects which increase the capacity of infrastructure unless such expenditure is consistent with the approved coastal management element.

The State Comprehensive Plan, under Section 8 Coastal and Marine Resources, contains the following policies that encourage retreat:

1. Accelerate public acquisition of coastal and beachfront land where necessary to protect coastal and marine resources or to meet projected public demand.

3. Avoid the expenditure of state funds that subsidize development in high-hazard coastal areas.

4. Protect coastal resources, marine resources, and dune systems from the adverse effects of development.

9. Prohibit development and other activities which disturb coastal dune systems, and ensure and promote the restoration of coastal dune systems that are damaged.

As part of Local Government Comprehensive Planning, Chapter 163 F.S. titled Intergovernmental Programs, Part II Growth Policy; County and Municipal Planning; Land Development Regulation and specifically the Coastal Management law in Chapter 163.3178(1) F.S. could encourage both shore protection and retreat depending on how local governments implement this law relative to natural disaster planning as follows:

(1) The Legislature recognizes there is significant interest in the resources of the coastal zone of the state. Further, the Legislature recognizes that, in the event of a natural disaster, the state may provide financial assistance to local governments for the reconstruction of roads, sewer systems, and other public facilities. Therefore, it is the intent of the Legislature that local government comprehensive plans restrict development activities where such activities would damage or destroy coastal resources, and that such plans protect human life and limit public expenditures in areas that are subject to destruction by natural disaster.

The Coastal High Hazard Area, as defined in the Coastal Management Law Chapter 163.3178(2)(h), is equivalent to the Category 1 hurricane storm surge zone. To provide direction on implementing the Coastal Management Law, the Florida Department of Community Affairs adopted rules in Chapter 9J5.012(3)(b) Florida Administrative Code. The following sections apply to encouraging retreat or shore protection:

(3) Requirements for Coastal Management Goals, Objectives, and Policies.

(b) The element shall contain one or more specific objectives for each goal statement which address the requirements of paragraph 163.3177(6) (g) and Section 163.3178, F.S., and which:

1. Protect, conserve, or enhance remaining coastal wetlands, living marine resources, coastal barriers, and wildlife habitat;
4. Protect beaches or dunes, establish construction standards which minimize the impacts of man-made structures on beach or dune systems, and restore altered beaches or dunes;

5. Limit public expenditures that subsidize development permitted in coastal high-hazard areas subsequent to the element's adoption except for restoration or enhancement of natural resources;
6. Direct population concentrations away from known or predicted coastal high-hazard areas;

(c) The element shall contain one or more policies for each objective and shall identify regulatory or management techniques for:

1. Limiting the specific impacts and cumulative impacts of development or redevelopment upon wetlands, water quality, water quantity, wildlife habitat, living marine resources, and beach and dune systems;
2. Restoration or enhancement of disturbed or degraded natural resources including beaches and dunes, estuaries, wetlands, and drainage systems; and programs to mitigate future disruptions or degradations;
3. General hazard mitigation including regulation of building practices, floodplains, beach and dune alteration, stormwater management, sanitary sewer and septic tanks, and land use to reduce the exposure of human life and public and private property to natural hazards;
4. Hurricane evacuation including methods to relieve deficiencies identified in the hurricane evacuation analysis, and procedures for integration into the regional or local evacuation plan;
5. Post-disaster redevelopment including policies to: distinguish between immediate repair and cleanup actions needed to protect public health and safety and long-term repair and redevelopment activities; address the removal, relocation, or structural modification of damaged infrastructure as determined appropriate by the local government but consistent with federal funding provisions and unsafe structures; limiting redevelopment in areas of repeated damage;
7. Designating coastal high-hazard areas and limiting development in these areas;
8. The relocation, mitigation or replacement, as deemed appropriate by the local government, of infrastructure presently within the coastal high-hazard area when state funding is anticipated to be needed.
10. Providing, continuing, and replacing adequate physical public access to beaches and shorelines; enforcing public access to beaches renourished at public expense; enforcing the public access requirements of the Coastal Zone Protection Act of 1985; and providing transportation or parking facilities for beach and shoreline access.

Local Policies and Programs

In Florida each local government is required to complete a comprehensive land use plan, which has policies that may either encourage shore retreat or protection. Normally, these policies would be in the Coastal Management Element which was discussed above in terms of state requirements.

Approaches for maintaining shorelines in the face of sea level rise include protection and retreat. Each of these approaches, or some combination of them, may be appropriate depending on the characteristics of a particular location (e.g., shore protection costs, property values, the environmental importance of habitat, the feasibility of protecting shores without harming the habitat). Note that the adaptations presented include both shoreline hardening/armoring and removing armoring to create living shorelines. These different and seemingly conflicting options are each appropriate in different situations. Protection options can include hardening the shoreline through measures such as bulkheads, seawalls, revetments, breakwaters, sills, and creating or reinforcing headlands. Shoreline protection can also be achieved through ”softening” measures, which develop living shorelines through beach nourishment, planting dune grasses, marsh creation, and planting submerged aquatic vegetation (SAV). Planned retreat (or wetland migration) is an alternative to shoreline protection in the face of natural forces such as coastal erosion or sea level rise (Martinich 2008).

With two simplifying assumptions, it is possible to estimate the value of real estate at risk from sea level rise. First, Stanton and Ackerman (2007) assumed that the value of real estate will grow uniformly in all parts of the state, in proportion to gross state product (GSP), throughout this century. Second, they assume that the fraction of the state's residential property at risk is proportional to the extent of sea level rise. Then, starting from the calculation of $130 billion of residential real estate, as of 2000, that would be vulnerable to 27 inches of sea level rise, it is possible to project the effects of both scenarios (business-as-usual and rapid stabilization) through 2100. The cost of inaction — that is, the annual increase in the value of residential real estate at risk of inundation — rises from $11 billion in 2025 to $56 billion in 2100, or almost 1 percent of GSP. And sea levels will continue to rise beyond 2100.

No one expects coastal property owners to wait passively for these damages to occur; those who can afford to do so will undoubtedly seek to protect their properties. But all the available methods for protection against sea level rise are problematical and expensive. It is difficult to imagine any of them being used on a large enough scale to shelter all of Florida from the rising seas of the 21st century, under the worst case (Stanton and Ackerman 2007).

Elevating homes and other structures is one way to reduce the risk of flooding, if not hurricane-induced wind damage. A FEMA estimate of the cost of elevating a frame-construction house on a slab-on-grade foundation by two feet is $58 per square foot, after adjustment for inflation, with an added cost of $0.93 per square foot for each additional foot of elevation (FEMA 1998). A house with a 1,000 square foot footprint would thus cost $58,000 to elevate by two feet. It is not clear whether building elevation is applicable to multistory structures; at the least, it is sure to be more expensive and difficult (Stanton and Ackerman 2007).

Another strategy for protecting real estate from climate change is to build seawalls to hold back rising waters. There are a number of ecological costs associated with building walls to hold back the sea, including accelerated beach erosion and disruption of nesting and breeding grounds for important species, such as sea turtles, and preventing the migration of displaced wetland species (NOAA 2000). In order to prevent flooding to developed areas, some parts of the coast would require the installation of new seawalls. Estimates for building or retrofitting seawalls range widely from $300 to $4,000 per linear foot (Yohe et al. 1999; U.S. Army Corps of Engineers 2000; Kirshen et al. 2004; Dean 2007b; Stanton and Ackerman 2007).

Specific costs for coastal armoring for southwest Florida are listed below in Table 54. Costs do not include labor for installation.

Description	Unit	Unit Cost ($)
Concrete seawalls, reinforced concrete, up to 6' high, include footing and tie-backs, maximum	L.F.	425.00
Concrete seawalls, reinforced concrete, to 12' high, include footing and tie-backs, maximum	L.F.	625.00
Concrete seawalls, pre-cast concrete bulkhead, complete, using 16' vertical piles, includes vertical and battered piles, face panels, and cap	L.F.	660.00
Concrete seawalls, pre-cast concrete bulkhead, complete, using 20' vertical piles, includes vertical and battered piles, face panels, and cap	L.F.	705.00
Steel sheet piling seawalls, steel sheeting, 12' high, shore driven	L.F.	465.00
Steel sheet piling seawalls, steel sheeting, 12' high, barge driven	L.F.	810.00
Steel sheet piling seawalls, crushed stone, placed behind bulkhead by clam bucket	C.Y.	60.50
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 4'-0" high, 2'-0" embedment, includes concrete cap and anchor	L.F.	161.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 4'-0" high, 3'-6" embedment, includes concrete cap and anchor	L.F.	201.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 4'-0" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	275.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 6'-0" high, 2'-6" embedment, includes concrete cap and anchor	L.F.	206.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 6'-0" high, 4'-0" embedment, includes concrete cap and anchor	L.F.	252.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 6'-0" high, 5'-6" embedment, includes concrete cap and anchor	L.F.	330.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 8'-0" high, 3'-6" embedment, includes concrete cap and anchor	L.F.	260.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 8'-0" high, 5'-0" embedment, includes concrete cap and anchor	L.F.	286.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 3'-0" high, 2'-0" embedment, includes concrete cap and anchor	L.F.	199.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 3'-0" high, 4'-0" embedment, includes concrete cap and anchor	L.F.	259.00

Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 3'-0" high, 5'-6" embedment, includes concrete cap and anchor	L.F.	320.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 5'-0" high, 3'-6" embedment, includes concrete cap and anchor	L.F.	295.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 5'-0" high, 5'-0" embedment, includes concrete cap and anchor	L.F.	355.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 5'-0" high, 6'-6" embedment, includes concrete cap and anchor	L.F.	450.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 7'-0" high, 4'-6" embedment, includes concrete cap and anchor	L.F.	430.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 7'-0" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	480.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 3'-0" high, 3'-0" embedment, includes concrete cap and anchor	L.F.	294.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 3'-0" high, 4'-6" embedment, includes concrete cap and anchor	L.F.	360.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 3'-0" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	425.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 4' 6" high, 4'-6" embedment, includes concrete cap and anchor	L.F.	395.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 4'-6" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	465.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 4'-6" high, 7'-0" embedment, includes concrete cap and anchor	L.F.	550.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 6'-0" high, 5'-6" embedment, includes concrete cap and anchor	L.F.	510.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 6'-0" high, 7'-0" embedment, includes concrete cap and anchor	L.F.	570.00
Rip-rap and rock lining, random, broken stone, machine placed for slope protection	C.Y.	77.50
Rip-rap and rock lining, random, broken stone, 3/8 to 1/4 C.Y. pieces, machine placed for slope protection, grouted	S.Y.	163.00
Rip-rap and rock lining, random, broken stone, 18" minimum thickness, machine placed for slope protection, not grouted	S.Y.	118.00
Rip-rap and rock lining, random, broken stone, 50 lb. average, dumped	Ton	44.50
Rip-rap and rock lining, random, broken stone, 100 lb. average, dumped	Ton	63.50

Rip-rap and rock lining, random, broken stone, 300 lb. average, dumped	Ton	73.50
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 6" deep	S.Y.	59.50
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 9" deep	S.Y.	84.00
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 12" deep	S.Y.	92.00
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 18" deep	S.Y.	133.00
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 36" deep	S.Y.	201.00

Table 54: 2009 Construction Bare Unit Costs for coastal armoring. (LF = linear foot; CY = cubic yard; SY = square yard)

Source: SFWMD 2008

The United States Geological Survey (USGS) has created an index to rate the vulnerability of U.S. shoreline to sea level rise, taking into consideration tides and erosion, as well as elevation (USGS 2000). According to their assessment, out of 4,000 miles of total Florida shoreline, 1,250 miles are in the "high" vulnerability category and 460 miles are in the "very high" category. If just these 1,700 miles of shoreline were protected with seawalls, and construction costs averaged $1,000 per linear foot (or a bit over $5 million per mile), the total cost would be just under $9 billion. The 4,000 total miles of shoreline assumed by USGS, however, do not take into account Florida's many channels and inlets, which make the actual coastline much longer. (Conversely, other estimates of the length of Florida's coastline range down to 1,350 or fewer miles; the varying estimates reflect the different resolutions at which the measurements are made.). The actual coastline length, when these features are accounted for, is 22,000 miles (Stanton and Ackerman 2007)If seawalls were needed for 42 percent of Florida's actual coastline (the share of very high and high vulnerability coastline under the USGS definition), or 9,200 miles, the cost would be $49 billion. In other words, constructing seawalls sufficient for statewide protection would be an engineering mega project, several times the size of the long-term Everglades restoration effort (Stanton and Ackerman 2007).

Yet another approach involves beach nourishment, bringing in sand as needed to replenish and raise coastal beaches (which as noted above can have major environmental impacts). A large-scale analysis of the costs of protecting the U.S. coastline from sea level rise, conducted by USEPA in 1989, relied heavily on restoring and building up beaches (Titus et al. 1991). The study projected that most of the sand would need to be dredged up from more than five miles offshore. It estimated the cost of sand to protect Florida against 39 inches of sea level rise (a level reached in 2087 in the worst case) would be between $6 billion and $30 billion in 2006 dollars, depending on assumptions about the quantity and cost of sand. As with statewide seawall construction, beach nourishment on this scale would be a mammoth engineering project, with uncertain environmental impacts of its own. In short, while adaptation, including measures to protect the most valuable real estate, will undoubtedly reduce sea level rise damages, there is no single, believable technology or strategy for protecting the vulnerable areas throughout the state (Stanton and Ackerman 2007).

Additional Adaptations to Sea Level Rise (from the literature review)

The existing scientific literature has identified actions that can better adapt human economies to sea level rise and associated geomorphic changes **(**Ebi et al. 2007; Fiedler et al. 2001; Lee County Visitor and Convention Bureau 2008; Peterson et al. 2007; Titus 1998; USCCSP 2008; USNOAA 2008; USEPA CRE 2008). These include:

- Allow coastal wetlands to migrate inland in areas explicitly indicated
- Allow shoreline hardening where appropriate
- Beach nourishment
- Create a regional sediment management plan
- Create natural buffers against sea level rise
- Ensure that master plans explicitly indicate which areas will retain natural shorelines
- Fortify dikes
- Construct groins
- Harden shorelines
- Increase shoreline setbacks and exchange/purchase/acquisition
- Living shorelines
- Natural breakwaters
- Prohibit development subsidies (federal flood insurance and infrastructure development grants) to estuarine and coastal shores at high risk
- Prohibit development or engineering "solutions" to block migration of wetlands
- Promote wetland accretion by introducing sediment and prohibiting hard shore protection
- Protect barrier islands that shelter beaches
- Remove hard protection or other barriers to shoreline retreat and replace shoreline armoring with living shoreline protections
- Retreat from and/or abandon shore headland control
- Use natural and artificial breakwaters to reduce wave energy
- Carbon offsets
- Change to energy efficient buses and taxis, including those using alternate fuels
- Create more energy- and cost-effective communities through community design and green building
- Increase use of alternative and renewable energy
- Partner with utility companies to educate the public on energy efficiency and expand and increase incentives to homeowners (free/low cost loans for photovoltaic systems, net metering, solar panels)
- Provide alternative transportation
- Consider congestion zone tolls in larger cities
- Reduce carbon emissions
- Subsidize retrofitting buildings for energy efficiency
- Adapt protections of important biogeochemical zones and critical habitats
- Connect landscapes with corridors
- Create dunes
- Create marsh

- Establish early warning sites and baseline
- Identify, protect and adapt protections of ecologically important areas/critical habitat
- Incorporate wetland protection into infrastructure planning data
- Plant submerged aquatic vegetation and other vegetation
- Protect water quality for fisheries and reefs
- Replicate habitat types in multiple locations to spread risks
- Restore submerged aquatic vegetation
- Wetland conservation/restoration accounting for climate change and human engineering such as canals, floodgates, levees, etc.
- Use adaptive stormwater management
- Create water markets
- Design new coastal drainage systems
- Establish or broaden use containment areas to allocate and cap water withdrawal
- Regulate fertilizer application and use
- Improve flood pain management/regulation
- Prevent or limit groundwater extraction from shallow aquifers to protect coast from subsidence and saltwater intrusion
- Redefine flood hazard zones
- Regulate pumping near shorelines, especially for flood control
- Change building codes to promote energy efficient building
- Consider sea level rise in infrastructure planning
- Consider sea level rise in site design
- Constrain locations for certain high risk infrastructure
- Develop and adopt building design criteria to deal with the consequences of possible sea level rise
- Ensure appropriate foundations for buildings
- Establish rolling easements to maintain sediment transport
- Expand planning horizons Improve land use and management
- Incorporate LEED standards into building codes
- Incorporate (Low Impact Development) LID principles
- Use integrated coastal zone management
- Land exchange programs
- Manage realignment of infrastructure
- Promote green building alternatives through education, taxing incentives, building and design standards, green-lending
- Promote green roof technology through building codes
- Purchase upland development rights or property rights
- Restrict/prohibit development in erosion/flood/damage prone areas
- Retreat

A hypothetical comparison of relative costs of various sea-level rise adaptations

The relative costs of different approaches to sea level rise can vary significantly.

In an example of rolling easements Volk (2008) reports that as of 2005, the Worcester County in Maryland secured $7.25 million from the Maryland Rural Legacy Program and contributed $400,000 in local funds to purchase rolling conservation easements for 6,000 acres of land (representing eight miles of shoreline) within the Worcester County Bays Rural Legacy Area. The county continues to work with land owners within the Coastal Bays Rural Legacy Area to encourage others to place conservation easements on their property as well.

This Rolling Easement total cost in Worcester County, Maryland is $7.65 million for 6,000 acres of land (representing eight miles of shoreline) that in 2005 dollars is $1,275/acre or $1,045,752/mile of shoreline. This would be $1,143,781 in 2008 dollars.

In estimating the shorelines of Punta Gorda SWFRPC GIS measured the total length of all manmade canals including all shorelines in the city as 101 miles or 536,485 linear feet.

The natural shoreline of the City of Punta Gorda can be measured in four different ways:

1. Total smooth city boundary out into the Harbor and River is 43 miles in length. (230,612 linear feet);

2. Total with irregular outer mangrove shoreline without overwash mangrove islands or many convoluted embayments. The outer shoreline without embayments is 61 miles (325,908 linear feet).

3. Total with irregular outer mangrove shoreline with convoluted embayments but not the overwash mangrove islands. The outer shoreline with embayments is 68 miles (362,060 linear feet)

4. Less than total set at the boundary between current uplands with freshwater wetlands and tidal coastal wetlands. The inland boundary is 51 miles (270,113 linear feet)

The inland boundary is the most likely measurement appropriate for estimating a rolling easement cost. If this were the length of shoreline to receive the rolling easement than the easement alone would be would be $ 58,332,852 in 2008 dollars.

By comparison the costs of a total shoreline treatment of the city boundary (set at the mean tide line and including the man-made canals) with a complete 6 foot vertical concrete bulkhead along all public and private properties would be $381,881,625 for the bulk head alone. Based on SWFWMD elevation data a 6 foot back fill of the currently developed areas of the city would add 32,199.81 acre/feet (51,949,027.548 cubic yards) of fill. At $18 a cubic yard this would cost $935,082,495.86 in materials. Estimated construction costs or the bulkhead installation with normal salaries would be approximately $252,472,273.88. This would be a total of $1,569,436,395 in 2008 dollars for complete currently developed City protection with Backfill to an approximately 6 foot elevation above the current mean tide line.

Utilizing the method of gradual sand filling to keep pace with se level rise the current estimate for careful sand placement would be in the neighborhood of 1.5 million for each mile of shoreline. At the manmade waterfront there would need to be a concomitant raising of bulkheads if the standard navigable depth of canals were to be maintained. Examining only the outer shoreline the cost for the method of keeping pace with sea level rise would range from $91,500,000 to $102,000,000. If the mangroves and salt marshes were unprotected the cost would be $76,500,000

Elevating the existing infrastructure in place would include increasing the height on buildings that were historical or too valuable to rebuild and replacing building that have exceeded their useful like with new construction that would be elevated at the new standards. As a unified are of structures achieves elevation then the roadway network and utilities would need to be brought up to the new height. Based upon house elevation flood hazard mitigation performed in Sarasota County for a house in the Myakka River flood plain the total cost was $170,000 (FEMA 2003). House elevation costs listed for post Hurricane Katrina recovery are in the neighborhood of $150,000. With a total of 9,986 buildings in storm surge zones and potential sea level rise inundation, the total cost of elevation of only the structures would be approximately $1,269,520,000.

Construction of perimeter earthen dikes that are generally waterproof with a seepage management system would be $25,843,400 to $28,789,382 in fill material along if all manmade canals are left open to tide. If canals are blocked then the fill material dike cost can go as low as $8,654,421 if the total wetlands are left waterward of the dike. If the dike is armored the increased cost would be from $713,109,125 to $2,372,194,742. In this method the area behind the dike would not be elevated but major pumps would be needed to address discharge of storm waters, dike seepage, and drainage. Pumps of sufficient scale to maintain a relatively dry city would range in cost from $7 to $20 million (SFWMD 2006, Wood 2006) depending on design, power sources and portability. Presuming a minimum of 4 major pumps for the City's four basins the costs of an armored dike system with pumps would range from $2,157,450,984 for a interior dike with the canals cut-off from direct navigation access to $3,868,536,601 for an exterior coastline with embayments and the canals open to navigation access. Of course this does not account for the costs accrued when the dike fails.

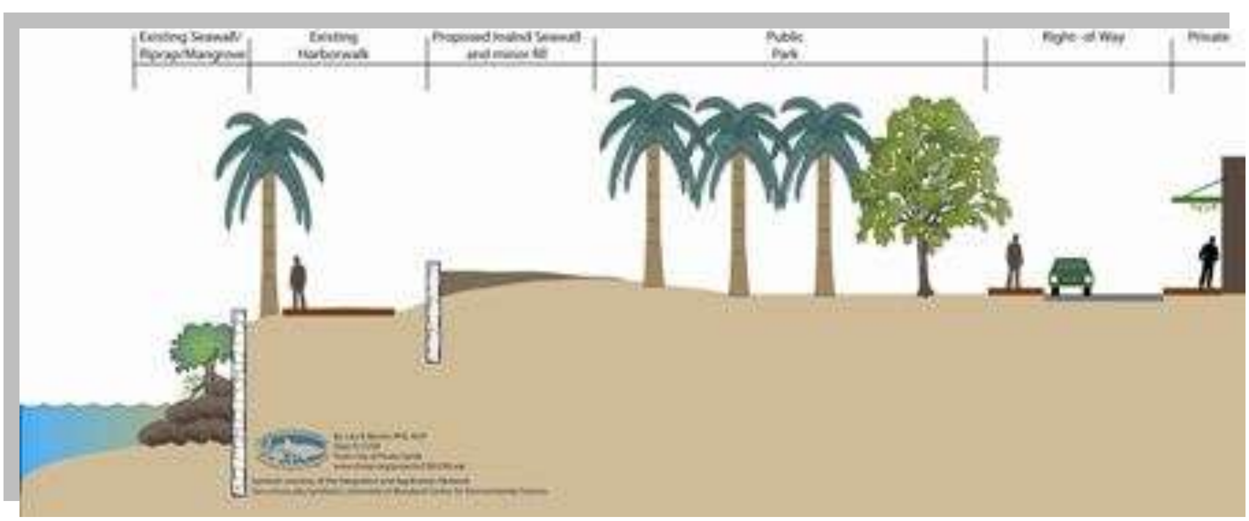
Alternative	Rolling Easement	Bulkhead with Fill to 6 feet (The Galveston Solution)	Gradual Sand Filling to Keep Pace (Volk 2008)	Elevating the Infrastructure (The Venice Solution)	Armored Dike with 4 Major Pumps (The New Orleans Solution)
Shoreline					
Less than total: set at the boundary between current uplands with freshwater wetlands and tidal coastal wetlands.	**$58,332,852**	**$1,530,358,919**	**$76,500,000**	**$1,269,520,000**	**$2,157,450,984**
Total: with irregular outer mangrove shoreline without overwash mangrove islands or many convoluted embayments	**$69,770,641**	**$1,554,071,794**	**$91,500,000**	**$1,269,520,000**	**$3,773,093,875**
Total: with irregular outer mangrove shoreline with convoluted embayments but not the overwash mangrove islands with canals open to navigation	**$77,777,108**	**$1,569,436,395**	**$102,000,000**	**$1,269,520,000**	**$3,868,536,601**

Table 55: A hypothetical comparison of relative costs of various sea-level rise adaptations for the City of Punta Gorda

The City of Punta Gorda Downtown Infrastructure Seawall Replacement Project

The City of Punta Gorda has recently applied for the latest round of Stimulus Funding for the TIGER Grants. The amount of funds being requested is $13,500,000. The purpose of the City of Punta Gorda Downtown Infrastructure Protection Seawall Replacement Project is to protect the key transportation corridors that link the Southwest Florida Region to the Road and Railway network of the nation. The southern terminus of US 17, the Charlotte Harbor crossing of US 41, and Charlotte, Lee and Collier County's only link to the nation's railroad network all converge in the Punta Gorda Community Redevelopment Area (CRA). The CRA encompasses the historic neighborhoods and downtown commercial and governmental core of the City and of Charlotte County. The City of Punta Gorda owns or controls the vast majority of the Charlotte Harbor shoreline in the CRA. This is primarily thanks to the original platting of the community in the 1880's, as all the waterfront lots were designated as parks. The project seawalls would be designed upland from the existing shoreline within these parklands.

The Project will consist of construction of innovative "inland" seawalls at a height exceeding the existing ground elevation by approximately 3 feet. These "inland" seawalls will provide storm surge protection from tropical storm events and sea level rise protection for the regionally critical transportation infrastructure and economic core that is the Community Redevelopment Area. An additional benefit of the inland location of the proposed seawalls is that sufficient space will be provided for potential habitat migration if sea levels rise at projected rates over the coming century.



The following is a discussion on how adaptation to sea-level rise could be implemented for the City of Punta Gorda.

First, the City of Punta Gorda would conduct comprehensive shoreline assessments to determine the unique characteristics of the specific shoreline, suitability analyses to determine which lands should be protected or where shoreline **managed relocation** should be allowed, and hazard projections to determine the area first in line to be inundated based on erosion, sea level rise, and storm surge estimates.

Second, rolling easements or similar policies that allow shoreline **managed relocation** and disallow coastal **armoring** or hardening could be implemented. Rolling easements are a special type of easement purchased from property owners along the shoreline to prevent them from holding back the sea but which allow any other type of use and activity on the land. As the sea advances, the easement automatically moves or "rolls" landward. Because shoreline stabilization structures cannot be erected, sediment transport remains undisturbed and wetlands and other important tidal habitat can migrate naturally. Similarly, there will always be dry or intertidal land for the public to walk along, preserving lateral public access to the shore. This step does not need to be implemented all at the same time and easements could be acquired in order of priority related to level and timing of exposure to coastal flooding.

Third, the City would designate a special overlay district in areas likely to be inundated based on hazard projections. Unique design guidelines should be implemented in these areas. Public financing in these areas should be minimized, particularly for new infrastructure. Within this area likely to be inundated, the City should create an along-shore buffer or easement for ecosystem retreat, management, and restoration. Property purchases, purchase of development rights, setbacks or deed restrictions, development disincentives, and sale incentives are some ways to create this easement. The City will need to plan for removal of inundated structures, infrastructure, and identify strategies for mitigation of hazards related to inundated structures. Creative reuse will be essential; for example, the reuse of building foundations as marine habitat could be appropriate.

Finally, the City will need to continue to integrate good waterfront design principles, and adapt existing useable infrastructure for new evolving waterfront. Communities that allow **managed relocation** must realize that the waterfront will be constantly evolving, and must allow for this change within land-use plans and waterfront projects.

Vulnerability 4: Unchecked or Unmanaged Growth

Land use and climate change in Florida are deterministically linked issues. Past and current projections of development within Florida are not consistent with either the goals of sustainable development or maximizing the opportunity for climate mitigation and adaptation through land management.

Adaptation options that protect coastal land and development focus on land use planning and management, land exchange and acquisition programs, and changes to infrastructure. Some adaptation options aim to protect the land itself, while others are aimed at protecting existing development (e.g., homes and businesses) and infrastructure (e.g., sewage systems, roads). Land use management involves using integrated approaches to coastal zone management as well as land use planning. Land exchange and acquisition programs allow for coastal land to be freed up for preservation uses. Changes to infrastructure can include limiting where hazardous and polluting structures can be built (including landfills and chemical facilities) as well as changing engineering structures that affect water bodies and will be impacted by climate change (Martinich 2008).

Land use planning and management, as well as changes in infrastructure, would be appropriate adaptation options for programs that are looking to implement anticipatory changes. These options require working with various key stakeholders and a have a longer timeline for implementation. Land exchange and acquisition programs would be viable options for estuaries that have a management goal of acquiring more land in order to protect currently threatened areas (Martinich 2008).

One way for decision makers to more completely understand the impacts of land use changes is to analyze choices using Cost of Community Services studies.

Cost of Community Services

Cost of Community Services (COCS) studies use a case study approach to determine the fiscal contribution of existing local land uses. It is a subset of the much larger field of fiscal analysis. COCS studies have emerged as an inexpensive and reliable tool to measure direct fiscal relationships (American Farmland Trust 2007).Their particular niche is to evaluate working and open lands on equal ground with residential, commercial and industrial land uses.

COCS studies are a snapshot in time of costs versus revenues for each type of land use. They do not predict future costs or revenues or the impact of future growth. They do provide a baseline of current information to help local officials and citizens make informed land use and policy decisions. In a COCS study, researchers organize financial records to assign the cost of municipal services to working and open lands, as well as to residential, commercial and industrial development. Researchers meet with local sponsors to define the scope of the project and identify land use categories to study. For example, working lands may include farm, forest and/or ranch lands. Residential development includes all housing, including rentals, but if there is a migrant agricultural work force, temporary housing for these workers would be considered part of agricultural land use. Often in rural communities, commercial and industrial land uses are combined. COCS study findings are displayed as a set of ratios that compare annual revenues to annual expenditures for a community’s unique mix of land uses (American Farmland Trust 2007).

COCS studies involve three basic steps:

1. Collect data on local revenues and expenditures.

2. Group revenues and expenditures and allocate them to the community’s major landuse categories.

3. Analyze the data and calculate revenue-to-expenditure ratios for each land use category.

The process is straightforward, but ensuring reliable figures requires local oversight. The most complicated task is interpreting existing records to reflect COCS land use categories. Allocating revenues and expenses requires a significant amount of research, including extensive interviews with financial officers and public administrators.

Communities often evaluate the impact of growth on local budgets by conducting or commissioning fiscal impact analyses. Fiscal impact studies project public costs and revenues from different land development patterns. They generally show that residential development is a net fiscal loss for communities and recommend commercial and industrial development as a strategy to balance local budgets. Rural towns and counties that would benefit from fiscal impact analysis may not have the expertise or resources to conduct a study. Also, fiscal impact analyses rarely consider the contribution of working and other open lands, which's very important to rural economies.

American Farmland Trust (AFT) developed COCS studies in the mid-1980s to provide communities with a straightforward and inexpensive way to measure the contribution of agricultural lands to the local tax base. Since then, COCS studies have been conducted in at least 128 communities in the United States.

Southwest Florida has paid a high price for unplanned growth. Scattered development frequently causes traffic congestion, air and water pollution, loss of open space and increased demand for costly public services. This is why it is important for citizens and local leaders to understand the relationships between residential and commercial growth, agricultural land use, conservation and their community's bottom line.

COCS studies help address three claims that are commonly made in rural or suburban communities facing growth pressures:

1. Open lands—including productive farms and forests—are an interim land use that should be developed to their "highest and best use."

2. Agricultural land gets an unfair tax break when it is assessed at its current use value for farming or ranching instead of at its potential use value for residential or commercial development.

3. Residential development will lower property taxes by increasing the tax base.

While it is true that an acre of land with a new house generates more total revenue than an acre of hay or corn, this tells us little about a community's bottom line. In areas where agriculture and/or forestry are major industries, it is especially important to consider the real property tax contribution of privately owned working lands. Working and other open lands may generate less revenue than residential, commercial or industrial properties, but they require little public infrastructure and few services.

COCS studies conducted over the last 20 years show working lands generate more public revenues than they receive back in public services. Their impact on community coffers is similar to that of other commercial and industrial land uses. On average, because residential land uses do not cover their costs, they must be subsidized by other community land uses. Converting agricultural land to residential land use should not be seen as a way to balance local budgets.

The findings of COCS studies are consistent with those of conventional fiscal impact analyses, which document the high cost of residential development and recommend commercial and industrial development to help balance local budgets. What is unique about COCS studies is that they show that agricultural land is similar to other commercial and industrial uses. In every community studied, farmland has generated a fiscal surplus to help offset the shortfall created by residential demand for public services. This is true even when the land is assessed at its current, agricultural use. As more communities invest in agriculture this tendency may change. For example, if a community establishes a purchase of agricultural conservation easement program, working and open lands may generate a net negative.

Communities need reliable information to help them see the full picture of their land uses. COCS studies are an inexpensive way to evaluate the net contribution of working and open lands. They can help local leaders discard the notion that natural resources must be converted to other uses to ensure fiscal stability. They also dispel the myths that residential development leads to lower taxes that differential assessment programs give landowners an “unfair” tax break, and that farmland is an interim land use just waiting around for development (American Farmland Trust 2007).

In COCS studies in Florida the ratios of public revenues gained to public costs are 1: 1.39 for residential including farm houses; 1: 0.36 for commercial and industrial; and 1: 0.42 for agricultural and natural lands (Dorfman 2004).

Carbon Markets and Land Use

Florida is uniquely endowed to become a leader in greenhouse gas mitigation through the effective management of agriculture, forestry, and natural ecosystems, but realizing this potential requires that policy makers consider the consequences of competing land uses. Appropriate land management and sustainable development can be partly driven by the economic incentive provided by carbon markets. Land use approaches to mitigation must consider the implications for sustainability through comprehensive planning over a timescale of at least a century. To the extent that enhanced carbon sequestration is consistent with maintenance of ecosystem services, creation of carbon offsets through land use represents the first step toward reconciling the planet’s living carbon economy with its monetary economy. Properly implemented, sustainable land management strategies for climate mitigation can be socially, environmentally, and economically viable, and can create jobs and opportunities for enhancing the wellbeing of Floridians for generations to come (Mulkey 2007).

Florida can become a leader in mitigation of GHGs through effective management of agriculture, forestry, and natural ecosystems. Mitigation in these sectors can significantly offset the projected increase in fossil fuel-derived GHGs over this century. Such management will not be possible without comprehensive data on the carbon budgets and emissions of these systems. The state could develop the resources necessary to collect these data.

Florida soils have the highest soil organic carbon content of all the states, and, with proper management, can sequester significant quantities of additional carbon. Agricultural lands can be managed to reduce methane (CH_4) and nitrous oxide (N_2O) through conservation tillage and management of livestock wastes. Biofuel crops and biogas production can significantly reduce the use of fossil fuels (Mulkey 2008).

Afforestation (the planting of trees or seeds in order to transform open land into forest or woodland) and management of industrial forests for both fuel wood and carbon sequestration provide the largest single land-use opportunity in Florida for climate mitigation over this century. To prepare for participation in carbon markets, the state could immediately begin to assess its forestlands and develop best-practices for management. Because much of Florida's forests are under private ownership, the legislature could consider mandates and incentives for the management of carbon on these lands.

There is no comprehensive assessment of the carbon dynamics of Florida wetlands, and, because of their significant carbon stores and CH_4 emissions, it is important that these data be developed. Loss of carbon from the vast stores in the Everglades can be reduced through proper management of hydroperiod and control of wildfires. Current wetland mitigation and wetland banking practices can be reviewed in the context of climate mitigation.

Development of carbon markets is an unparalleled opportunity for monetizing ecosystem services and thereby progressively incorporating the natural economy into the human economy. Through targeted land use, Florida can participate in carbon markets with the potential for development of a major new source of revenue.

For carbon markets to function effectively there must be transparent and comprehensive accounting of carbon sequestration, reversal, and leakage associated with biological systems over spatial and temporal scales consistent with the goals of GHG mitigation. Existing state agencies can establish appropriate accounting and best-practices procedures, and provide a mechanism for certification of verifiers. Appropriate environmental safeguards are essential to ensure that the methods of mitigation are consistent with the long-term health of Florida's ecosystems. The Critical Lands and Waters Identification Program, (CLIP), developed by the Florida Natural Areas Inventory (FNAI) and others, is a comprehensive inventory that provides essential data for this purpose.

Table 56: Adaptations to Address Unchecked and Unmanaged Growth Vulnerabilities (from public workshops)

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples	Level of Support (%)
Constrain locations for certain high risk infrastructure	Unchecked or Unmanaged Growth	Economy	Reduces infrastructure exposure; Improves risk assessments	Land owners will likely resist relocating away from prime coastal locations	City of Punta Gorda TDR	67.5
Urban growth boundaries	Unchecked or Unmanaged Growth	Economy			Sarasota 2050 Comprehensive Plan; Charlotte County Comprehensive Plan	67.5
Consider climate change in infrastructure planning	Unchecked or Unmanaged Growth	Economy				67.5
Change building codes to promote energy efficient building	Unchecked or Unmanaged Growth	Economy		Cost		67.5
Don't allow development or engineering solutions to block migration of wetlands	Unchecked or Unmanaged Growth			Requires fee simple acquisition of conservation	Charlotte Harbor Buffer Preserve	67.5

				easements		
Consider sea level rise in site design	Unchecked or Unmanaged Growth	Economy				67.5
Reduce/eliminate development in sensitive areas/coast	Unchecked or Unmanaged Growth	Economy		Will not help areas already developed		50
Strict enforcement of existing codes	Unchecked or Unmanaged Growth			Cost		50
Improve land use management	Unchecked or Unmanaged Growth	Economy				50
Adopt building design criteria that consider sea level rise	Unchecked or Unmanaged Growth	Economy		Cost		50
Provide alternative transportation	Unchecked or Unmanaged Growth	Economy		Cost		50
Control building with zoning and permitting	Unchecked or Unmanaged Growth	Economy				50
Insist on "greening" measures	Unchecked or Unmanaged	Economy				37.5

	Growth					
Use coastal management in land planning	Unchecked or Unmanaged Growth	Economy				37.5
Infill incentives	Unchecked or Unmanaged Growth	Economy		Cost of incentives		37.5
Acquire/protect critical habitat areas	Unchecked or Unmanaged Growth	Economy		Cost of acquisition		37.5
Ensure that master plans explicitly indicate which areas will retain natural shorelines	Unchecked or Unmanaged Growth					37.5
Adopt building design criteria that consider more severe hurricanes	Unchecked or Unmanaged Growth	Economy		Cost		37.5
Promote green roofs through building codes	Unchecked or Unmanaged Growth	Economy		Cost		37.5
Infill incentives	Unchecked or Unmanaged Growth	Economy		Cost		37.5
Create more energy- & cost-effective communities through community design and green	Unchecked or Unmanaged	Economy		Cost		37.5

building	Growth					
Establish rolling easements	Unchecked or Unmanaged Growth			Cost	Worcester County, MD; South Carolina Coastal Council; California Coastal Commission	37.5
Consider climate effects in choice of building materials	Unchecked or Unmanaged Growth	Economy				37.5
Subsidize retrofitting buildings for energy efficiency	Unchecked or Unmanaged Growth	Economy		Cost		37.5
Purchase upland development rights/property rights	Unchecked or Unmanaged Growth			Cost		25
Increase use of alternative and renewable energy	Unchecked or Unmanaged Growth	Economy		Cost		25
Identify conflicting policies between programs	Unchecked or Unmanaged Growth					25
All measures to reduce local GHG emissions	Unchecked or Unmanaged Growth	Economy		Cost		12.5
Integrate carrying capacity principles into comprehensive	Unchecked or	Economy				12.5

planning	Unmanaged Growth					
Elevate land surfaces	Unchecked or Unmanaged Growth			Cost		12.5
Establish living shorelines	Unchecked or Unmanaged Growth				Peconic Bay (NY); Living Shorelines Stewardship Initiative (Chesapeake Bay)	12.5
Increase shoreline setbacks	Unchecked or Unmanaged Growth			Will not help areas already developed		12.5
Adopt building design criteria that consider all adaptation requirements	Unchecked or Unmanaged Growth	Economy				12.5
Redefine flood hazard zones	Unchecked or Unmanaged Growth					12.5
Use LED standards in building	Unchecked or Unmanaged Growth	Economy		Cost		12.5
Use flexible planning	Unchecked or Unmanaged Growth					12.5
Ensure appropriate foundations for buildings	Unchecked or			Cost		12.5

	Unmanaged Growth					
Plan for regional relocation & displacement	Unchecked or Unmanaged Growth					12.5
Remove unnecessary/inundated infrastructure	Unchecked or Unmanaged Growth			Cost		12.5
Use LID principles in development	Unchecked or Unmanaged Growth			Cost		12.5

Table 57: Adaptations to Address Unchecked and Unmanaged Growth Vulnerabilities Recommended Against (from public workshops)

Insist on "greening" measures						37.5
Increase bridge clearances						25
Consider congestion zone tolls in larger cities						25
Consider immigration to SWF due to sea level rise impacts to the Bahamas and the Keys						12.5

ADAPTATION: Constrain locations for certain high risk infrastructure

Constrain locations for certain high risk infrastructure was the top adaptation recommendation to address unchecked and unmanaged growth vulnerabilities to climate change. The following is a discussion on how this adaptation could be implemented for the City of Punta Gorda.

Transfer of Development Rights and Rolling Easements

For the lands that are acquired for natural habitat or preservation benefits, as discussed in the adaption section on flooding , the City of Punta Gorda currently takes additional steps to protect these lands and the endangered and threatened species on those lands through a variety of measures, which will be important to maintain as the City continues to grow. These protection measures include:

- Ordinances which lay out the general policies for limiting uses in environmentally sensitive lands for the purpose of protecting natural resources from the potential adverse impacts of future land development activities;

- Intergovernmental coordination efforts which implement protection measures associated with Outstanding Florida Waters (OFWs), Class I and Class II waterbodies, and adjacent uplands; specific habitats; and wildlife corridors;

- The Future Land Use Map (FLUM) which is used to advise landowners, land developers, and the City that land development proposals for lands within the Preservation and Conservation designations are subjected to a more comprehensive environmental review process and may be subject to more restrictive plan policies which, in turn, may alter development potential;

In order to implement a program in which these Conservation, Preservation and Natural Public-Recreation Lands will not be developed, thus altering the natural shoreline, an explicit ordinance in the land development code must provide that, irrespective of state and federal permits or exemptions, shorelines designated as Conservation, Preservation, and Natural Public-Recreation will not be subjected to human alteration with shoreline hardening, excavation, or filling. If it is felt that there are sufficient property rights extinguished by this process, the loss of the ability to alter shoreline on a private property parcel could be offset by a transfer of development rights (TDR) in the form of density or another acceptable variance to a site that is not Conservation, Preservation, or Natural Public-Recreation. This could act as an incentive for private, speculative development entities to purchase private areas in Conservation and/or Preservation designations and move the transferrable rights to acceptable in-fill sites.

However, if a public entity purchases private lands designated as Conservation or Preservation, the development rights associated with those lands should not be transferred from the new public lands and given for free to private entities. Instead, the public entity could, at its own choice, sell the development rights to private entities to use in in-fill areas and then use the funding for operations and land management of the conservation lands.

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The Land Development Regulations of the City of Punta Gorda, Florida Chapter 26_002, Section 8.16. currently provide this type of Transfer of Development Rights [TDRs]. The Transfer of Development Rights means the transfer of the lawful development rights pertaining to the allowable density and/or intensity of use held by a property owner from one parcel of land which is targeted for limited development to another parcel of land, which can accommodate the added development density/intensity permitted on the first parcel. The protection and preservation of certain areas designated for limited development without denying a property owner reasonable use of his land is a valid public purpose and promotes the general health, safety, prosperity, and welfare of the people of the City. More specifically the intent of this subsection is to promote the protection and conservation of environmentally sensitive areas of the City including, but not limited to, wetlands, mangrove clusters, aquifer recharge areas, endangered species habitats, etc.; to provide an incentive to property owners of historic structures to renovate, repair or restore them; and to establish an incentive for the dedication and/or discounted sale of property to the City for general public purposes such as parks, road rights-of-way, government services sites, public access to the waterfront, affordable housing, etc.

The land use map for the city could be conceived as having three categories of development right transfer overlays associated with climate change impacts:

- Sending areas of Conservation, Preservation, and Natural Public-Recreation that contribute density to the other two categories,
- Receiving areas of all other land uses that have a designated amount of transferred density that can be accepted while remaining in their existing land use category and,
- Receiving areas of land development uses that can receive a designated amount of transferred density that will convert the current land use to a new land use designated and desired in the future land use plan.

This system generates a practice of locating and consolidating density in locations preferred in the City of Punta Gorda Comprehensive Land Use plan without generating virtual density that benefits some but not the whole community. This could also assist in moving infrastructural investment into areas where the City will best be able to provide protection from flooding and thereby reduce the public and private exposures to loss and expense. This has the potential of reducing variable risk with associated opportunity to reduce the costs of insurance against hazards and loss from the negative effects of climate change.

Vulnerability 5: Water Quality Degradation

Harmful polluting discharges of nutrients that could be exacerbated by changes in precipitation or sea level rise can be mitigated by protecting existing infrastructure and planning for impacts to new infrastructure (e.g., sizing drainage and sewer systems to accommodate changes in flow). Other options for maintaining water quality of marshes and wetlands include preventing or limiting groundwater extraction from shallow aquifers, establishing rolling easements, and protecting land subject to flooding by plugging canals or fortifying dikes.

Determining the type of adaptation option to implement is dependent on what specific management challenge a particular area is facing, or is expecting to face in the future. If the water quality is being threatened by development, then rolling easements may be an appropriate option. However, if saltwater inundation is predicted to pose future risks, then options such as modifying or designing new drainage/sewer systems may be more appropriate.

The EPA Climate Ready Estuaries Program has identified adaptation options for maintaining water quality of marshes and wetlands, in the 2008 document entitled *Draft synthesis of adaptation options for coastal areas.*

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples
Prevent or limit groundwater extraction from shallow aquifers	Sea level rise	Protect infrastructure; Maintain wetlands; Maintain water availability	Will limit relative sea level rise by preventing subsidence and reduce saltwater intrusion into freshwater aquifers	Need to find an alternative water source	Capping of artesian and old agricultural wells.
Establish rolling easements	Sea level rise	Maintain wetlands; Maintain sediment transport	Lower long-term costs; sediment transport remains undisturbed; property owner bears risks of sea level rise	Does not prevent migration of salinity gradient	Worcester County, MD; South Carolina Coastal Council; California Coastal Commission
Plug canals	Sea level rise; Changes in precipitation	Protect coastal land/ development	Protect land subject to flooding; prevent subsidence-inducing saltwater	Elimination of recreational and commercial transportation routes. Impairs the basis of the real estate and fisheries based	Pamlico-Albemarle Peninsula (The Nature Conservancy has considered this option to protect

			intrusion	economy	conservation lands)
Fortify dikes	Sea level rise; Changes in precipitation; Increases in sea surface temperatures	Protect coastal land/ development	Protect land subject to flooding and storm surges	Can be costly; salinity gradient may still migrate Creates a bigger disaster when failure occurs and all dikes ultimately fail	Tyrell County, NC (dikes primarily used to protect agricultural land); Thames River Barrier, London, England (built during the 1970s)
Design new coastal drainage system	Changes in precipitation; Sea level rise	Maintain water availability	Many systems need to be restructured anyway	Planning and construction can be very costly and time-consuming	Vancouver, Canada (planned – CitiesPLUS 100-year plan)
Incorporate sea level rise into planning for new infrastructure (e.g., sewage systems)	Sea level rise	Protect coastal development	Preserves long-term functional integrity of structures; prevents contamination of water supply	Measures can be costly but this will have to be addressed anyway	Deer Island, Boston, MA

Table 58: Climate Ready Estuaries Program has identified adaptation options for maintaining water quality of marshes and wetlands

Source CRE EPA 2008

In contrast the citizens of the City of Punta Gorda saw a combination of daily protection of water quality through improved management of resources and a soft approach that does not involve drainage, diking, plugs or rolling easements.

Table 56: Adaptations to address Water Quality Degradation Vulnerabilities (from Public Workshops)

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples	Level of Agreement
Restrict fertilizer use	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Protects water quality; Reduces algae blooms; Enhances fishery ; Maintains and increases habitat	State regulated with weak preemption; Cost	SWFRPC Resolution(07-01) March 15, 2007	67.5
Conservation land acquisition	Water Quality Degradation	Fish and Wildlife Habitat Degradation; Unmanaged Growth	Maintains and increases habitat; Enhances fishery; Improved water quality	Cost	Conservation Charlotte; Sarasota ELAPP; Lee Conservation 2020; Florida Communities Trust; Conservation Collier	67.5
Control flow of pollutants into harbor	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Improved water quality; Improves harbor habitats and fisheries	Cost	CHNEP; BMAP	50
Improved site drainage designs and improved water penetration	Water Quality Degradation	Flooding	Reduces flooding ; Increasing groundwater recharge; Improved water quality	Cost		50

Proper consideration of hazardous materials disposal	Water Quality Degradation	Economy	Protection of public health and ecosystems; Improved water quality	Cost		50
Develop adaptive stormwater management	Water Quality Degradation	Flooding	Reduces flooding ; Reduces run-off; Increasing groundwater recharge; Improved water quality	Cost	SWFRPC Resolution((08-011) August 28, 2008	50
Watershed/basin protection	Water Quality Degradation		Improved water quality; Improves harbor habitats, water quality, and fisheries	Needs cooperation of many entities		37.5
Stormwater retention	Water Quality Degradation	Flooding	Reduces flooding ; Reduces run-off; Increasing groundwater recharge	Cost		37.5
Fertilizer regulation	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Protects water quality; Reduces algae blooms; Enhances fishery ; Maintains and increases habitat	State regulated with weak preemption; Cost	SWFRPC Resolution(07-01) March 15, 2007	37.5
Modify wetland conservation/restoration plans	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Improved response to climate changes; Improved water quality			37.5

Reduce impervious surface allowed	Water Quality Degradation	Flooding	Reduces run-off; Increases groundwater recharge; Improved water quality			37.5
Create marsh	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Enhances habitats and fisheries; Improved water quality	Cost		25
Design new coastal drainage system	Water Quality Degradation	Flooding	Reduces Flooding; Depending on design it could improve water quality	Cost		25
Boater education	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Improved water quality; Reduces propeller dredging; improves safety on the waters; reduces impacts to wildlife	Cost		25
Establish early warning sites and increase data collection on existing conditions	Water Quality Degradation		Increased knowledge of trends and sources of water quality pollution	Cost		25

Create regional sediment management plan	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Improved water quality; Improves ability of wetlands and estuary to maintain eustatic elevations for mangroves, marshes, and seagrasses	Cost		25
Reduce atmospheric carbon dioxide	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Decreases ocean acidification; Mitigates rate of climate change; Improved water quality	Cost		12.5
Stop flow of pollutants into harbor	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Improved water quality	Cost		12.5
Carbon offsets	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Mitigates rate of climate change; Improved water quality	Cost		12.5
All measures to reduce local GHG emissions	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Mitigates rate of climate change; Improved water quality	Cost		12.5

Integrated Coastal Zone Management	Water Quality Degradation	Fish and Wildlife Habitat Degradation	Improved water quality; Preserve habitat extent; Maintain/ restore wetlands; Maintain water availability; Maintain water quality of marshes and wetlands; Maintain sediment transport; Maintain shorelines; Considers all stakeholders in planning, balancing objectives; addresses all aspects of climate change	Stakeholders must be willing to compromise, requires much more effort in planning	European Union	12.5
Replace septic tanks with sewers with government subsidies for homeowners	Water Quality Degradation	Unchecked Growth	Improved water quality; Reduces non-point pollution of nutrients and bacteria from failed systems	Cost		12.5

Control runoff through improved land grading techniques	Water Quality Degradation	Flooding	Reduced run-off; Reduced flooding; Improved water quality	Cost		12.5

Table 59: Adaptations to address Water Quality Degradation Vulnerabilities Recommended Against (from Public Workshops)

Recommended Against						
Carbon offsets						25

ADAPTATION: Restrict fertilizer use

Restrict Fertilizer Use was the most popular adaptation measure proposed to address climate change impacts in the City of Punta Gorda to water quality. The following is a discussion on how this adaptation could be implemented for the City of Punta Gorda.

A regulatory and public investment structure has evolved to manage water quality impacts from development in the southwest Florida region. The development resulting from this structure in the last four decades has raised issues regarding environmental quality, infrastructure costs, and quality of life. A structure of environmental regulation and presumptive water quality standard has been developed to protect the water quality of freshwater, estuarine, and marine waters of southwest Florida. Development continues to expand with southwest Florida watersheds, regulatory releases of polluted water are introduced from other watersheds, older water management systems age and degrade in function, and native and semi-native landscapes are converted to developed and intensive agricultural uses. Subsequently water quality has continued to degrade in natural and man-altered rivers, creeks, estuaries, and marine waters. These changes in water quality have contributed to significant negative environmental events in southwest Florida including but limited to loss of submerged aquatic vegetation, including sea grass, increased frequency and duration of harmful algae blooms, (red tide, blue-green alga, etc.), subsequent mortality of invertebrates (blue crabs, shellfish, etc.) sports and commercial fishes, water birds, and manatees, and imbalances in macro-algae diversity and abundance. These negative environmental events negatively affect the base of the City of Punta Gorda economy impacting tourism, property values, sports and commercial fisheries, municipal and agricultural water supply, and public health (respiratory, digestive, cardiac). Currently the largest recorded red drift algae strandings impair the winter tourist recreation season, stimulating negative media through the United States and the world, and creating enormous costs for its removal.

Application of existing basis-of-review water quality standards did not prevent the water quality degradation experienced to date and will not prevent futures major declines in water quality. The subsequent environmental results can only be expected to become much worse.

Therefore the Southwest Florida Regional Planning Council (SWFRPC) has formed the Lower West Coast Watershed Subcommittee (LWCWS) to develop recommended water quality guidance for staff review of Comprehensive Plans, Comprehensive Plan Amendments, Developments of Regional Impact, and other regionally significant developments and public infrastructure projects. The work plan of the committee included the gathering of existing successful water quality protection measures and the development of and creation of new standards that will arrest and ultimately improve water quality within the watersheds and subsequently the receiving waters of the southwest Florida region.

The first resolution of the LWCWS of the SWFRPC was "A RESOLUTION SUPPORTING THE REGULATED USE OF FERTILIZERS CONTAINING NITROGEN AND/OR PHOSPHORUS WITHIN SOUTHWEST FLORIDA; PROVIDING SPECIFIC RECOMMENDATIONS AND GUIDELINES TO BE CONSIDERED BY LOCAL GOVERNMENT JURISDICTIONS FOR THE REGULATION AND CONTROL OF FERTILIZER APPLICATION; PROVIDING RECOMMENDED DEFINITIONS; PROVIDING RECOMMENDATIONS RELATING TO TIMING OF FERTILIZER APPLICATION, CONTENT AND APPLICATION RATE, IMPERVIOUS SURFACES, BUFFER ZONES AND MECHANICAL APPLICATION;

PROVIDING RECOMMENDED EXEMPTIONS; PROVIDING RECOMMENDATIONS FOR LICENSING OF COMMERCIAL AND INSTITUTIONAL APPLICATORS; PROVIDING RECOMMENDATIONS FOR PUBLIC EDUCATION PROGRAMS; PROVIDING RECOMMENDATIONS RELATING TO THE RETAIL SALE OF FERTILIZER; PROVIDING RECOMMENDATIONS FOR APPEALS, ADMINISTRATIVE RELIEF AND PENALTIES; PROVIDING FOR AN EFFECTIVE DATE". SWFRPC Resolution #07-01 was adopted on March 15, 2007.

Subsequently three Counties, including Charlotte County and 9 Municipalities have adopted a fertilizer resolution. In November of 2007 the Punta Gorda City Council considered an ordinance to limit the use of fertilizer by waterfront property owners. The City staff is drafted an ordinance that would limit when and what fertilizers could be used by property owners based on the Sarasota County and Charlotte County ordinances.

The City of Punta Gorda did not implement the draft ordinance and opted to utilize an educational program, coordinating with SWFWMD and Charlotte Harbor Environmental Center, to provide information on fertilizer use.

In 2009, the Florida legislature passed SB 494 that among other things encourages county and municipal governments to adopt and enforce the Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes or an equivalent requirement as a mechanism for protecting local surface water and groundwater quality. And SB2080 that among things promotes "Florida-friendly landscaping" by prohibiting deed restrictions or local government ordinances that would restrict a landowner's ability to use such landscaping, and requires the development of programs and ordinances to facilitate the use of this landscaping. The State Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes is less protective of water quality than the SWFRPC resolution or the local ordinances adopted by 12 local governments in southwest Florida.

In order to implement the top water quality protection recommendation the City of Punta Gorda could adopt and implement a fertilizer protection ordnance based on the SWFRPC Resolution #07-01 (attached as Appendix AAA) or if it plans to be less protective the first State Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes (attached as Appendix BBB)

Vulnerabilities 6, 7, and 8: Education, Economy and Lack of Funds

Three of the vulnerabilities identified by Punta Gorda citizens at the first workshop are closely linked. "Education" as a vulnerability referred to the need to communicate more with the public in a variety of areas: general information about the environment and ways to conserve land, air and water in order to live with less impact on the environment; and communication from the government to the public about current chronic, as well as emergent, climate-related issues. "Economy" as a vulnerability referred to the relationship between the actions needed to avoid, mitigate, minimize, or adapt to climate change and the funding needed to complete these actions. This is differentiated from "lack of funds" in that the latter refers mainly to a City's or the individual's financial situation at any given time and the amount of resources they might have, for example, to accomplish improvements that increase resilience to storms and flooding. These three vulnerabilities are distinct, and yet they are interdependent. As the public is made more aware of things they can do to be more energy efficient ("education"), they may examine their own resources and find that there are improvements they can't pay for, in whole or in part, on their own ("lack of funds"). Grants or loans from local, state and/or federal governments may be a solution to this problem, if those entities have prepared and made such funds available ("economy"). Alternatively, a city may invest in a mass transit system fueled by compressed natural gas in order to reduce the carbon footprint of the area, use less petroleum-based fuel and reduce the number of vehicles on the road ("economy"). Citizens need to be made aware of the new program ("education") and it needs to be priced right ("lack of funds") in order for this move to be successful. Because of this close linkage, these three vulnerabilities have been examined together.

In particular, critical facilities form a nexus where education, economy and lack of funds meet. Many people turn to critical facilities for information about their community, about impending severe weather, about recovery from disaster events and about planning and preparation. Critical facilities provide, on behalf of local government a logical point of contact with the public. Unfortunately, critical facilities are often built in vulnerable locations. Properly locating, and constructing critical facilities, and using them efficiently to keep the public informed about all aspects of climate change avoidance, minimization, mitigation and adaptation can help to reduce impacts and speed recovery after severe weather events.

Critical Facilities

Critical facilities are those that are critical to the health and welfare of the population and that are especially important following hazard events. Critical facilities include, but are not limited to, shelters, police and fire stations, and hospitals.

The Disaster Mitigation Act of 2000 (DMA2K) requires each state to have in place a Federal Emergency Management Agency (FEMA) approved State Mitigation Plan to remain eligible for the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), or other federal mitigation assistance program funds. The Act requires each local jurisdiction to have either its own local mitigation plan or actively participate in the development and maintenance of multi-jurisdictional plans such as Florida's Local Mitigation Strategies (LMS). Local plans must be compliant with new federal mitigation planning criteria and receive FEMA approval. Non-compliant jurisdictions will be ineligible for federal mitigation assistance (SWFRPC website).

Critical facilities, as defined and mapped in the Charlotte County local mitigation strategy plan, were used to further assign protection scenario status and to also bring long-term sea level rise response planning into the more current local mitigation strategy planning. The critical facilities used in this study are as follows: Correctional Facility; Clinic; Communication; Emergency Operation Center; Red Cross Shelter; Inactive Landfill; Electrical; Refuge of Last Resort; Emergency Medical Services; School; Water Treatment Facility; Fire Station; Hospital; Sheriff Department; Florida Highway Patrol; Police Department; Sewage Treatment Facility; Potable Water; Landfill; and Active Transportation

There are many facilities in Punta Gorda that are in need of protection from natural hazards because they play a vital role in the community's operation.

A listing of critical facilities in the City was determined and the value for each structure was provided by the Charlotte County Property Appraiser's Office. Content value and functional use value for all structures were determined using tables provided by FEMA. Values were determined for every structure in the county. An explanation of the methodology used can be found in Appendix A.

Less than 1.0% of the structures in Punta Gorda are critical facility structures. These 147 buildings have a replacement value of $112 million and a total value of 245 million, which is 9.0% of the total value for all the structures in Punta Gorda (Table 60 and Figures 83 and 84).

Estimated Values for Facility Structures Located within Punta Gorda Based on Critical Facility Status					
	No. of Buildings	**Replacement Value**	**Contents Value**	**Functional Use Value**	**Total Value**
Critical Facility	147	$111,822,832	$113,868,691	$18,848,628	$244,540,151
Not a Critical Facility	9,839	$1,481,089,008	$869,379,191	$96,723,374	$2,447,191,573
Total	**9,986**	**$1,592,911,840**	**$983,247,882**	**$115,572,002**	**$2,691,731,724**

Table 60: Estimated Values for Facility Structures Located within Punta Gorda Based on Critical Facility Status

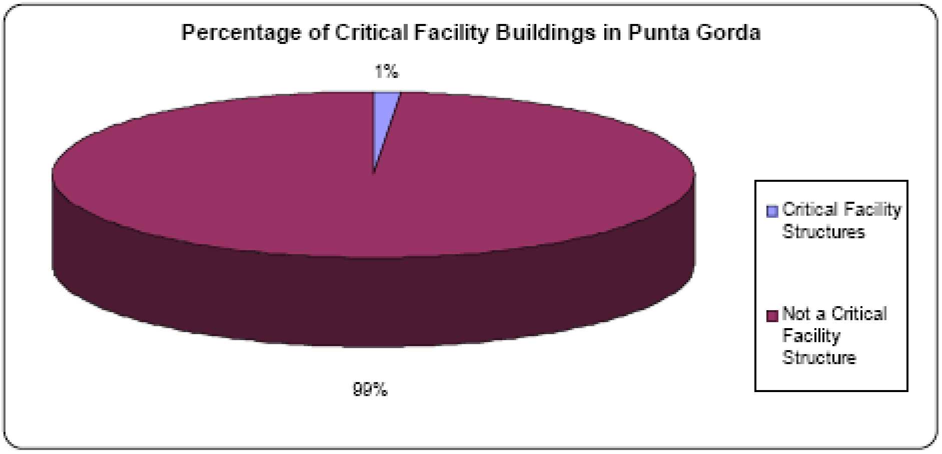

Figure 83: Percentage of Critical Facilities in Punta Gorda

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

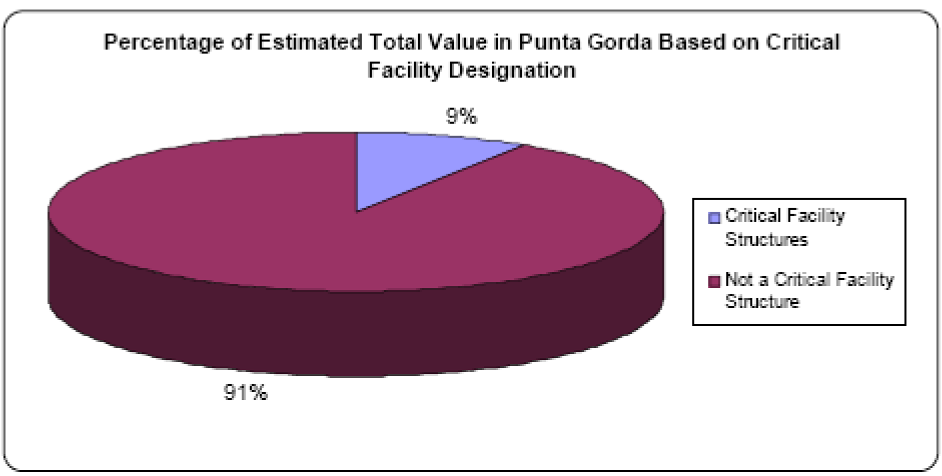

Figure 84: Percentage of Estimated Total Value in Punta Gorda Based on Critical Facility Designation

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

In Charlotte County there is one airport, two clinics, 19 communication towers, 14 community centers, 15 electrical facilities, 10 fire and emergency medical services (EMS) stations or facilities, 18 government facilities, one hospital, three boat locks, four police/sheriff facilities, six elementary schools, one middle school, three high schools, two private schools, and a community college, one telephone remote building, and 12 telephone switching stations in hazard of maximum five to 10 foot hurricane storm surge.

Incorporating critical facilities into sea level response planning is probably the best way to begin encouraging local governments to implement the sea level rise protection scenarios. For example, when the SWFRPC approved sea level rise maps in 2005, staff sensed frustration from elected officials as to what they could do to address this problem in their constituents' short-term outlooks. The SWFRPC concluded that the 2005 study would be used to work with local government staffs to consider sea level increases when planning for public facility expansions and reconstruction after hurricane damage or due to old age. Therefore, the intent of the study is being met by facilitating local government decision makers and staffs' efforts to begin considering sea level rise impacts on land uses and the supporting public critical facilities.

Seven colors are used to define the sea level rise maps (Figure 85 below). First, all water areas in the Gulf of Mexico, bays, rivers, canals or lakes are shown in the color light blue. Second and third, all wetlands either fresh or saltwater are shown in the color dark green with the non-tidal wetlands shown as purple. Fourth, uplands where no shore protection from sea level rise is assumed are shown in the color light green. Fifth, uplands where shore protection from sea level rise is assumed unlikely are shown in the color blue. Sixth, uplands where shore protection is assumed to be likely are shown in the color red. The seventh color is brown where shore protection is almost certain. Finally, the non-color white is everything above 10' in elevation and is outside the study area.

During a multi-jurisdictional effort, assumptions regarding the protection scenarios were made according to elevation and generalized land uses and are defined as follows. The counties agreed with SWFRPC staff that agriculture, mining and upland preserves would not protect their property from sea level rise and therefore would be colored light green. Commercial, estate, industrial, military, multi-family and single family would "almost certainly" protect their property from sea level rise and therefore would be colored brown. Dark blue areas would be land uses between zero and five feet in elevation that is not likely to be protected from sea level rise and might be areas such as unbridged barrier islands, low income housing, low value property not on central water and sewer or repetitive flood loss properties. In this phase of the process only critical facilities between the elevation of five and ten feet were colored brown, but the land itself was colored red. Critical facilities below five feet in elevation were shown as blue and protection was not recommended. Planners from all the counties agreed that we should assume that government owned critical facilities in this area should relocate these facilities to higher ground.

We completed the maps in GIS shape files or coverage. JPGs and PDFs for each map have been created for easy distribution through the Internet and for display on the SWFRPC website and Environmental Protection Agency website. The SWFRPC provided a readme file on CD for further explanation on the GIS development of these maps to assist the most interested user in this GIS mapping effort.

Once other regional planning councils started to implement the SWFRPC staff initial methodology, it became clear that other data sources were becoming available, such as the Florida Land Use Cover Classification System for existing and future land uses in GIS format, and that even more up-to-date land use information was needed to better determine how to assign the shore protection colors. The table below was subsequently developed.

State-Wide Approach for Identifying the Likelihood of Human Land Use Protection from the Consequences of 10 Feet of Sea Level Rise		
Likelihood of Protection[2]	**Land-Use Category**	**Source Used to Identify Land Area**
Shore Protection Almost Certain (brown)	Existing developed land (FLUCCS Level 1-100 Urban and Built-up) within extensively developed areas and/or designated growth areas.	Developed Lands identified from Water Management Districts (WMD) existing Florida Land Use, Cover and Forms Classification System (FLUCCS) as defined by Florida Department of Transportation Handbook (January 1999); Growth areas identified from planner input and local comprehensive plans.
	Future development within extensively developed areas and/or designated growth areas (residential/office/commercial/industrial).	Generalized Future Land Use Maps from local comprehensive plans, local planner input and Water Management Districts.
	Extensively-used parks operated for purposes other than conservation and have current protection [3] or are surrounded by brown colored land uses.	County-Owned, State-Owned, and Federally-Owned Lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input and Florida Marine Research Info System (FMRIS) for current protection measures.
	Mobile home developments outside of coastal high hazard[4], expected to gentrify, or connected to central sewer and water.	Local planner input and current regional hurricane evacuation studies.
Shore Protection Likely (red)	Existing development within less densely developed areas, outside of growth areas.	Developed Lands identified from WMD existing FLUCCS; Growth areas identified from local planner input, local comprehensive plans and current regional hurricane evacuation studies.
	Mobile home development neither within a coastal high hazard area that is neither anticipated to gentrify nor on central water and sewer.	Local comprehensive plans and current regional hurricane evacuation studies.
	Projected future development outside of growth areas could be estate land use on Future Land Use Map.	Local planner input
	Moderately-used parks operated for purposes other than conservation and have no current protection or are surrounded by red colored land uses.	County-Owned, State-Owned, and Federally-Owned Lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input and FMRIS.
	Coastal areas that are extensively developed but are ineligible for beach nourishment funding due to CoBRA (or possibly private beaches unless case can be made that they will convert to public)	Flood Insurance Rate Maps for CoBRA, local knowledge for beach nourishment.

	Undeveloped areas where most of the land will be developed, but a park or refuge is also planned, and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so red is a compromise between.	Local planner input
	Agricultural areas where development is not expected, but where there is a history of erecting shore protection structures to protect farmland.	Local planner input
	Dredge Spoil Areas likely to continue to receive spoils or be developed, and hence unlikely to convert to tidal wetland as sea level rises	Local planner input
	Military Lands in areas where protection is not certain.	FLUCCS Level 173
Shore Protection Unlikely (blue)	Undeveloped privately-owned that are in areas expected to remain sparsely developed (i.e., not in a designated growth area and not expected to be developed) and there is no history of erecting shore protection structures to protect farms and forests.	Undeveloped Lands identified from WMD existing FLUCCS Level 1- 160 mining, 200 Agriculture, 300 Rangeland, 400 Upland Forest, 700 barren land ; Non-growth areas identified from planner input, local comprehensive plans, Flood Insurance Rate Maps for CoBRA and current regional hurricane evacuation studies.
	Unbridged barrier island and CoBRA areas or within a coastal high hazard area that are not likely to become developed enough to justify private beach nourishment.	Flood Insurance Rate Maps for CoBRA, local knowledge for beach nourishment and local planner input.
	Minimally-used parks operated partly for conservation, have no current protection or are surrounded by blue colored land uses, but for which we can articulate a reason for expecting that the shore might be protected.	County-Owned, State-Owned, and Federally-Owned Lands (based on local knowledge) or lands defined as preserve on Future Land Use Map, local planner input and FMRIS.
	Undeveloped areas where most of the land will be part of a wildlife reserve, but where some of it will probably be developed; and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so blue is a compromise between red and green.	local planner input
	Dredge Spoil Areas unlikely to continue to receive spoils or be developed, and hence likely to convert to tidal wetland as sea level rises	local planner input
	Conservation Easements (unless they preclude shore protection)	local planner input

No Shore Protection (light green)	Private lands owned by conservation groups (when data available)	Private Conservation Lands
	Conservation Easements that preclude shore protection	local planner input
	Wildlife Refuges, Portions of Parks operated for conservation by agencies with a policy preference for allowing natural processes (e.g. National Park Service)	local planner input
	Publicly-owned natural lands or parks with little or no prospect for access for public use.	County-Owned, State-Owned, and Federally-Owned Lands (based on local knowledge) defined as preserve on the Future Land Use Map and local planner input.

Notes:
1. These generalized land use categories describe typical decisions applied in the county studies. County-specific differences in these decisions and site-specific departures from this approach are discussed in the county-specific sections of this report.
2. Colored line file should be used in areas where less than 10 ft. elevations exist within 1,000 feet of the rising sea or color can't be seen on ledger paper map.
3. Current protection may include sea walls, rock revetments, beach renourishment, levees, spreader swales or dikes.
4. Coastal High Hazard Area defined in Rule 9J-5 FAC as the Category 1 hurricane evacuation zone and/or storm surge zone.

Table 61: State-Wide Approach for Identifying the Likelihood of Human Land Use Protection from the Consequences of 10 Feet of Sea Level Rise

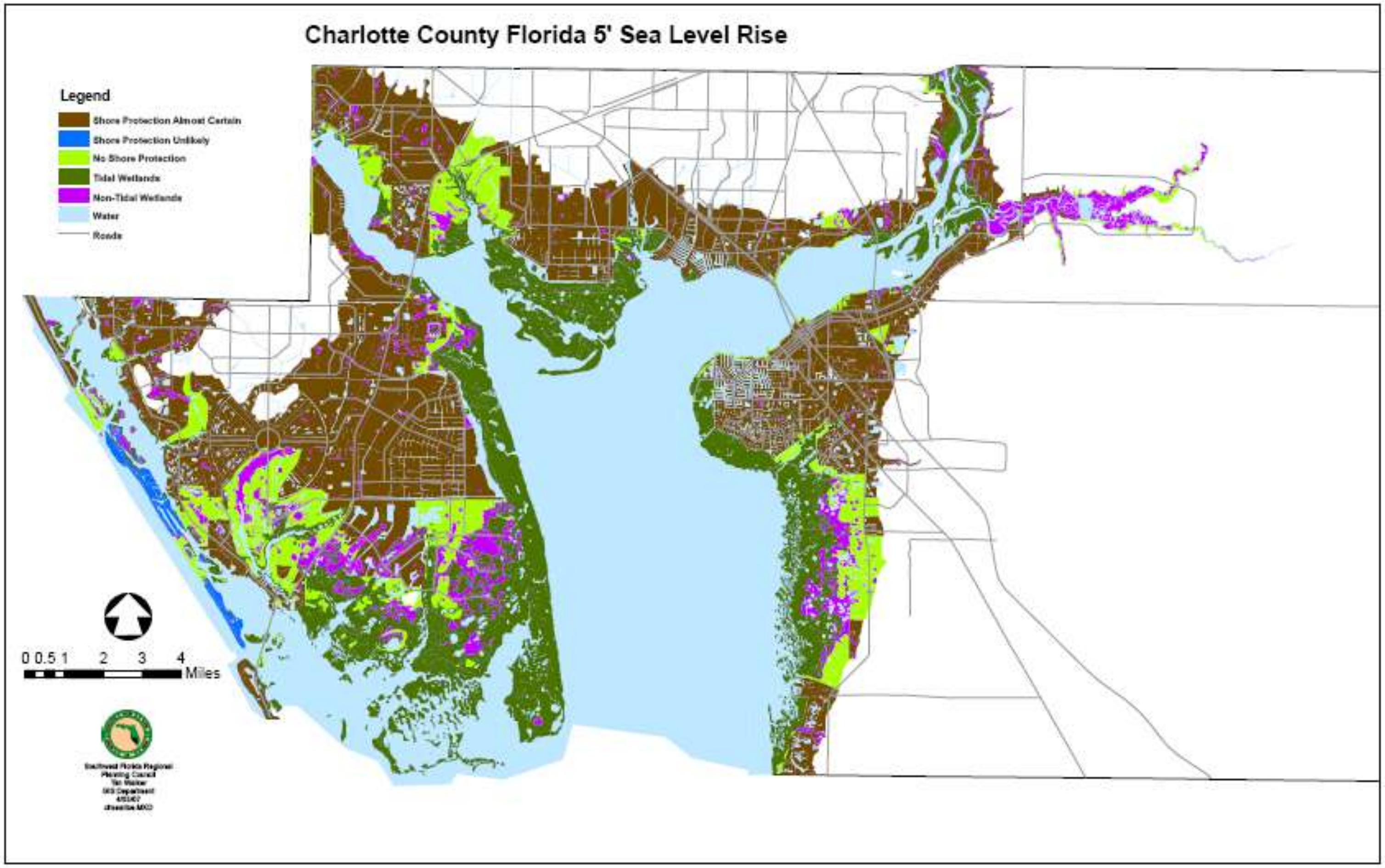

Figure 85: Land Use Projection Map Charlotte County at 5 foot sea level rise.

Table 62: Adaptations to address Education and Economy Vulnerabilities (from public workshops)

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples	Level of Support (%)
Promote green building alternatives through education, taxing incentives, green lending	Education and Economy		Reduces energy and water use	Cost of programs		67.5
Partner with utility companies to educate the public on energy efficiency	Education and Economy		Reduces energy use	Temporary benefit may be absorbed by future population growth		67.5
Increase public awareness	Education and Economy		Improves public understanding of issues to improve the decision-making process	Takes time; Need to continue education as more residents immigrate; Has to deal with mis-information campaigns		50
Hold public information workshops	Education and Economy		Improves public understanding of issues to improve the	Cost; Takes time; Need to continue education as		50

			decision-making process	more residents immigrate		
Educate homeowners associations regarding xeriscaping	Education and Economy		Improves public understanding of issues to improve Acceptance of xeriscaping	Availability of a variety of xeric plant material		50
Identify critical coastlines, wetlands, species, and water supplies	Education and Economy	Fish and Wildlife Habitat Degradation	Prepares information for decision making; Assists in prioritization	Cost and time for identification; results need periodic updates		37.5
Identify vulnerable populations	Education and Economy		Focuses on sector s of the population in the most need of attention	Population may not want to be identified as vulnerable; Some non-vulnerable groups may want identification to obtain benefits		37.5
Incorporate consideration of climate change impacts into planning	Education and Economy		Prepares for impacts at a lower cost than post-facto response; Avoids crisis response errors	Requires change in planning paradigm; planning in a longer time frame than current		37.5

				political schedules		
Change to energy efficient buses and taxis	Education and Economy		Reduces costs , use of fossil fuels, and GHG production	Initial investment cost; Availability of vehicles		37.5
Invest in alternative energy	Education and Economy		Can reduce GHG depending on the alternate fuel; Expands options when fossil fuels become more costly or less available	High up-front investment cost; Some forms of alternative energy use more energy to produce than the energy obtained		37.5
Improve overall natural resource management to increase habitat resilience	Education and Economy	Fish and Wildlife Habitat Degradation	Can prepare management areas to survive stress and impacts of climate change	Can conflict with short-term management goals; raises questions about what ecosystem should be maintained 'the current or the future?'		37.5

Acquire sensitive lands for retreat of habitat	Education and Economy	Fish and Wildlife Habitat Degradation	Allows continued existence of a variety of ecotonal ecosystems	Cost of acquisition and management; Not many areas available in built-out areas		37.5
Stop providing government subsidized insurance in high-risk areas	Education and Economy	Flooding	Reduced costs to government and public; Provides incentive to not develop in high-risk areas	Unpopular with those currently receiving or financially benefiting from development that receives the subsidy		37.5
Better distribution of information	Education and Economy		Increase general level of knowledge; Improves understanding of the public and decisions-makers	Costs of distribution; Unpopular with those who benefit from controlling information for financial or political purposes	CHNEP; Sea Grant; Charlotte Cooperative Extension	25

Use pure science/proven information	Education and Economy	Fish and Wildlife Habitat Degradation	Provides objective information allowing accurate decision making; Success track record for this approach is very good	Science does not always provide the popular answer; Many do not understand the scientific method; Advocates for particular positions will attack science that does not agree with their position; many scientists refuse to reach conclusions, instead always asking for continued funding for continued study and employment; non-scientist will use this terminology to attack science	CHNEP; Sea Grant; Mote Marine Laboratory	25

Identify conflicting policies between programs	Education and Economy		Provides information on institutional barriers and inefficiencies; Identifies import areas for conflict resolution	Knowing about a conflict does not mean anything will be done about it; Programs can be possessive of their authority and jurisdictions; Some conflicts are needed for checks-and-balances system of government to work - a non-conflicted government can make bad decisions much faster and more thoroughly.		25
Establish climate archives for baseline and tracking data	Education and Economy	Fish and Wildlife Habitat Degradation	Vital for measuring success and anticipating impacts that must be addressed	Cost of creating baseline and maintaining the archives; debates on protocol; institutional territorialism		25

Provide rebates for installation of low flow technology	Education and Economy	Water Supply	Reduces water use and water use demand;	Cost of rebates; value of rebate may not be sufficient to alter perceived benefits of higher water use; If it take three uses of a 50% low flow to do the same job as normal floe then the conservation benefit is lost		25
Create more energy- and cost-effective communities through community design and green building	Education and Economy		Reduces costs in the long term; conserves energy; improves community lifestyle	Initial investment cost; Maintenance of some green building features		25

Fund and perform long-term research	Education and Economy	Fish and Wildlife Habitat Degradation	Provides valuable scientific information for planning, management and decision - making	Costly; Requires a longer time commitment than most governments and institutions are willing to provide; results may take a long time to obtain and may not satisfy the goals and positions of the sponsor or other interest groups		25
Install groins to control beach erosion	Education and Economy		Short term collection of sand up-flow of beach along-shore current	Costly to builds and maintain Causes beach erosion; impairs beach nesting animal species; interferes with renourishment actions; causes more long term harm than short-term benefit		25

Solve insurance problem to encourage business to thrive, including tourism business	Education and Economy		Vital to long-term sustainable economic development	Insurance companies are not charitable organizations and attempt to maximize profits will minimizing risk to themselves; variable risks are increasing in unpredictable ways so actuarial methods are less certain		25
Drought resistant corps	Education and Economy	Water Supply	Improved survival and yield of crops for food, fiber, and other uses; crops can use less water	Drought resistance can cause crop to be more susceptible to other stresses such as disease or freezes		25

Prohibit federal subsidies and flood insurance in high risk areas	Education and Economy	Fish and Wildlife Habitat Degradation	Reduced costs to government and public; Provides incentive to not develop in high-risk areas	Unpopular with those currently receiving or financially benefiting from development that receives the subsidy		25
Eliminate flat-rate billing and re-price water on a sliding scale	Economy	Water Supply	Can provide incentive to use less water	Can negatively impact some businesses that by their nature require high water use		25
Raise taxes for living near the coast	Economy		Increased revenue to government and public to offset cost of services to costal development ; Provides incentive to not develop in high-risk areas	Unpopular with those currently living near the coast or receiving financially benefits from development on the coast		25
Establish funds for purchase of lands	Economy	Fish and Wildlife Habitat Degradation	Protects habitats, species and fisheries	Cost of acquisition and management; Not many areas available in built-out areas		25

Obtain state/federal grants/loans	Education and Economy		These funds can start new initiatives that are not normally available in operating budgets	These funding sources tend to be short term and not expendable for long-range projects or planning; Reporting and monitoring costs can be high		25
No rebuild laws in vulnerable areas	Economy	Flooding	Reduces cost of community services; reduces financial and human safety exposure	Not very useful when the entire community I in a vulnerable area as is the case for the City of Punta Gorda		25
Review, update and improve building and zoning standards and codes	Economy	Flooding	Improves climate, flood, and storm resistance	Cost; Takes time; Need to continue as building stock rebuilds or retrofits		25

Funding for (education)programs at all levels	Education		Increases general level of knowledge; Improves understanding of the public and decisions-makers	Costs of programs; Unpopular with those who benefit from controlling information for their own purposes	CHNEP; Sea Grant; Charlotte Cooperative Extension; CHEC; Public School System, Edison College	12.5
Establish early warning sites and gather baseline data	Education and Economy		Vital for measuring success and anticipating impacts that must be addressed	Cost of creating baseline and maintaining the archives; debates on protocol; institutional territorialism	FDEP; SWFWMD	12.5
Identify barriers to adaptation	Education and Economy		Provides information on institutional, socioeconomic, philosophical, political, and physical barriers to adaptation and inefficiencies in implementation; Identifies import areas for conflict resolution	Knowing about a barrier does not mean anything will be done about it; Entities can be possessive of their authority and jurisdictions; Some barriers can only be addressed by entities larger than the local community.		12.5

Consider temperature when choosing building materials	Education and Economy		Provides safer longer lasting more energy efficient infrastructure; Improves habitability	requires change in building paradigm; Initial cost may be higher but long-term payoff may exceed cost		12.5
Look at causes	Education and Economy		Provides information on the proximal and distal causes of climate change and its impacts. By identifying ac a cause a solution can be postulated	Knowing about a cause does not mean anything can or will be done about it; The cause may be beyond the control of the local community; Other causes may be transferred costs from those that benefit without harm to themselves		12.5

Climate policy integration where federal, state ,and local governments work collaboratively	Education and Economy		Can improve response and obtaining useful and cost effective adaptations; Improves response time and likely-hood of success	Established policies often favor one type of response over another, causing institutional biases. There are relatively few examples of organizations already preparing to adapt to climate changes. Institutional barriers to changes in management and political behavior favor inaction and non-cooperation, due to uncertainty		12.5
Redirect revenues to these issues/make funding a government priority	Education and Economy		Provides needed resources to offset cost constraints	Current economic recession imperils funding for all vital services		12.5

Implement land exchange programs	Economy	Fish and Wildlife Habitat Degradation	Preserve habitat extent; Maintain/ restore wetlands; Preserves open spaces; more land available to protect estuaries	There may not be sufficient land to exchange in a small jurisdiction. Exchanged land is likely to be in a less desirable location than costal properties	Suffolk County, NY	12.5
Subsidize retrofitting buildings for energy efficiency	Economy		Reduces energy use; Increases property values; Reduces GHG production	Cost of subsidy; In some cases it is less expensive to build new than to retrofit		12.5
Reuse of foundations	Economy		Saves costs in construction; Reduces GHG produced by demolition and placement of the new foundation	Some old foundations do not meet new code; If elevation is needed the old foundation elevation is not sufficient		12.5
Require new structures to meet National Flood Insurance Program requirements or local flood ordinance requirements whichever are stricter	Economy		Good planning; Improves public safety; Reduces infrastructure damage	Cost to meet stricter standards		12.5

Control costs so that homeowners are not taken advantage of	Education and Economy		Reduces cost of community services; reduces financial and human safety exposure; improves standard of life for residents	Does not provide subsidy for speculative development; Contrary to current practice endorsed by the current Florida legislature promoting unfunded mandates		12.5
Diversify economy	Education and Economy		Improves sustainability; Decreases susceptibility of local economy to single case depressions in specific economic activities	Can be costly if subsidized; Not all diversity is beneficial to the quality of life		12.5

Additional insulation in buildings	Education and Economy		Improved energy efficiency; reduced costs of operation; reduced GHG production	Costs of installation; Availability of best insulation products; Some chemical issues with some products when burned or wetted		12.5
Create out-of-area coalitions for mutual aid	Education and Economy		Improves resiliency when disasters are localized; Can improve water source availability	Can create limits to autonomy; Some partnerships are unequal benefiting the out-of- area entity more than the City of Punta Gorda		12.5
Create a regional sediment management plan	Education and Economy	Fish and Wildlife Habitat Degradation	Can supplement natural accretion to keep pace with sea-level	Cost of plan; Sediment may not be available to manage		12.5
Beach nourishment	Education and Economy		Can offset erosion loss if beach quality material is used	Costly; Beach quality material can be rare and unavailable;		12.5

Allow shoreline hardening where appropriate	Education and Economy		Can temporarily arrest erosion effects to protect infrastructure	Costly; Prevents wetland habitat migration; require regular maintenance and occasional rebuilding		12.5
Develop resilience in agricultural systems	Education and Economy		Helps maintain agriculture in a changing environment ; Improves local economic stability	Economics may abrogate agriculture and eliminate it form an area		12.5
Retrofit program for existing structures	Education and Economy		Improves energy efficiency and human safety and health; Improves local housing stock and upscale economy	Cost; retrofit materials are not always readily available		12.5
Plan for regional relocation and displacement	Education and Economy		Provides organized approach to move people out of harm's way; reduces negative impacts of ad hoc panic responses	Cost of developing plan; Plan can crate winners and losers in displacement		12.5

All measures to reduce local GHG emissions	Education and Economy		Reduces energy use and waste; Improves respiratory health; Can mitigate watering and ocean acidification	Cost; Some methods of locally reducing GHG emissions have negative consequences that a more deleterious than the GHG		12.5
Solve environmentally related problems which affect recreational activities	Education and Economy		Improves recreational opportunities; Recues negative environments impacts			12.5
Minimize dredging	Education and Economy	Fish and Wildlife Habitat Degradation	Reduced costs to government and public; Improves estuaries natural response to sea-level changes	Not popular for advocates of dredging for deeper vessels draft; the City of Punta Gorda has a large inventory of canals and channels that will need continued maintenance dredging		12.5

Public purchase of private development rights	Education and Economy	Fish and Wildlife Habitat Degradation	Protects habitats, species, fisheries; Reduces flooding	Costly; uncertainty about climate change extents means uncertainty in the amount of property to be purchased		12.5
Free/low cost loans for photovoltaic systems, net metering, solar panels	Education and Economy		Reduction in energy use and GHG	Cost of programs		12.5
Increase public awareness on renewable energy	Education and Economy		Reduction in energy use and GHG			12.5
Incorporate drastically increased fees/rates for high water consumption	Education and Economy		Reduction in water use	Unpopular with high water consumers		12.5
Flood insurance rate maps should take climate change into account	Education and Economy	Flooding	Potential decrease in amount and density of development in floodplains	Will result in higher flood insurance costs for previously unidentified areas		12.5
Sell carbon offsets	Education and Economy		If set for a net benefit then there could be a decrease in GHG. If set neutral than no benefit is accrued	Cost of purchase of carbon offset; Program may be set at net balance s no improvement is actually implemented		12.5

Redefine flood hazard zones	Education and Economy	Flooding	Protects Habitats and resources in the flood hazard zones	Impacts on flood insurance; may require changing zoning ordinances, which can be difficult		12.5

Table 63: Adaptations to address Education and Economy Vulnerabilities Recommended Against (from public workshops)

Recommended Against						
Require new residents to attend local environment school						
Raise insurance prices						
Prohibit federal subsidies and flood insurance in high risk areas						
Link sale of other forms of insurance to offering property insurance as a requirement of doing business in Florida						
Insurance coverage should reflect risk vs. actual loss						
Socialize insurance						
Raise taxes for living nearer the coast						
Eliminate flat-rate water billing and r-price water on a sliding scale						
Stop dredging						
Incorporate drastically increased fees/rates for high water consumption						
Consider congestion zone tolls in larger cities						
Sell carbon offsets						

ADAPTATION: Promote green building alternatives through education, taxing incentives, green lending.

"Promote green building alternatives through education, taxing incentives, green lending" and "Partner with utility companies to educate the public on energy efficiency " were the top- adaptation measures proposed to address education, economic and lack of money vulnerabilities to climate change in the City of Punta Gorda. The following is a discussion on how this adaptation could be implemented for the City of Punta Gorda.

Green building energy efficient alternatives encompass a wide variety of measures. Some activities make a structure more energy efficient, thereby reducing needs for electricity generation with its associated fossil fuel use and greenhouse gas emission. Some activities reduce the amount of water needed to sustain the people using the building as well as the landscaping surrounding it. As it has been noted, education, economy and individual financial resources are all closely linked; this is well demonstrated in this adaptation measure.

Many green building alternatives are enumerated in the following pages. Many of these measures can only be accomplished with a financial commitment from the owner of the structure. A cycle is initiated when building and property owners, (including the City of Punta Gorda), become educated about the financial and environment-related advantages of green building alternatives and seek to incorporate changes into their buildings and landscape. While these changes should eventually save the owners money, which can be invested into further improvements, the initial investment can be difficult to come by. When local, state and/or federal entities, or private foundations help initiate the cycle with instruments such as taxing incentives and lending specifically to encourage green building alternatives, those savings can begin. These actions can encourage owners to continue the cycle, making more and more improvements.

The results can include more and better energy efficient buildings, increased conservation of energy and water, and more and better storm- and flood-resilient buildings. Benefits accrue not just to the individual building owner, but also to the community, which is better equipped to face the effects of climate change, such as drought and flood, and which will have to expend fewer resources on recovery from such events.

Carbon reducing efforts

Buildings annually consume more than 30% of the total energy and 60% of the electricity used in the U.S. (USGBC 2006). The residential sector consumes 108,836 million kilowatt hours (kWh) and the commercial sector consumes 75,073 million kWh of electricity annually (ACEEE, 2007). These two uses consume 90% of all electricity generated in the state (53% for residential and 37% for commercial). Florida utilities generate 70% of electricity from fossil fuels (ACEEE 2007). Obviously, buildings have a tremendous impact on the demand for electrical consumption and the production of greenhouse gases in Florida.

Beginning in 1978, the State Energy Office, under the Department of Administration, issued Florida's first statewide building energy efficiency code (Fairey 2007). This code has been modified over the years and is now more efficient than ever. The 2007 Florida Building Code was most recently updated on March 01, 2009. These modifications required a 15% increase in energy efficiency over the 2004 Florida Building Code (Stanton 2008). Still, modifications can be made to the design and construction of new and existing buildings to increase the energy efficiency and thus lower the monthly cost of operation. Possible modifications are listed below.

Energy Efficiency Measures

- **Cool Roofs and Green Roofs**

  A cool roof is one that reflects the sun's heat and emits absorbed radiation back into the atmosphere. The roof literally stays cooler and reduces the amount of heat transferred to the building below, keeping the building a cooler and more constant temperature. A cool roof can significantly reduce cooling energy costs and increase the comfort level by reducing temperature fluctuations inside the home. Average energy savings range from 7% to 15% of total cooling costs. (Cool Roofs 2009) White tile provides excellent cooling related performance. Relative to a black asphalt shingle roof, a white tile roof produced a 76% reduction in overall summer ceiling heat flux (Parker et al. 1998).

  Green roofs (also known as garden roofs or vegetated roofs) use plants as roof covering. Though technically not highly reflective, green roofs do provide similar energy savings and urban heat island mitigation benefits as cool roofs. They also absorb water, reducing storm water runoff. Both cool roofs and green roofs extend roof life and reduce the amount of solid waste generated by reroofing (Cool Roofs 2009; Green Roofs 2009).

- **HVAC Systems**

  Cooling of building space creates a significant electrical demand for southwest Florida utilities. Efficiencies in cooling can be improved in a number of ways. Duct systems are often located in the attic space in Sun Belt homes with slab-on-grade foundations (Parker et al. 2002). Building owners should consider sealing all duct joints and seams and testing the system for leaks. If possible, air handlers and duct systems should be moved from unconditioned spaces to conditioned spaces. Previous research has shown that air handlers located in the attic space can increase space cooling by up to 30% (Parker 1998). Tests at the Florida Solar Energy Center have shown that, not only does the attic sometimes reach 135^{o}F in Florida's summers (Parker et al. 1998); heat transfer to the duct system can rob the air conditioner of up to a third of its cooling capacity during the hottest hours. Central air conditioners are rated according to their seasonal energy efficiency ratio (SEER). SEER indicates the relative amount of energy needed to provide a specific cooling output. Builders and home owners should evaluate the seasonal energy efficiency ratio of air conditioners. Manufacturers are required by the Federal government to build air conditioners to a minimum SEER of 13 (USDOE 2009). Additionally, if the condenser is shaded, the energy efficiency of the unit increases.

  Homeowners and builders should evaluate the refrigerants used in central air conditioners. CFCs, or chlorofluorocarbons, are known to deplete the ozone layer. Many air conditioning systems contain chemicals that either contribute to ozone depletion or have a high global warming potential. Air conditioners with these chemicals should not be installed in new building and a phase out schedule with a five year deadline for removal of these systems should be created for existing buildings (USGBC 2006). Air conditioners with these chemicals should be replaced with new systems that do not use these gases. When old units are being removed, special care should be taken to prevent leakage of remnant gases out of the system.

Other energy efficiency strategies such as increased attic insulation and more efficient windows also contribute to the overall energy efficiency of the HVAC unit.

- **Attic Insulation**
  One of the fastest and easiest things to do to increase the energy efficiency of a structure is to increase the amount of insulation installed in the attic space. Insulation installed in Florida homes generally rests directly on top of the ceiling. The amount of required attic insulation has steadily increased over the past 30 years (Fairey 2007). Attic insulation also has a tendency to resist heat less and less over time due to compression of the material from settling and from human activity in attics. It is important to evaluate leakage in the HVAC duct systems in the attic and potential structural hardening of the home prior to the installation of attic insulation. Once attic insulation has been installed, every attempt should be made to reduce the amount of human activity in the attic space as this activity will probably lead to compression of the insulation and a loss of insulating efficiency.

- **Windows**
  Windows in the U.S. consume 30 percent of building heating and cooling energy (Arasteh 2006). Many windows installed in homes today are single pane glass with a high solar heat gain coefficient or SHGC. The lower a window's solar heat gain coefficient, the less solar heat it transmits (Efficient Windows Collaborative 2009). New construction should utilize lower SHGC windows and retrofit projects may consider the replacement of only certain windows which are more prone to solar heat gain due to a lack of vegetative shading or the orientation of the structure relative to the sun’s travel path.

  Other strategies to reduce heat gain from windows include strategic planting of vegetation and increasing structural overhangs or awnings to provide shading of window surfaces. The building owner should carefully evaluate plant characteristics prior to the selection and planting. Placement of the plant is also very important as some fire prone communities recommend clearing around structures to 30 feet.

  Structural shading can have a significant impact on the amount of solar radiation a window receives.   In Florida "Cracker" homes, built at the turn of the century before air conditioning, wide porches and deep overhangs were considered essential to achieve comfort (Haase 1992). However, with the advent of air conditioning, many new homes have sacrificed overhangs in interest of first cost. New residences in modern developments often have practically no overhangs (Parker et al. 1998).

- **Sealing the building envelope**
  Selecting the appropriate windows and doors can reduce air leaks and promote energy efficiency. Weather stripping can also increase energy efficiency by reducing air leaks. Building owners should also seal all penetrations through the wall or ceiling where heat

could be transferred from unconditioned spaces to conditioner spaces. A few of these are the plumbing ventilation stacks, wiring drops, ceiling outlet boxes and air conditioning vents and recessed lighting cans (Parker et al. 1998).

- **Interior lighting and daylighting**
  Electric lighting accounts for 40% of a commercial building's electricity consumption (Rogers 2007). Lighting represents a smaller percentage of the energy budget for residential structures, but it is still a significant part of a home's energy budget. Also, the more electricity the lighting system consumes, the more heat gain the building experiences. This adds to the burden of the air conditioning system requiring the air conditioning system to work longer and consume more power. The Florida Solar Energy Center has demonstrated the large savings potential of using compact florescent lamps for residential lighting (Parker et al. 1998). There are multiple sizes and efficiencies of fluorescent light bulbs available. The most efficient bulb for the setting should be used.

  Daylighting features, such as windows, clearstories, and skylights, should be considered wherever possible. The use of daylight to replace or supplement electric lighting in commercial or residential buildings can result in significant energy savings (Selkowitz 1998).

  Other considerations for lighting should include daylight sensors, dimmable ballasts, and occupancy sensors.

Other adaptations to increase energy efficiency include:

- Higher solar reflectance materials (paints) for walls
- Increase the number of trees on site to serve as a carbon sink
- Use renewable materials such as bamboo onsite
- Recycling, including construction materials
- Composting – homeowner scale and municipal scale
- Minimize impervious surfaces – open grid concrete pavers
- Low impact development
- High albedo (more reflective) paving materials
- Reduce ghost loads from plugged in but unused electrical devices
- Elevation of structures reduce heat island effect
- Use of native vegetation to reduce need for fertilizers (which require power for manufacture), and water consumption (which requires power for extraction, production, delivery and treatment);
- Replacement of traditionally generated electricity with renewable energy, such as wind, biogas, geothermal, tidal, photovoltaics, solar thermal (water heaters) etc.
- Make communities more walkable and encourage mass transit to reduce the need for cars

Water conservation efforts to address water supply issues

Each day, five billion gallons of potable water is used solely to flush toilets (USGBC 2006). Eighty percent of water in the Southwest Florida Water Management District comes from groundwater sources. Households in this district consume 113 gallons per capita per day. It is difficult to determine the amount of water that is used for irrigation of turf grass due to the number of private wells used either exclusively for landscape irrigation or for combined domestic in-home and landscape irrigation needs. Some homes use a significant amount of water for landscape irrigation (SWFWMD 2007). Water is a precious resource that must be conserved.

Climate change may affect water resources in several ways. Increased drought conditions will increase demand for both irrigation and potable water while at the same time reducing the amount of surface and groundwater available for those uses. Lower water tables may lead to saltwater intrusion into wells, requiring higher levels of desalination. Increased atmospheric carbon dioxide may acidify surface water sources, requiring more and different treatment protocols.

Modifications that can be made to the design and construction of buildings to decrease water consumption include:

- Change zoning ordinances that require specific vegetation such as turf grass
- Use rain gardens to reduce runoff and encourage recharge
- Use rainwater harvesting for irrigation
- Remove regulatory barriers to grey water reuse
- Increase the numbers of trees on site to reduce evaporation from the ground
- Encourage composting and mulching on the homeowner and municipal scales to reduce irrigation needs
- Minimize impervious surfaces with options such as open grid concrete pavers to increase recharge
- Use Low Impact Development principles
- Channel water from impervious surfaces to pervious areas
- Use native vegetation to reduce use of fertilizers and water
- Install rainfall sensors to reduce automatic irrigation in wet seasons
- Reduce potable water consumption by installing fixtures with more efficient flow rates and flush rates
- Reverse the compaction of soil for vegetated (non-constructed) areas after building is complete
- Reduce or eliminate shallow aquifer groundwater extraction
- Impose irrigation restrictions or reductions for turf grasses
- Use cisterns to gather rainwater

Hardening ideas that address increasing storm frequency and intensity, and steps that can be taken to protect communities from flooding, erosion and wind damage associated with storm events are listed below:

- Raise structures with fill and/or pilings.
- Channel stormwater runoff from impervious to pervious areas to help reduce erosion (and promote aquifer recharge).
- Implement stormwater dispersal methods, such as spouts and gravel areas beneath downspouts, to reduce the physical impact of more intense rainwater flow.

- Build “deconstructable” buildings which can be taken apart and easily moved to higher ground, such as Rinker Hall at the University of Florida.
- Modify stormwater conveyance systems and control elevations to be relative to sea level instead of being required at a set elevation.
- Make sure fill is used in a way to reduce the run off onto adjacent properties in order to prevent erosion.
- Implement adaptations for wind risks: shuttering of windows or installation of windows with impact glass; bracing of garage doors; roof- or truss-to-wall and wall-to-floor hurricane hardening measures including the installation of gussets, addition of straps, cross bracing gable end chords; requiring complete tear offs for roofs to evaluate the deck nailing; and determining if the integrity of vinyl and aluminum soffits are appropriate for the wind risk the region faces.
- Consider increased fire risk in vegetative choices and placement and consider the fire risks associated with roofing materials and other potentially flammable building material choices. Asphalt shingles, the most common roofing material choice in Florida, are more flammable than other non petroleum based roofing materials.

Adaptations for Transportation Infrastructure

Climate change will affect transportation primarily through increases in several types of weather and climate extremes. Climate warming over the next 50 to 100 years will be manifested by increases in very hot days and heat waves, increases in average temperatures, rising sea levels coupled with storm surges and land subsidence, more frequent intense precipitation events, and increases in the intensity of strong hurricanes. The impacts will vary by mode of transportation and region, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems (Transportation Research Board 2008).

Transportation professionals should acknowledge the challenges posed by climate change and incorporate current scientific knowledge into the planning, design, construction, operation, and maintenance of transportation systems. Every mode of transportation and every part of the southwest Florida region will be affected as climate change poses new and often unfamiliar challenges to infrastructure providers (Transportation Research Board 2008).

“Special Report 290: Potential Impacts of Climate Change on U.S. Transportation”—the report of a study conducted by a committee of experts under the auspices of the Transportation Research Board and the Division on Earth and Life Studies of the National Research Council—makes the case that focusing on the problem now should help avoid costly future investments and disruptions to operations (Transportation Research Board 2008).

One response to the threat of inundated transportation infrastructure is simply to elevate it to keep pace with the sea level rise. While elevation may be less expensive than letting rising waters wash out entire highways, it is expensive. One estimate put the average cost of elevating roads at $2 million per mile (Dean 2007b). Over 2,400 miles of existing highway and other major roads in the entire state of Florida are at risk of inundation from 27 inches of sea level rise. The cost of elevating just these roads sums to over $4.8 billion. This estimated total of road miles does not take into account the millions of miles of city streets in Florida's vulnerable areas that would need to be elevated, nor does it consider the many additional miles and lanes of roads that will likely be built as Florida's population doubles over the next 50 years.

Elevating roads, however, may cause other problems. Streets are typically built lower than surrounding residential and commercial property so that water from the land can drain into the street. Elevating the roads can prevent this drainage and put flooding back onto the adjacent lands. In such cases, it becomes necessary to raise surrounding land along with the street, so that relative engineered heights are preserved (Titus 2002).

The past several decades of historical regional climate patterns commonly used by transportation planners to guide their operations and investments may no longer be a reliable guide for future plans. In particular, future climate will include new classes (in terms of magnitude and frequency) of weather and climate extremes, such as record rainfall and record heat waves, not experienced in modern times (Transportation Research Board 2008). Decisions transportation professionals make today, particularly those related to the design and retrofitting of existing transportation infrastructure or the location and design of new infrastructure, will affect how well the system adapts to climate change far into the future (Transportation Research Board 2008).

Inventory Critical Infrastructure

Potentially, the greatest impact of climate change on southwest Florida's transportation system will be flooding of coastal roads, bridge approaches and causeways because of a rise in sea level coupled with storm surge and exacerbated in some locations by land subsidence. The vulnerability of transportation infrastructure to climate change, however, will extend well beyond coastal areas. Railways, transit systems, and airport runways may also be flooded by interior precipitation-driven floods.

Therefore, federal, state, and local governments, in collaboration with owners and operators of infrastructure such as ports, airports, and private railroad and pipeline companies, should inventory critical transportation infrastructure to identify whether, when, and where projected climate changes in particular regions might be consequential (Transportation Research Board 2008).

Incorporate Climate Change into Investment Decisions

Public authorities and officials at various governmental levels, and executives of private companies are making short- and long-term investment decisions every day that have implications for how the transportation system will respond to climate change in the near- and long-terms. Transportation decision makers have an opportunity now to prepare for projected climate changes. State and local governments and private infrastructure providers should incorporate climate change into their long-term capital improvement plans, facility designs, maintenance practices, operations, and emergency response plans. Table 63 lays out a six step approach for determining appropriate investment priorities (Transportation Research Board 2008).

Decision Framework for Transportation Professionals to Use in Addressing the Impacts of Climate Change on Transportation Infrastructure
1. Assess how climate changes are likely to affect various part of the region and modes of transportation.
2. Inventory transportation infrastructure essential to maintaining network performance in light of climate change projections to determine whether, when, and where their impacts could be consequential.
3. Analyze adaptation options to assess the trade-offs between making the infrastructure more robust and the costs involved. Consider monitoring as an option.
4. Determine investment priorities, taking into consideration criticality of the infrastructure components as well as opportunities for multiple benefits (e.g., congestion relief, removal of evacuation of route bottlenecks).
5. Develop and implement a program of adaptation strategies for the near and long-terms.
6. Periodically assess the effectiveness of adaptation strategies and repeat Steps 1 through 5.

Table 63: Decision Framework for Transportation Professionals to Use in Addressing the Impacts of Climate Change on Transportation Infrastructure

Source: Transportation Research Board 2008

Adopt Strategic, Risk-Based Approaches to Decision Making

The significant costs of redesigning and retrofitting transportation infrastructure to adapt to the potential impacts of climate change suggest the need for more strategic, risk-based approaches to investment decisions. Transportation planners and engineers should incorporate more probabilistic investment analyses and design approaches that apply techniques for trading off the costs of making the infrastructure more robust against the economic costs of failure, and should communicate these trade-offs to policy makers who make investment decisions and authorize funding. One model is the California Seismic Retrofit Program, which uses a risk-based approach to analyze vulnerability to earthquakes and criticality of highway bridges to determine priorities for retrofitting and replacement (Transportation Research Board 2008).

Improve Communication

Transportation decision makers note that one of the most difficult aspects of addressing climate change is obtaining the relevant information in the form they need to plan and design. Transportation professionals often lack sufficiently detailed information about expected climate changes, and their timing, to take appropriate action. The National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Transportation (USDOT), the U.S. Geological Survey (USGS), and other relevant agencies should work together to institute a process for better communication among transportation professionals, climate scientists, and those in other relevant scientific disciplines, and should establish a clearinghouse for transportation-relevant climate change information. In addition, better decision support tools are needed to assist transportation decision makers. Ongoing and planned research at federal and state agencies, and universities that provides climate data and decision support tools should include the needs of transportation decision makers (Transportation Research Board 2008).

Integrate Evacuation Planning and Emergency Response into Transportation Operations
Projected increases in weather and climate extremes underscore the importance of emergency response plans in vulnerable locations and require that transportation providers work more closely with weather forecasters and emergency planners, and assume a greater role in evacuation planning and emergency response. Climate extremes, such as more intense storms and more intense precipitation, will require near-term operational responses from transportation providers and greater attention to emergency response in transportation operations and budgets. Transportation agencies and service providers should build on the experience in locations where transportation is well integrated into emergency response and evacuation plans (Transportation Research Board 2008).

Develop and Implement Monitoring Technologies
Monitoring transportation infrastructure conditions, particularly the impacts of weather and climate extremes, offers an alternative to preventive retrofitting or reconstruction of some facilities in advance of climate change. Greater use of sensors and other "smart" technologies would enable infrastructure providers to receive advance warning of potential failure due to water levels and currents, wave action, winds, and temperatures exceeding what the infrastructure was designed to withstand. Federal and academic research programs should encourage the development and implementation of these technologies (Transportation Research Board 2008).

Share Best Practices
As the climate changes, many U.S. locations will experience new climate-induced weather patterns. The geographic extent of the United States—from Alaska to Florida and from Maine to Hawaii—and its diversity of weather and climate conditions can provide a laboratory for best practices and information sharing as the climate changes. Drawing on existing technology transfer mechanisms, relevant transportation professional and research organizations should develop a mechanism to encourage sharing of best practices to address the potential impacts of climate change (Transportation Research Board 2008).

Reevaluate Design Standards
Environmental factors are integral to transportation infrastructure design. However, engineers have not given much thought to whether current design standards are sufficient to accommodate climate change. Climate change projections indicate that today's 100-year precipitation event is likely to occur every 50 years or perhaps even every 20 years by the end of this century. Reevaluating, developing, and regularly updating design standards for transportation infrastructure to address the impacts of climate change will require a broad-based research and testing program and a substantial implementation effort. USDOT should take a leadership role along with professional organizations in the forefront of civil engineering practice across all modes to initiate immediately a federally funded, multiagency research program. The program

should focus on the reevaluation of existing design standards and the development of new standards as progress is made in understanding future climate conditions and the options available for addressing them. A research plan and cost proposal should be developed for submission to Congress for authorization and funding. Until new standards are developed, infrastructure rehabilitation projects in highly vulnerable locations should be rebuilt to higher standards.

The development of appropriate design standards to accommodate climate change is only one of several possible adaptation strategies that may require federal leadership, research, and funding. Federal agencies have not focused generally on adaptation in addressing climate change. Better collaboration could help focus attention on these issues and shape existing research programs. USDOT should take the lead in developing an interagency working group focused on adaptation (Transportation Research Board 2008).

Include Climate Change in Transportation and Land Use Planning
One of the most effective strategies for reducing the risks of climate change is to avoid placing people and infrastructure in vulnerable locations. Transportation planners are not currently required to consider climate change and its effects on infrastructure investments. Land use decisions are made primarily by local governments, which have too limited a perspective to account for the broadly shared risks of climate change. Integration between transportation and land use planning is uncommon. Federal planning regulations should require that climate change be included as a factor in the development of public-sector, long-range transportation plans; eliminate any perception that such plans be limited to 20 to 30 years; and require collaboration in plan development with agencies responsible for land use, environmental protection, and natural resource management to foster more integrated transportation–land use decision making (Transportation Research Board 2008).

Evaluate the National Flood Insurance Program and Flood Insurance Rate Maps
The federal government is the insurer of last resort for homeowners in specially designated flood hazard areas. The National Flood Insurance Program (NFIP), administered by the Federal Emergency Management Agency (FEMA), and the flood insurance rate maps (FIRMs) that determine program eligibility do not take climate change into account. FEMA should reevaluate the risk reduction effectiveness of the NFIP and the FIRMs, particularly because climate change may trigger more intense storms and sea level rise which will extend the scope of flood damage in some special flood hazard areas. At a minimum, updated FIRMs that account for sea level rise (incorporating land subsidence) should be a priority in coastal areas (Transportation Research Board 2008).

Develop New Organizational Arrangements
The impacts of climate change do not follow modal, corporate, or jurisdictional boundaries, yet decision-making in the transportation sector is based on these boundaries. Current institutional arrangements for transportation planning and operations were not organized to address climate change and may not be adequate for the purpose. Some models of cross-jurisdictional cooperation exist. Among them are regional authorities for specific facilities; regional and multistate emergency response agreements; and state-mandated regional authorities, such as those responsible for air quality improvement. Similar arrangements could emerge to address the

effects of sea level rise on coastal real estate and infrastructure, the effects of drought on shipping along inland waterways, and the effects of hurricanes in the Gulf Coast region. However, state or federal incentives may be required to ensure the development of such organizational arrangements at the regional or multistate level. Actions to prepare for climate change can be taken almost immediately. Some steps can be undertaken by local governments and private infrastructure providers. Others depend on federal and state action. In all cases, leadership and continuing commitment are essential (Transportation Research Board 2008).

Vulnerability 9: Fire

A wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. They often begin unnoticed and spread quickly and are usually signaled by dense smoke that fills that area for miles around. Naturally occurring and nonnative species of grasses, brush, and trees fuel wildfires (FEMA). A wildland fire is a wildfire in an area in which development is essentially nonexistent, except for roads, railroads, power lines, and similar facilities. An urban-wildland interface fire is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels (FEMA).

Wildfires are nature's way of managing wild plant life and regenerating growth. But, they also can be the result of other factors. Wildfires can be caused by lightning, campfires, uncontrolled burns, smoking, vehicles, trains, equipment use, and arsonists. People start more than four out of every five wildfires, usually as debris burns, arson, or carelessness. Lightning strikes are the next leading cause of wildfires (FEMA).

Wildfire behavior is based on three primary factors: fuel, topography, and weather. The type and amount of fuel, as well as its burning qualities and level of moisture affect wildfire potential and behavior. The continuity of fuels, expressed in both horizontal and vertical components is also a factor, Topography is important because it affects the movement of air (and thus the fire) over the ground surface. The slope and terrain can change the rate of speed at which fire travels. Weather affects the probability of wildfire and has a significant effect on its behavior. Temperature, humidity, and wind (both short and long term) affect the severity and duration of wildfires (FEMA).

Wildfires can cause extensive damage to personal property, residences, acres of grassland and forest, and agricultural interests. Wildfires also threaten the health and lives of citizens living in or around the fires. Since 1998, more than 15,000 Florida wildfires have devastated over one million acres and destroyed more than 750 structures.

Aside from the potential losses to physical structures, losses that communities face as a result of a wildfire include, but are not limited to loss of businesses, damage to drinking water supplies, decreases in tourism opportunities, suppression costs to communities, and fatalities or injuries (Western Wildfire Primer). Wildfire events cause a release of certain emissions into the surrounding air. The major emissions include: particulate matter, carbon dioxide, and carbon monoxide. All of these can affect the local environment. A reduction in air quality can negatively impact elderly people or people with respiratory conditions such as asthma. In addition to temporarily reducing air quality, there can also be a decrease in visibility, which can become of great concern with respect to road rights-of-way and traffic hazards (Florida Division of Forestry Fire Website).

Charlotte County experiences brush and wild land fires annually. The peak times for forest fires are usually January through May of each year. This is the dry season for Charlotte County.

During these months, grass, leaves, and underbrush are in an optimal burning condition. Climate change will likely increase wildfires in the area due to increased drought conditions, lower water tables (which make it more difficult to fight fires), and higher winds.

None of Punta Gorda's 9,986 structures are located in the fire risk zone. None of Punta Gorda's 44 historic structures are located in the fire risk zone. None of Punta Gorda's 174 structures owned by Charlotte County's top employers are located in the fire risk zone. None of Punta Gorda's four structures classified as repetitive loss structures are located in the fire risk zone .

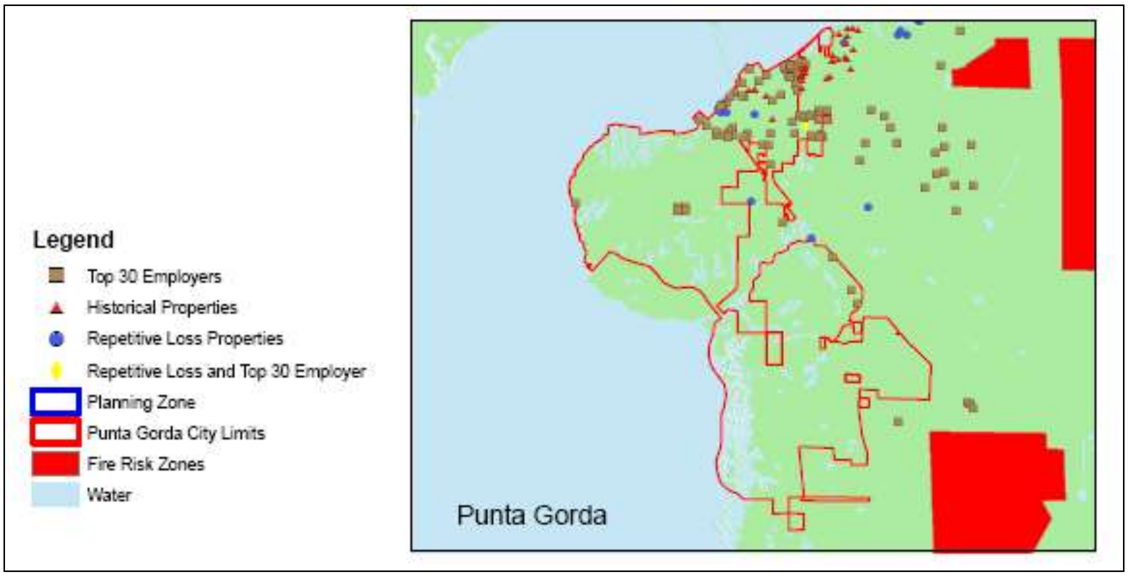

Figure 86: Fire risk zones closest to Punta Gorda

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy 2005

Table 64: Adaptations to address Fire Vulnerabilities (from public workshops)

Adaptation Option	**Climate Stressor Addressed**	**Additional Management Goals Addressed**	**Benefits**	**Constraints**	**Examples**	**Level of Agreement**
Drought preparedness planning	Fire		Provides a more accurate picture of future water sources. Does not commit to sources that will not be there.	Uncertainty in future climate change scenarios	Knutson et al (1998)	67.5
Control invasive exotic species	Fire	Fish and Wildlife Habitat	Maintains and increases habitat; Reduces negative impacts such as encrusting by Zebra mussels	Cost		37.5
Increase tree cover to reduce evaporation from ground	Fire	Fish and Wildlife Habitat	Provides improved micro-climate; Reduces water demand; Can reduce energy use	Cost of installation and maintenance		37.5

Limit development	Fire	Water Quality Degradation	Reduces water use demands and costs for water supply planning and development	Contrary to current Florida practices; Discouraged by the current Florida Legislature	City of Sanibel	25
Control sprawl	Fire	Water Quality Degradation	Reduces a wide variety of environmental and socioeconomic impacts	Contrary to current Florida practices; Discouraged by the current Florida Legislature	Pre-2050 Sarasota County Comprehensive Plan	25
30 foot buffer in residential landscaping	Fire		Reduces chances that fire will catch onto a building from landscapes' fires	Will not help areas already developed; Reduces habitat for wildlife		12.5
Consider risks associated with roofing materials and other flammable building materials	Fire		Reduces chances that fire will catch onto a building from landscapes' fires	Safer material may be more expensive and/or difficult to obtain		12.5
Restriction on uses	Fire		Reduction in the use of potable water for irrigation.	Could be contrary to State Burt Harris Act		12.5

Identify conflicting policies between programs	Fire		Provides information on institutional and governmental barriers to protecting water supplies	Can reduce intergovernmental coordination when conflicts are exposed; Could engender pre-emption by Federal or State entities that desire to climate conflict in favor of their authority		12.5
Reinforce existing infrastructure	Fire		Protects against windstorms and climate instability	Cost		12.5
Acquire land for flood/water supply	Fire	Flooding	Reduces flooding; Increase water available for water supply uses	Costs of acquisition		12.5
Evict smokers	Fire					Recommended Against

ADAPTATION: Drought preparedness planning.

“Drought preparedness planning“ was the top adaptation measure proposed to address fire vulnerabilities to climate change in the City of Punta Gorda. The following is a discussion on how this adaptation could be implemented for the City of Punta Gorda.

Drought is a normal part of virtually every climate on the planet, even rainy ones. It is the most complex of all natural hazards, and it affects more people than any other hazard. Financial analysis shows that it can be as expensive as floods and hurricanes.

The impacts of drought are greater than the impacts of any other natural hazard. They are estimated to be $6-8 billion annually in the United States and occur primarily in agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

Florida experienced three to four consecutive years of drought from 1998 to 2001, The City of Punta Gorda’s vulnerability to drought is affected by (among other things) population growth and shifts, urbanization, demographic characteristics, technology, water use trends, government policy, social behavior, and environmental awareness. These factors are continually changing, and the City’s vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations put increasing pressure on water and other natural resources since in typical manmade Florida landscapes more people need more water.

Although drought is a natural hazard, the CIty can reduce its vulnerability and lessen the risks associated with drought episodes. The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought gives decision makers the chance to relieve the most suffering at the least expense. Reacting to drought in “crisis mode” decreases self-reliance and increases dependence on government and donors.

One of the major impediments to drought planning is its cost. Officials may find it difficult to justify the costs of a plan, which are immediate and fixed, against the unknown costs of some future drought. But studies have shown that crisis-oriented drought response efforts have been largely ineffective, poorly coordinated, untimely, and inefficient in terms of the resources allocated. In fact, since 1989, Congress has appropriated more than $25 billion in agriculture disaster assistance alone. Compared to expenditures of this magnitude, an investment in drought preparedness programs is a sound economic decision. Moreover, drought planning efforts can use existing political and institutional structures, and plans can (and should) be incorporated into general natural disaster or water

Drought preparedness plans promote a more preventive, risk management approach to drought management. They reduce vulnerability to drought and dependence on emergency assistance from governments and international organizations. The process of developing a plan will identify vulnerable areas, population groups, and economic and environmental sectors. The process also seeks to identify data and informational gaps and research and institutional needs. Ultimately, preparedness plans will improve coordination within and between levels of government; procedures for monitoring, assessing, and responding to water shortages; information flow to primary users; and efficiency of resource allocation. The goals of these plans are to reduce water shortage impacts, personal hardships, and conflicts between water and other natural resource users. These plans should promote self-reliance by systematically addressing issues of principal concern to the region or nation in question. To be successful, drought preparedness plans must be integrated between levels of government and with other regional, state and national plans. Drought preparedness plans contain three critical components: (1) a comprehensive early warning system; (2) risk and impact assessment procedures; and (3) mitigation and response strategies. These components complement one another and represent an integrated institutional approach that addresses both short- and long-term management and mitigation issues.

Knutson et al (1998) describes a practical step-by-step process for identifying actions that can be taken to reduce potential drought-related impacts before a drought occurs.

- Step 1. Getting Started . begins with making sure that the right people are brought together and supplied with adequate data to make informed and equitable decisions during the process
- Step 2. Drought Impact Assessment and
- Step 3. Ranking the Impacts narrow the focus of the study by identifying high priority drought-related impacts that are relevant to the user's location or activity.
- Step 4. Vulnerability Assessment demonstrates that in order to reduce the potential for the identified impacts to occur in the future, it is necessary to understand the underlying environmental, economic, and social causes of the impacts.
- Step 5. Action Identification and
- Step 6. Developing the "To Do" List utilize all of the previous information to identify feasible, cost-effective, and equitable actions that can be taken to address the identified causes. In this manner, true drought vulnerabilities can be addressed that will subsequently reduce drought-related impacts and risk.

Vulnerability 10: Availability/Cost of Insurance

The City of Punta Gorda is exposed to a wide array of natural hazards that threaten both human life and property. Increased climatic variability will make the risks associated with these climatic events less predictable. These vulnerabilities should be expected to be exacerbated by climate change. Coastal erosion and sea level rise, hurricanes and coastal storms, floods other than storm surge, drought/heat wave, and wildfires have previously been discussed in this report.

The remaining variable climatic risks include tornadoes, thunderstorms/high winds, and winter storms and freezes.

Tornadoes

The National Weather Service defines a tornado as "a violently rotating column of air in contact with the ground and extending from the base of a thunderstorm. A condensation funnel does not need to reach to the ground for a tornado to be present; a debris cloud beneath a thunderstorm is all that is needed to confirm the presence of a tornado, even in the total absence of a condensation funnel" (National Weather Service 2003). The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Damage paths can be in excess of one mile wide and 50 miles long (NOAA 2007).

Tornadoes come in all shapes and sizes and can occur anywhere in the U.S. at any time of the year. In the southern states, peak tornado season is March through May, while peak months in the northern states are during the summer. Tornadoes develop as an outgrowth of thunderstorms. Large, strong, and long-lasting tornadoes are spawned by supercells. Once a thunderstorm has formed, given the right ingredients, a tornado can develop. Tornadoes occasionally accompany tropical storms and hurricanes that move over land. Tornadoes are most common to the right and ahead of the path of the storm center as it comes onshore (NOAA 2007).

Tornadoes are categorized in terms of the Fujita Scale, which ranks tornadoes on the basis of wind speed and damage potential and separates them into six categories. A description of each category can be found in the appendix**.** F0 and F1 tornadoes comprise 70% of all tornadoes that occur in the U.S. They usually touch down briefly and cause minor damage. However, forecasting these tornadoes is less reliable than for stronger tornadoes, so less than 50% occur during tornado watches. F2 and F3 tornadoes comprise about 28% of the tornadoes in the U.S. They can cause significant damage, injuries, and deaths. F4 and F5 tornadoes comprise about 2 percent of the tornadoes in the U.S. and cause 70% of the death and destruction. Over 95% of these tornadoes, therefore, occur during tornado watches (National Weather Service).

Waterspouts are weak tornadoes that form over warm water. Waterspouts are most common along the Gulf Coast and southeastern states. Waterspouts occasionally move inland becoming tornadoes causing damage and injuries.

Florida is known as the number two state when it comes to tornado occurrence. Although tornadoes do occur in Florida, Florida tornadoes have a tendency to be somewhat smaller than those that occur in Texas and throughout the Midwest. However, the effects can be just as damaging. Many tornadoes and water spouts have been sighted in Charlotte County, with only a few causing significant damage. Because climate change is expected to bring more intense storm activity, including the types of Florida thunderstorms that frequently spawn tornadoes, tornado activity could be expected to increase with climate change.

On the basis of 40 years of tornado history and more than 100 years of hurricane history, the United States has been divided up into four zones that geographically reflect the number and strength of extreme windstorms. Zone IV in the central United States has experienced the most and strongest tornado activity. Zone III, which includes Florida, has experienced significant tornado activity and includes coastal areas that are susceptible to hurricanes.

Using the “Assessing Your Risk” risk analysis determination worksheet provided in FEMA’s “Taking Shelter from the Storm: Building a Safe Room Inside Your House” publication, the risk Charlotte County faces from high wind events was determined. This information, coupled with Charlotte County’s history of tornado events, was used to ascertain the potential threat tornadoes create in Charlotte County.

The value for each structure was provided by the Charlotte County Property Appraiser’s Office. Content value and functional use value for all structures were determined using tables provided by FEMA. Values were determined for every structure in the county.

There have been a total of 46 tornado/waterspouts officially reported in Charlotte County between January 1, 1950 and September 30, 2004 (NOAA 2007). These events resulted in two deaths and eight injuries. An estimated $13.6 million in property damage is attributed to these events. Following is a brief description of the 14 tornado events that have occurred in Charlotte County since January 1, 2000.

August 1, 2003, Punta Gorda:
One weak F0 tornado was reported to have downed some trees. There were no reported injuries with this incident.

June 10, 2002, Punta Gorda:
The newspaper reported a small tornado at the Charlotte County Speedway, just south of the airport. A tower, fence, billboards, and lightning system were all marred. Approximately $5,000 of damage was associated with this event.

September 14, 2001, Punta Gorda:
A weak F0 tornado sporadically touched down near the intersection of State Road 765 and768, south southeast of Punta Gorda. The tornado continued north where it sporadically touched down and toppled trees, power lines, and a few sheds before it crossed into Desoto county, six miles east northeast of Murdock. Approximately $20,000 of damage was associated with this event.

September 14, 2001, Punta Gorda:
A weak F0 tornado sporadically touched down along a narrow path, west of State Road 765, near the Lee - Charlotte County line in rural southwest Charlotte County, to one mile west-southwest

of Punta Gorda. The weak tornado downed a few large trees, several large branches, rolled a few small sheds, and toppled a few power lines before it lifted and dissipated. Approximately $15,000 of damage was associated with this event.

Identifying assets at risk for tornado damage is virtually impossible since tornadoes are so unpredictable. With that being said, it can be assumed that every structure has an equal chance of exposure to a tornado event. Therefore, all of the assets of Charlotte County should be included. Table 65 lists the information for all the structures in Charlotte County. Table 66 lists the information for all the structures in Punta Gorda. Please see the Asset Overview Section of this report for a detailed discussion of Charlotte County and the city of Punta Gorda's Assets.

ESTIMATED VALUES FOR STRUCTURES LOCATED WITHIN CHARLOTTE COUNTY BY PLANNING ZONE					
Planning Zone	**No. of Buildings**	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
North	45,911	$4,420,168,131	$2,834,196,748	$494,108,252	$7,748,473,131
South	23,380	$2,381,537,412	$1,536,586,646	$419,544,697	$4,337,668,755
West	25,458	$3,102,523,240	$1,720,331,533	$203,090,518	$5,025,945,291
Total	**94,749**	**$9,904,228,783**	**$6,091,114,926**	**$1,116,743,467**	**$17,112,087,176**

Table 65: Estimated Values for Structures Located Within Charlotte County by Planning Zone

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

ESTIMATED VALUES FOR STRUCTURES LOCATED WITHIN PUNTA GORDA					
	No. of Buildings	**Building Value**	**Contents Value**	**Functional Use Value**	**Total Value**
Total	**9,986**	**$1,592,911,840**	**$983,247,882**	**$115,572,002**	**$2,691,731,724**

Table 66: Estimated Values for Structures Located Within Punta Gorda

Source: Charlotte County Property Appraiser Data Analysis by Southwest Florida Regional Planning Council

There are between 1 to 5 recorded tornadoes per 1,000 square miles for Charlotte County. Charlotte County is located in Wind Zone IIII, which includes areas that have experienced significant tornado activity and coastal areas that are susceptible to hurricanes. These two factors place Charlotte County at a high risk for extreme winds. This high risk designation means that a shelter from high winds in each home is the preferred method for protection (FEMA Taking Shelter from the Storm Publication).

As FEMA points out, the nature of tornadoes is to strike at random. While it is known that some places in the country experience tornadoes more frequently and at higher intensities than other places, it is very difficult to predict which portions of Charlotte County have a greater chance of being struck by a tornado than other portions of the county. However, the likelihood and potential severity of tornado events can be determined by looking at the number and severity of tornadic events that have occurred in Charlotte County's history.

Of the 46 recorded tornado/waterspout events in Charlotte County, all of them were tornado events. There is no recorded history of a tornado with a classification greater than F2 striking in Charlotte County. Of the tornado events that have occurred in Charlotte County, none of them were F0 tornadoes and 13% of them were classified as F1 tornadoes. This means that the majority of the tornado events that occur in Charlotte County are events that cause only moderate damage (Table 67 and associated figures).

NUMBER OF TORNADO/WATERSPOUT EVENTS IN CHARLOTTE COUNTY FROM JANUARY 1, 1950 – SEPTEMBER 30, 2004		
Tornado Category	**Classification**	**Number of Events**
F0	Gale Tornado (40 – 72 mph)	37
F1	Moderate Tornado (73 – 112 mph)	6
F2	Significant Tornado (113 – 157 mph)	3
F3	Severe Tornado (158 – 206 mph)	0
F4	Devastating Tornado (207 – 260 mph)	0
F5	Incredible Tornado (261 – 318 mph)	0
Waterspouts	Weak tornado that forms over water	0
Total	--	**46**

Table 67: Number of Tornado/Waterspout Events in Charlotte County from January 1, 1950 – September 30, 2004

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

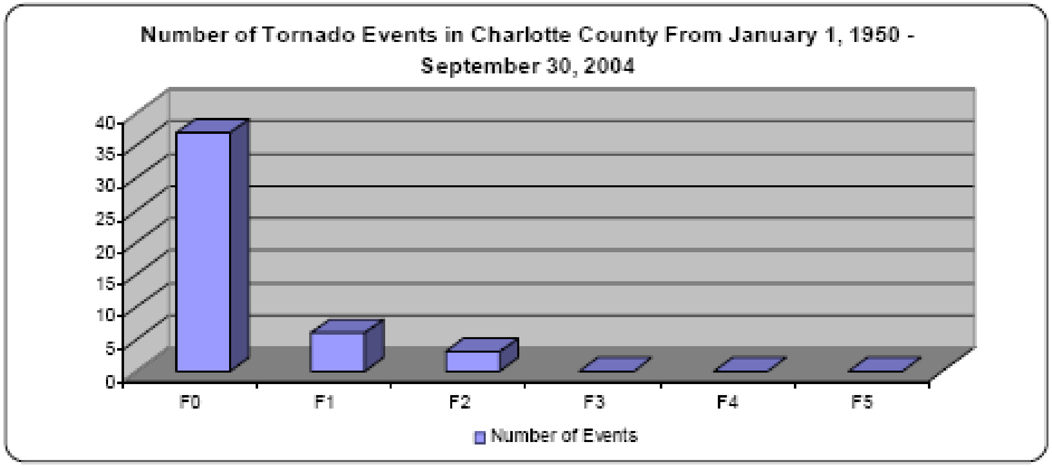

Figure 87: Number of Tornado Events in Charlotte County from January 1, 1950 – September 30, 2004

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy
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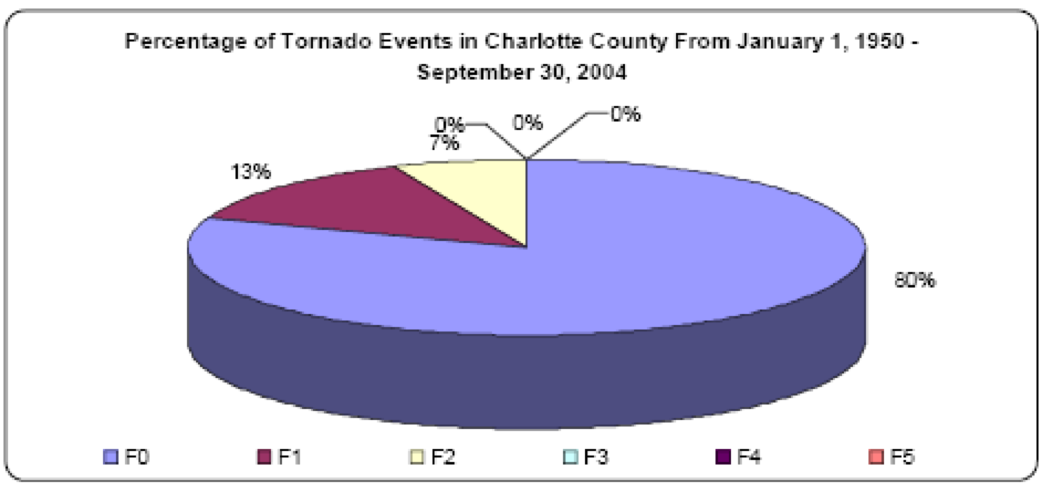


Figure 88: Percentage of Tornado Events in Charlotte County by Category

Source: Charlotte County/City of Punta Gorda Local Mitigation Strategy

Thunderstorms and High Winds

A thunderstorm is formed from a combination of moisture, rapidly rising warm air, and a force capable of lifting air such as a warm or cold front, a sea breeze, or a mountain. All thunderstorms contain lightning. Thunderstorms may occur singly, in clusters, or in lines, thus, it is possible for several thunderstorms to affect one location in the course of a few hours. Some of the most severe weather occurs when a single thunderstorm affects one location for an extended time. Although the average Florida thunderstorm is less than 15 miles in diameter, they can grow vertically to great heights in excess of 10 miles into the upper atmosphere. This stacking effect of concentrated moisture can explain why a Florida thunderstorm directly overhead could produce four or more in less than one hour while a location only a few miles away may receive just a trace (NWS).

Thunderstorms are capable of producing two kinds of damaging winds. The first is tornado winds, which are rotational in character. The second is downburst/gust front winds, which are straight-line in character. In Florida, occurrences of damaging downburst winds outnumber tornado winds by nearly 10 to 1. A typical gusty breeze around 25 mph accompanied by a temperature drop of 10 to 20 degrees in a few minutes of time is the result of the downdraft of a nearby thunderstorm. However, at times, this downdraft becomes more vigorous and can become a downburst. Downburst winds can become severe, reaching speeds in excess of 58 mph and causing considerable damage. In extreme cases, some downburst winds can be as strong as an F2 tornado (NWS).

While thunderstorms and lightning can be found throughout the United States, they are most likely to occur in the central and southern states. Map 3 in Appendix D shows the average number of thunderstorm days each year throughout the U.S., with Florida having the highest incidence (80 to 100+ thunderstorm days per year). It is in this part of the country that warm, moist air from the Gulf of Mexico and Atlantic Ocean is most readily available to fuel thunderstorm development (National Weather Service). Heavy rains (which can cause flash flooding), strong winds, hail, lightning and tornadoes are all products of thunderstorms. Lightning is a major threat. Each year 75 to 100 Americans are hit and killed by lightning,

According to the National Weather Service, damaging wind from thunderstorms is much more common than damage from tornadoes. In fact, many people confuse damage produced by "straight-line" winds attributing it to tornadoes. Wind speeds can reach up to 100 mph (161 km/h) with a damage path extending hundreds of miles. Damaging winds are classified as those winds exceeding 50-60 mph (80-100 km/h) (NWS).

Increased air and water temperatures related to climate change may result in stronger, more frequent thunderstorms. It is one of the paradoxes of climate change that "rains will be rainier and droughts will be droughtier", but the increased intensity of storms will have many consequences. These stronger storms will contribute to more coastal as well as inland erosion along rivers and creeks, urban and suburban erosion from stormwater runoff, and urban and suburban flooding.

According to NOAA (2007), 60 significant thunderstorm/high wind events were recorded in Charlotte County between January 1, 1950 and September 30, 2004. These events resulted in 0 deaths and 8 injuries. An estimated $1.0 million in property damage is attributed to these events. Following is a brief description of the 8 thunderstorm/high wind events that have recorded by NOAA (2207) in Charlotte County since January 1, 2000.

August 1, 2000, Punta Gorda:
The Charlotte County Sheriff's Department reported that thunderstorm winds downed several large trees, branches, and power lines near the intersection of U.S. Highway 17 and Cleveland Drive in Punta Gorda. Approximately $10,000 in property damage was associated with this event.

August 6, 2000, Countywide:
The Charlotte County Emergency Management reported that thunderstorm winds downed several large trees, downed numerous large branches, and power lines across the county. Damage estimates associated with this storm reached $100,000.

June 5, 2001, Englewood to Punta Gorda:
Florida Power & Light utility and the public reported that a few large trees, branches and powers lines were downed by thunderstorm winds from Englewood to Punta Gorda. Damage estimates associated with this storm reached $20,000.

June 16, 2001, Port Charlotte:
Charlotte County Emergency Management reported that thunderstorm winds downed a few large trees, large branches and power lines in Port Charlotte. Damage estimates associated with this storm reached $5,000.

July 10, 2001, Punta Gorda:
Thunderstorm winds caused minor damage to a few homes and downed several large branches on Riverside Drive in the River Forrest mobile home park in Punta Gorda. Damage estimates associated with this storm reached $10,000.

March 2, 2002, Countywide:
A departing high pressure system combined with an approaching cold front to produce strong and gusty south winds across the central coastal counties from late morning through the afternoon. Sustained winds ranged from 25 to 30 mph, with a period of gusts in excess of 40mph between noon and 2 pm. The winds enhanced a small brush fire along highway 41 in Charlotte County. Property damage was reported at $7,000 for this event.

June 28, 2003, Punta Gorda:
Thunderstorm winds damaged a pool cage and part of a roof. This damage was estimated at$3,000.

April 12, 2004, Regional:

An unusually strong pressure gradient developed between small scale high and low pressure systems across central and southern Florida. The high pressure area was caused by a cold pool of air formed from early morning thunderstorms. The low, called a "wake low", formed behind the cold pool. A 41 knot wind gust was recorded at the Charlotte County Airport at Punta Gorda. Damage estimates from this event in the region reached $55,000.

Table 68 shows the number of structures and their value for each expected damage classification of the TAOS wind zones. With a Category 1 wind event, all of Charlotte County's structures are at risk for light damage. A Category 2 event places 43.5% of the structures at risk for moderate damage. A Category 3 event places 97.1% of the structures at risk for moderate damage and the remainder at risk for heavy damage. A Category 4 wind event creates risk zones of moderate (1.0%), heavy damage risk (45.1%), and severe damage risk (53.9%). A Category 5 wind event creates risk zones of heavy damage (0.1%) and severe damage (18.5%), and destroyed risk zone (81.3%).

VALUATIONS FOR CHARLOTTE COUNTY STRUCTURES BASED ON TAOS WIND ZONES						
		Category 1	**Category 2**	**Category 3**	**Category 4**	**Category 5**
Light Damage (<10%)	**# of Bldgs**	83,153	46,961			
	Value	$7,293,936,640	$4,331,565,056			
Moderate Damage (10%-30%)	**# of Bldgs**		36,192	80,783	744	
	Value		$2,962,351,616	$7,042,878,976	$124,992,096	
Heavy Damage (30% - 50%)	**# of Bldgs**			2,370	37,510	102
	Value			$251,059,136	$3,258,510,336	$19,132684
Severe Damage (50%-80%	**# of Bldgs**				44,869	15,424
	Value				$3,910,423,808	$1,358,951,168
Destroyed (>80%)	**# of Bldgs**					67,627
	Value					$5,915,866,624

Table 68: Valuations for Charlotte County Structures Based on Taos Wind Zones

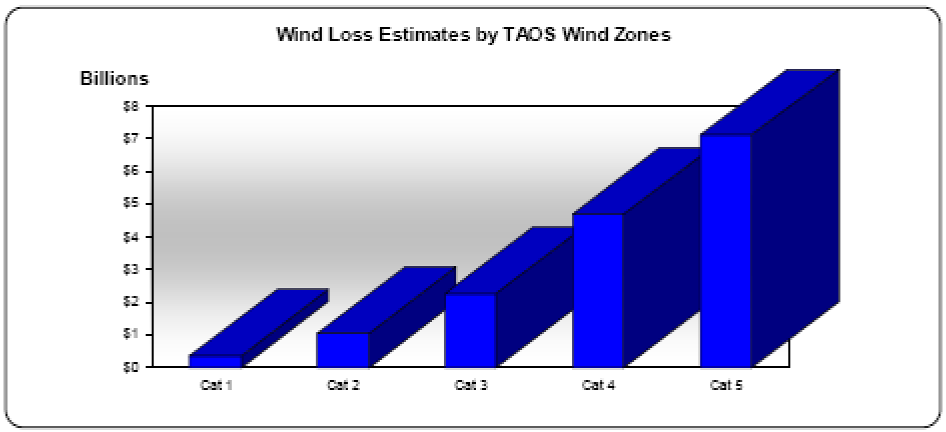
Source: TAOS MEMPHIS -- Mapping for Emergency Management, Parallel Hazard Information System

The City of Punta Gorda is located in Wind Zone IIII, which includes areas that have experienced significant tornado activity and coastal areas that are susceptible to hurricanes. The City of Punta Gorda is considered a high risk for extreme winds because of the potential for hurricanes. This high risk designation means that a shelter from high winds in each home is the preferred method for protection (FEMA Taking Shelter from the Storm Publication).Table 69 and the associated figure express the loss estimations for Charlotte County based on the wind categories. For obvious reasons, the amount of potential loss increases with each higher wind category. Similar to storm surge events, as the category levels increase, the area that faces the risk/damage increases. A Category 4 wind event has the potential of damaging structures in the Category 4 wind zone as well as structures in lesser wind zones.

WIND LOSS ESTIMATES FOR CHARLOTTE COUNTY IN 2005 $						
Total Structures	Total Exposure	Category 1 Winds	Category 2 Winds	Category 3 Winds	Category 4 Winds	Category 5 Winds
83,153	7,293,936,640	376,828,416	1,060,707,456	2,293,352,192	4,680,625,664	7,110,317,568

Table 69: Wind Loss Estimates For Charlotte County in 2005 $

Source: TAOS MEMPHIS -- Mapping for Emergency Management, Parallel Hazard Information System



Potential future risks are hard to determine since they can impact all parts of the county. Damage from wind events relating to coastal storms should decrease the farther from the coast development moves since it would require a stronger event to reach the parcels further inland. However, wind damage events from thunderstorms can and do occur everywhere throughout the county.

Winter Storms and Freezes

Although Florida, and especially southwest Florida, escapes most of the severe winter weather experienced by much of the rest of the U.S., winter storms do occur. Heavy storm systems resulting from cold fronts can bring conditions similar to the severe thunderstorms of the summer, with high sustained winds, gusting winds and rain that can result in flooding. The high winds, which, in these storms come from the northwest, tend to blow tidal waters toward shore, creating very high high tides and damaging waves. Additionally, southwest Florida experiences frosts and/or freezes nearly yearly, with sometimes devastating effects on agricultural crops.

Charlotte County can expect a moderate freeze at least once every two years. It is estimated that a severe freeze that can potentially destroy all crops can be expected once every 15 – 20 years on average. Freezes normally occur at night, and are more likely and severe in low-lying and inland areas. Strawberry and orange crops are frequently affected by frosts and freezes, with significant economic consequences for farmers and for consumers as well.

Climate change may have a beneficial effect on winter storms, reducing their frequency and severity and pushing the freeze line further north to allow more cultivation of certain crops that might be damaged in the cold. Conversely, crops that require a "cold snap" may be less successful in southwest Florida than in the past.

During the harsh winter of 1989-1990, 26 Floridians died of hypothermia. Because of normally mild temperatures, Florida homes often lack adequate heating and insulation and the Florida outdoor lifestyle, leads to danger for those not prepared. In addition to the actual temperature, when the wind blows, a wind chill (the temperature that it feels like) is experienced on exposed skin. When freezing temperatures, or low wind chills are expected, the National Weather Service will issue warnings or advisories.

A freeze is a condition that exists when, over a widespread area, the surface temperature of the air remains below freezing (32ºF or 0ºC) for a sufficient time to constitute the characteristic feature of the weather. A freeze is a term used for the condition when vegetation is injured by these low air temperatures, regardless if frost is deposited. Frost is cover of ice crystals produced by deposition of atmospheric water directly on a surface at or below freezing.

While winter storms and freezes do not cause a direct impact on structures that can be measured in terms of numbers of buildings or total value, it can impact the county. The risk analysis for drought focuses on the agricultural elements of the County.

According to NOAA (2007), eight winter storm/freeze events were reported in Charlotte County since 2000. A description of these nine events follows.

January 23 - 25, 2003, Charlotte County:
Arctic high pressure settled over the southeastern United States which maintained the clear and cold weather across the Florida peninsula. Northeast winds of 10 to 15 mph produced wind chills down to 25 degrees from Tampa to Lakeland to Fort Myers. Citrus crops fared well during the freeze but strawberries took an estimated $4.5 million dollar loss and tropical fish an estimated $4 million dollar loss.

January 9, 2002, Charlotte County:
Polar high pressure settled over the Florida peninsula early on the 9th, allowing for the most widespread freeze event of the winter. Temperatures fell into the low and mid 20s north of Tampa Bay, and in the upper 20s to lower 30s elsewhere away from large bodies of water, extending south to Charlotte County. This freeze featured a heavy frost. The frost caused additional thinning of excess foliage, but was also a good thing for local crop farmers, who were able to use insulating methods to minimize damage.

January 10, 2001, Charlotte County:
Freezing temperatures were observed over most of West Central and parts of Southwest Florida during the pre-dawn through mid-morning hours of January 10th, 2001. In northern Charlotte County, low temperatures dropped into the upper 20s to lower 30s for durations below freezing of up to three hours. Approximately $4.0 million in crop damages are

associated with this event.

January 5, 2001, Charlotte County:
Widespread freezing temperatures were observed across most of West Central and Southwest Florida during the pre-dawn and mid-morning hours of January 5th, 2001. Low temperatures ranged from the middle 20s inland to the lower 30s along the immediate coast with durations below freezing for up to six hours. In Charlotte County, the freeze caused nearly 250thousand dollars in damage to the pepper crop.

January 1, 2001, Charlotte County:
Low temperatures dropped into the upper 20s and lower 30s and remained below freezing for durations of five to seven hours. In Charlotte County, the freeze caused at least 100 thousand dollars damage to the pepper crop.

December 30, 2000, Charlotte County:
In eastern Charlotte County, temperatures dropped into the lower 30s and remained below freezing for periods of two to five hours. The freeze caused an estimated 25 to 50 percent damage to tomato, pepper and squash crops in Lee and Charlotte Counties.

December 30, 2000, Charlotte County:
Low temperatures dropped into the upper 20s to lower 30s over Polk, Hardee, De Soto, Manatee, Sarasota, Hillsborough and eastern Charlotte counties and stayed below freezing for durations of five to seven hours. No damage was reported.

January 26, 2000, Charlotte County:
Temperatures dropped into the upper 20s and lower 30s over Polk, eastern Hillsborough, DeSoto, Hardee, Highlands, eastern Manatee, eastern Sarasota, and eastern Charlotte counties and stayed below freezing from two to six hours. No damage was reported.

The assets most at risk to freezes in Charlotte County include the agricultural interests of the county. The 1995-1996 growing season yielded 5,252,000 million boxes of citrus fruit. This fruit came from 2,695,200 citrus trees on 23,107 acres (11% of total agricultural acreage) of land. There are also 4,000 acres in vegetables (2% of agricultural acreage) consisting of watermelon, potatoes, eggplant, tomatoes, squash, peppers, cabbage and cucumbers. There are 174,000 acres of cattle grazing pastures (87% of agricultural acreage) and 216 farms making up 227,202 acres. (August 1998) (Charlotte Community CCP profile).

Charlotte County can expect a moderate freeze at least once every two years. It is estimated that a severe freeze that can destroy all crops can be expected once every 15 – 20 years on average. While the greatest economic impact of freezes is to agricultural production, freezes may also necessitate the opening of local shelters and the mobilization of personnel and resources for the protection of homeless persons or residents of sub-standard dwellings.

All crops are susceptible to freeze damage. The primary winter growing season is November through March. As the population increases, the demand placed on farmers becomes higher. Due to this larger demand, we can expect to have higher financial losses in the future.

Synergistic Risks

Many other stresses and disturbances are also affecting the resources affected by climate change**.** For many of the changes documented in this assessment, there are multiple environmental drivers - land use change, nitrogen cycle change, point and non-point source pollution, wildfires, invasive species, and others - that are also changing. Atmospheric deposition of biologically available nitrogen compounds continues to be an important issue, along with persistent, chronic levels of surface water nutrient pollution in many parts of southwest Florida. It is very likely that these additional atmospheric and water quality effects cause biological and ecological changes that interact with changes in the physical climate system. In addition, land cover and land use patterns are changing, e.g., the increasing fragmentation of upland forest and interior wetlands as exurban development sprawls to previously undeveloped areas, further raising fire risk and compounding the effects of summer droughts, pests, and warmer winters. There are several dramatic examples of the spread of invasive species with land clearing and suburbanization throughout the region. It is likely that the spread of these invasive species, which often change ecosystem processes, will exacerbate the risks from climate change. For example, in some cases invasive exotic plant species increase fire risk and decrease forage quality for native wildlife (Backlund et al. 2008).

Ecosystem Services Risks

Climate change impacts on ecosystems will affect the services that ecosystems provide, such as cleaning water and removing carbon from the atmosphere, but we do not yet possess sufficient understanding to project the timing, magnitude, and consequences of many of these effects. One of the main reasons for needing to understand changes in ecosystems is the need to understand the consequences of those changes for the delivery of services that our society values. Many analyses of the impacts of climate change on individual species and ecosystems have been published in the scientific literature, but there is not yet adequate integrated analysis of how climate change could affect ecosystem services. A comprehensive understanding of the way such services might be affected by climate change will only be possible through quantification of anticipated alteration in ecosystem function and productivity. As described by the Millennium Ecosystem Assessment, some products of ecosystems, such as food and fiber, are priced and traded in markets. Others, such as carbon sequestration capacity, are only beginning to be understood and traded in markets. Still others, such as the regulation of water quality and quantity, and the maintenance of soil fertility, are not priced or traded, but are valuable nonetheless. Yet, although these points are recognized and accepted in the scientific literature and increasingly among decision makers, there is no analysis specifically devoted to understanding changes in ecosystem services in southwest Florida from climate change and associated stresses. It is possible to make some generalizations from the existing literature on the physical changes in ecosystems, but interpreting what this means for services provided by ecosystems is very challenging and can only be done for a limited number of cases. This is a significant gap in our knowledge base (Backlund 2008). The Southwest Florida Regional Planning Council has proposed to undertake such a study with the CHNEP but this has not been funded.

While the exact pace of sea level rise is not precisely quantifiable, it is virtually certain that each amount of sea level rise will occur at some point if greenhouse gas emissions continue unchecked. In other words, the question is not whether Florida will need to cope with significant sea level rise, but rather when it will need to do so. Stanton and Ackerman (2007) state that arguments against strong action to combat climate change often implicitly assume that inaction would be cost-free. The overwhelming scientific consensus now holds that this assumption is incorrect, and that the more greenhouse gases that are released, the worse the climate change consequences will be. The probable risks of disastrous climate impacts are high and waiting for more information is likely to mean waiting until it is too late to protect the natural and human resources of southwest Florida and the CHNEP study area.

Insurance

Insurance companies are designed to operate assuming predictable risks. Variable risk is a significant danger to their profitable operation. Insurance companies make their profit based upon their ability to accurately predict the risks associated with the objects or persons they are insuring and by obtaining a fee or premium that is greater than the amount that is expended in claims for damages accrued.

The Florida insurance industry has made mistakes at times by setting premiums too low to cover claims, and at other times charging more than their customers can afford. Under the best case scenarios, hurricane damages will continue to vary widely from year to year, and the industry will need to take a long-term perspective to avoid bouncing between very low and very high rates.

Under the median case climate change scenarios, about the same number of hurricanes will occur but more of them will be Category 4 or 5 statuses, and damages will be higher on average and more variable from year to year. Worst case scenarios include more severe storms with a higher frequency of storm events. With greater uncertainty (higher variable risk) the insurance companies will be more likely err in either direction, either under- or over- collecting premiums. It will become harder for homeowners, businesses, and governments to pay the increased average cost of insurance. Greater and greater public subsidies will be required as private insurers raise their rates, or leave the market. Currently, many of the largest national insurance firms in the country have left or are planning to leave the riskiest parts of the Florida market after the strong hurricanes of recent years. Smaller, state-based insurance firms, an increasingly important part of the industry, do not have the resources to provide adequate coverage for hurricane damages on their own. As a result, the state and federal governments have been drawn into subsidizing Florida property insurance. Florida's property insurance industry is second only to California's in value of premiums sold (Florida Office of Insurance Regulation 2006).

In Florida, property insurance is provided by leading private companies such as State Farm and Allstate, as well as smaller companies active only in Florida; by a state-created not-for-profit insurer called Citizens' Property Insurance Corporation; and by the federal government's National Flood Insurance Program (NFIP). Homeowners living on the coast often have one policy from a private insurer covering general threats such as theft or fire, another from Citizens' to cover wind risk from hurricanes, and a third from NFIP for flood damage. There is a

$250,000 limit to NFIP, so either additional private coverage is obtained or the property owner suffers exposure to uninsured damages.

Before Hurricane Andrew hit in 1992, many property insurers, eager to increase their market shares, were charging rates that proved too low to pay for the claims filed after the storm. These low rates made high risk areas look misleadingly attractive and affordable, encouraging investment in real estate. As a result of Andrew, Florida insurers faced $15.5 billion in claims, and 12 insurance companies went bankrupt (Florida Office of Insurance Regulation 2006; Scott 2007). Premiums went up an average of 82 percent across the state (Wilson 1997). For the companies that remained in the state's insurance industry, rates increased enough to restore financial health. From 1996 to 2006, the loss ratio for Florida insurers was less than 70 percent of all premiums collected, meaning that insurers paid less than seventy cents in claims out of every dollar of premiums paid by consumers. Florida's loss ratio was only two percentage points higher than the average for all insurers nationwide (Florida Office of Insurance Regulation 2007a; Hundley 2007). Insurance companies were somewhat better prepared for the massive storms of 2004 and 2005. One large Florida-based insurer, Poe Financial Group, was bankrupted, and many other companies dropped their policies in vulnerable parts of Florida to limit their exposure to future storms. Rate increases after these storms roughly doubled the average premium charged across the state, according to a spokesperson for the Florida Office of Insurance Regulation (Kees 2007). These increases brought the loss ratio down to 45 percent in 2006, allowing insurers to rapidly recoup their losses from 2004 and 2005 (Florida Office of Insurance Regulation 2007b). But despite the higher rates, several of the larger insurance companies continued to move out of the Florida market: the two largest insurers, State Farm Group and Allstate Insurance Group, reduced their share of the market from 50.9 percent in 1992 to 29.9 percent in 2005 (Grace and Klein 2006). Although a few large national firms remain in Florida, 12 of the state's top 15 insurers sell only Florida residential property insurance (Florida Office of Insurance Regulation 2006).

The state government plays an active role in Florida's insurance markets, and has expanded its involvement in response to recent hurricane activity. One key role of the state is to regulate insurers' activities to prevent sudden abandonment of policyholders or unfair premium hikes. All rate increases are subject to public hearings and require regulatory approval; companies wishing to cancel policies must provide 90 days' notice and some assurance that their withdrawal is "not hazardous to policyholders or the public" (Florida State Legislature 2006; Kees 2007). Companies have pursued a strategy of dropping the policyholders with the riskiest properties, which allows them to reduce their risk and improve their expected level of profitability without requiring state approval for rate increases (Grace and Klein 2006; Florida Office of Insurance Regulation 2007b). The state has also played an ever-growing role as an insurer of last resort for homeowners who cannot find private insurance. Prior to Hurricane Andrew, the state acted as an insurer of last resort through the Florida Windstorm Underwriting Association (FWUA), but only to a limited set of customers. When thousands of customers were dropped after Andrew, a new insurer of last resort was set up called the Residential Property and Casualty Joint Underwriting Association (JUA), which grew to 936,000 policies by September of 1996, before shrinking again as new private insurers moved into the state (Wilson 1997). The FWUA and JUA merged in 2002 to become Citizens' Property Insurance Corporation, partly in response to private insurers' demands that the government assume some of their wind risk. After the 2004 and 2005 storms, many more customers were dropped by private insurers and picked up by Citizens', raising the number of its policyholders to over 1.3 million. In June 2007, a new bill was passed which froze Citizens' rates until January 1, 2009 and allowed policyholders of private companies to switch to Citizens if their private insurer charged 15 percent more than the state's rates. With these changes, the number of properties insured by Citizens was projected to reach 2 million by the end of 2007 (Liberto 2007).

The state has also increasingly taken on the role of providing reinsurance for private insurance companies. After the wave of bankruptcies following Hurricane Andrew, the state government set up the Florida Hurricane Catastrophe Fund or CAT Fund for short, to provide a limited level of reinsurance to private insurers, which would cover a portion of their claims in the event of a hurricane. The rates charged were below private market rates for reinsurance, especially after the storms of 2005 nearly doubled private reinsurance rates (Florida Office of Insurance Regulation 2007a). In January 2007, the state injected more money into the CAT fund, expanding it from $16 billion to $28 billion, and required private insurers to purchase more reinsurance through them, and to pass on the savings to customers through lower rates (Florida Office of Insurance Regulation 2007a). The projected savings, however, did not materialize.

One impact of this expanded government role in insurance markets is that the state's potential liability in the event of a large hurricane has increased. In 2005, the state had to bail out Citizens', which had a $1.4 billion deficit. This was done through a combination of a charge to all insurance companies, which is passed on to policyholders and a payment from the state budget of $750 million (Kees 2007). With the expansion of Citizens' and the increase in subsidized reinsurance, the state could be left with an even larger bill in the event of another big storm.

All these changes have increased the amount that the state government effectively subsidizes property insurance rates. Citizens' rates may not appear artificially low to policyholders, but according to a spokesman for the organization, the rates necessary for the premiums of homeowners in high risk coastal areas to cover their own claims would be entirely prohibitive (Scott 2007). In addition, the federal government provides flood insurance through NFIP that is often pegged at rates too low to break even with claims. The nationwide effects of Hurricane Katrina left NFIP bankrupted 10 times over by the $16 billion it paid in flood claims.

Stanton and Ackerman (2007) argue that if a bad outcome is a real risk, and run-away greenhouse gas emissions lead to a very bad outcome indeed, isn't it worth buying insurance against it? People buy fire insurance for their homes, even though any one family is statistically unlikely to have a fire next year. Young adults often buy life insurance out of concern for their families, even though they are very unlikely to die in the next year. One idea to mitigate the hazards of variable risks has been proposed for North Carolina (Holman 2008). The idea is to legally establish a Climate Change Adaptation and Hazard Mitigation Fund:

1) to acquire either conservation easements or fee simple properties in floodplains and other high risk areas,

2) to protect and restore wetlands and floodplains,

3) to restore oyster reefs, and

4) to help local and state agencies plan for and adapt to global climate change and other natural hazards to protect the public, prevent property damage and lower risks before sea level rises and storms occur.

This would be funded with appropriations from the federal General Fund, a surcharge on property insurance, a surcharge on high risk properties, and/or fee for filling or building in high risk areas such as 100-year floodplains. Insurance costs would rise or insurance would become unavailable after storms. U.S. Senate Bill 2191, the Lieberman-Warner Climate Security Act of 2008 provides funds from the auction of some carbon allowances to states for adaptation. Lieberman-Warner will probably not pass the US Senate or the Congress in 2008, but will be reintroduced in the 2009 session.

Some activities recorded in the literature that can address variable risks include (Bollman 2007; Cerulean 2008; Titus 1998; USCCSP 2008; NOAA 2008; USEPA CRE 2008; Volk 2008):

- allowing inland migration of coast/wetlands;
- beach nourishment;
- creating regional plans for conservation;
- establishing funds for purchase of lands;
- establishing/expanding land purchase programs;
- consideration of climate impacts and positive environmental services when considering acquisition;
- use of CLIP, FNAI, Cooperative Conservation Blueprint, etc. to prioritize land purchases;
- growth management and land use planning that results in a connected, ecologically functional network of conservation areas buffered by land uses consistent with land management needs;
- identifying important biogeochemical zones, ecologically significant areas, wildlife corridors, and critical habitats;
- preserving structural complexity in tidal marshes, estuaries, etc.;
- land exchange/purchase;
- retreat from and abandonment of inhabited areas;
- removal of canal walls in areas of inundation;
- removal or reconfiguration of hazardous building elements and utilities;
- removal of structures already inundated;
- reuse of foundations;
- armoring, elevating land surfaces;
- establishing rolling easements;
- Incorporating LID principles into development;
- planning for regional relocation and displacement;
- considering sea level rise impacts to the Bahamas and the Keys and the immigration and migration effects for Florida;
- establishing early warning sites and baseline data;

- expanding planning horizons of land use planning to incorporate longer-range climate predictions;
- consideration of climate change in long-term regional planning
- improving risk modeling methods;
- explicitly indication in local master plans of which areas will retain natural shorelines;
- recognizing that values might change as to what constitutes “wealth” and how that relates to the economy.
- expecting there will be less food, both to import and export;
- planning for agricultural impacts affecting local food providers as well as rising transportation costs for food grown outside Florida; and
- promotion of local food providers and community gardens.

Insurance (Variable Risk) adaptations that were identified in the first public workshop included the following:

- "Call out" most vulnerable properties
- No rebuild laws in vulnerable areas
- Socialize insurance
- Stop providing government subsidized insurance in high-risk areas
- Retrofit program for existing structures
- Review, update and improve building and zoning standards and codes
- Harden homes
- Control costs so that homeowners are not taken advantage of
- Stronger enforceable laws re: insurance coverage and faster remediation of claims
- Link sale of other forms of insurance to offering property insurance as a requirement of doing business in Florida.
- Insurance coverage should reflect risk vs. actual loss
- Improve risk modeling methods
- Raise insurance prices
- Make insurance unavailable after storms
- Flood insurance rate maps should take climate change into account
- Require structures to meet National Flood Insurance Program requirements or local flood ordinance requirements, whichever are stricter
- Prohibit federal subsidies and flood insurance
- Climate policy integration where fed, state & local governments work collaboratively
- Adapt protections to changing climates & conditions
- Establish climate archives for baseline & tracking data
- Heat health planning
- Redefine flood hazard zones

At the second workshop none of the suggested variable risk adaptations were utilized in the City-Wide or Place-Based adaptations placement; so no level of consensus or prioritization was obtained. Several of the adaptations listed above associated with improvements in building design, building standards and land use planning were also identified within the Economy and unchecked growth vulnerabilities and are addressed there.

Three of the primary recommended adaptations including explicitly indicating in the comprehensive plan which areas will retain natural shorelines; constraining locations for certain high risk infrastructure and promotion of green building alternatives through education, taxing incentives, green lending will also address and reduce variable risks from climate change effects.

How the plan affects existing management goals

This climate change adaption plan is designed to utilize the prioritized proposals with the highest level of consensus as the tools to first implement adaptation to the identified vulnerabilities experienced by the city of Punta Gorda. To a large extent the plan with employee actions that provide positive benefits for the City irrespective of climate change issues in the areas of habitat protection, water quality, water management, economy, standard of living education, drought protections and reduction of natural hazard risks. The coordination of benefits both in the near term and for long term planning are a happy synergy for the City in that its investments will be beneficial irrespective of the uncertain further predictions of the rate, severity and extent of the identified vulnerabilities. All of the adaptations can be easily incorporated in to the ongoing progress that the City of Punta Gorda has been making as it has recovered and redesigned for a future improved City plan envisioned in the 2025 Comprehensive Plan.

The City of Punta Gorda has already undertaken a variety of affirmation adaptation actions that will assist in reducing the impacts form climate change and increasing resiliency to climate change effects. These include elevation of structure and improvements of drainage systems as part of the City's recovery from the impacts of Hurricane Charley; relocation of the public works facility to a location of lower hazard from natural disasters and coastal flooding, adoption of a Transfer of Development Rights program to protect historical and natural resource areas, and a completed Local Mitigation Strategy for natural disasters.

The 2010 City of Punta Gorda Strategic Plan Focus Area Objectives includes several affirmative adaptations that will address some of the issues of Avoidance, Minimization, Mitigation and Adaptation for climate change identified in this study. These include:

- Enhance energy independence of city-owned property, including more use of solar and other forms of power to eventually take the city "off the grid".

- Enhance green initiatives to include adoption of green building ordinance modeled after Charlotte County, participation in Green Futures Expo & Energy Options Conference and publicizing programs in City departments.

- Achieve progress of annexations along US 41 corridor, Jones Loop Rd. (pending successful voluntary annexation of the Great Loop), US 17 corridor and other areas as deemed appropriate during the year.

- Undertake through design and/or completion of ongoing infrastructure improvements including the Public Works/Utilities Cooper Street Campus; Downtown Flooding Improvements; San Rocco/Madrid Blvd. Drainage Improvements; Carmalita Street, West of Cooper Street, Drainage & Streetscape Improvements; Multi Use Recreational Trail

Phase 1 (Monaco to Aqui Esta); Multi Use Recreational Trail Phase 2 (Aqui Esta to Airport and Monaco to Taylor) – Design; Hendrickson Dam Spillway Replacement; East Side Wastewater Improvements; Reverse Osmosis Plant - Design

- Develop a bike path program that meets the requirements of Bicycle Friendly Community and prepare an application for the City to apply for that designation.

- Utilize pavers in parking areas.

- Consider expanding wastewater treatment capacity by having residential lawns, irrigated parks, golf courses etc. served by gray water.*)*

The adaptation implementations for seagrass protection and restoration; Florida Friendly 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 and drought preparedness planning can easily be incorporated by education programs, ordinance, or comprehensive plan additions/amendments in the normal course of City plan reviews and updates. The identified adaptations do not constitute a cultural change for the City but rather a continuation of a general progressive approach undertaken by the City to improve and enhance its resource base and standard of living.

Monitoring and evaluation of results

The following discussion of monitoring and the monitoring plan for this adaptation plan follow the standards and suggestion outline in Perez and Yohe (2004) for Monitoring **Continuing the Adaptation Process.** The purpose of monitoring is to keep track of progress in the implementation of an adaptation strategy and its various components in relation to the targets. This enables management to improve operational plans and to take timely corrective action in the case of shortfalls and constraints. As part of the management information system, monitoring is an integral part of the function of management, and should be conducted by those responsible for the project/program implementation. The resulting data, in whatever form, must be archived so that they can be readily accessed for internal or external evaluation. Monitoring should be carried out during implementation, as well as during the lifetime of the project. Both the selection of indicators for monitoring and the frequency of monitoring can evolve over time as the adaptation process matures; this evolution may continue as the adaptation process is incorporated into a country's overall policy mix. The most important point is that monitoring continues.

Monitoring and Evaluation (M&E) must go hand-in-hand. In the context of adaptation, evaluation is a process for systematically and objectively determining the relevance, efficiency, effectiveness and impact of an adaptation strategy in light of its objectives. Whereas monitoring is carried out only during implementation, evaluation is carried out during implementation (ongoing evaluation), at the completion of a project (final evaluation) or some years after completion (post evaluation). Much of the evaluation activity can be based on self-assessment of the responsible operational staff, but external evaluation is also a common practice. Formal M&E processes should be practical. In principle, a network of concerned institutions and stakeholders (data suppliers and users) could be established. Increasingly, the trend in this field is towards participatory M&E, which includes the most vulnerable group(s) in decision-making. The concept of a central M&E unit to co-ordinate all of the functions could be established within, or under the jurisdiction of, a strategic government agency (e.g., Public Works, Planning or Environment).While institutional barriers can impede M&E, these barriers can be assessed during project design and addressed during its implementation. Comprehensive adaptation strategies consist of policies, measures and projects. Appropriate M&E processes may be quite different for each strategic level. Furthermore, gaps in the structure and design of the strategy can impede progress toward long-term goals of sustainability. Policies that exist without tangible measures are paper tigers; conversely, projects that exist outside of a clear policy context can be redundant or contradictory. Monitoring for gaps of this sort can pay enormous dividends.

Monitoring alone is useless if the raw data and basic information it generates are not analyzed in the evaluation process. M&E processes depend on carefully developed sets of indicators by which the performance of adaptation activities can be assessed. These indicators provide the basis for before-and-after analyses and describe the effects (positive and negative) of project interventions – anticipated and unanticipated, intended and unintended. Indicators are quantitative or qualitative measures that can be used to describe existing situations and measure changes or trends over time. Performance indicators developed by the CHNEP will be criteria for success. In the context of the logical framework approach, at least one indicator should be defined as a performance standard for each adaptation to be reached in order to achieve an objective (GEF 2002). Indicators should include both outputs and outcomes (impacts), with explicit statements of how the indicator demonstrates that the project goal has been met, and what the functional relationship is between a change in the indicator and the outcome of a project.

Exploring the success or failure of the adaptation process depends on more than just the success or failure of implemented projects. More critically, it depends upon the concept of learning by doing. This approach enables users to undertake midcourse corrections in implemented adaptations, so that they meet their objectives more efficiently; and improve their understanding of the determinants of adaptive capacity so that capacity development activities can be more successful from the start. To accomplish these tasks, two earlier insights can be revisited.

First, establish the necessary criteria for evaluation. Second, the M&E process will eventually have historical evidence of what actually happened over a period of time; this can be compared to the conjectural characterization of future conditions. To learn from mistakes and successes, it is important to combine these insights to:
 compare actual experience with the initial characterization, and with the criteria; and
 construct a revised adaptation baseline that describes how the system would have performed in the absence of the implemented adaptation. This revised adaptation baseline will differ from the adaptation baseline. It will be more accurate, based on actual experience and on the evolution of the structural, economic, and political context. This can be critical, since it will suggest whether an adaptation to climate is “swimming uphill” against some non-climatic impediment or “being carried along” by other reforms. Thus, an evaluation could improve the team’s forecasting capability. A review of the criteria used for making the original implementation decision will yield insights about needed changes, and will improve the next adaptation decision.

Participatory processes in support of adaptation can add value and enhance feasibility. Engaging as many stakeholders as possible can democratize the overall process of adapting to climate change, including variability. It follows that participatory M&E can be productive, but care must be taken to note the potential pitfalls. Stakeholder engagement can uncover obstacles, including a healthy degree of initial skepticism on the part of the public about the information provided by the government.

In the context of adaptation, mainstreaming refers to the integration of adaptation objectives, strategies, policies, measures or operations such that they become part of the City’s development policies, processes and budgets at all levels and stages. The idea is to make the adaptation process a critical component of existing development plans. Likely entry points for mainstreaming climate adaptation include: environmental management plans (particularly when they incorporate environmental impact assessments), conservation strategies, disaster preparedness and/or management plans and sustainable development plans for specific sectors (e.g., agriculture, forestry, transportation, fisheries, etc.)Moreover, working through the determinants of adaptive capacity makes it clear that promoting capacity can complement or even advance the broader objectives of improved economics and sustainable development. The issue is to recognize an opportunity for mainstreaming and to use it.

The ability of adaptation to ameliorate climate impacts is fundamentally path dependent and site specific. As a result, an adaptation that works well in one place and time may or may not work in a different place or time. Whether it does or does not is essentially an empirical question, and M&E can inform the framing of such a question. This diversity should not, however, discourage mainstreaming.

While evaluation can occur at any stage in the adaptation process, the final evaluation may require additional funding following the project's completion. To enable the lessons learned to feed back into and inform subsequent actions, it is essential that the necessary resources (e.g., human, financial, technical) be factored in during the project design phase. This step is recommended, but is often neglected.

For successful continuation of the adaptation process, isolated evaluations are not sufficient. The notion of opportunity cost, expressed as monetary units, is really an observation that any action occurs at the expense of another. These costs are diminished if adaptations complement one another either directly or by promoting synergies across the underlying determinants of adaptive capacity; they are exaggerated when adaptations contradict and/or create obstacles for each other or with other developmental objectives (maladaptation).Careful evaluation of any adaptation will therefore contemplate the interaction of a suite of adaptations in the context of a more general pursuit of social and economic objectives. A review and evaluation should repeat the analysis – following all the Components in the APF – incorporating new and/or updated information from the intervening years. Care must be taken, though, not to apply insights derived from one location to another location, without careful review of the underlying analysis. Adaptation is, by its nature, site specific and path-dependent.

Current thinking assumes that stand-alone adaptations are neither desirable nor cost-effective. In developing countries, one group of stakeholders responsible for facilitating adaptation includes the international development agencies and donor governments. Like other environmental issues, this group has collectively agreed that climate change adaptation would be cost-effective if mainstreamed into the development processes. As the term "mainstreaming" implies the approach places environment squarely in the centre of development poverty reduction. This approach is warranted because global environmental issues remain marginalized in all but a few countries – even ten years after Rio – leading to conclusion that rather than introducing additional environmental plans at this stage, governments should renew effort on implementing those plans. Note that mainstreaming is not unique to adaptation; it is a policy principle for introducing all multilateral environmental issues onto the policy agenda.
Environmental mainstreaming is seen as both a popular and elusive goal. In reality, the process is poorly documented, and the gap between theory and practice is acute.

M&E supports opportunistic review of adaptation processes, particularly if a learning-by doing approach is adopted, and if significantly informed by engaged stakeholders. The stakeholders can be important players in an assessment of the effectiveness of any adaptation strategy or suite of strategies. The stakeholders can provide valuable information about whether the proposed interventions have been successful in achieving the strategic objectives. They also provide insight into how existing social, economic, institutional and political factors have supported or impeded implementation. More importantly, substantial findings from the M&E process will point to corrective action for the adaptation strategies, measures or policies. The inclusion of adaptation into the development mainstream must focus not only on the pre-decision stages of the process (i.e., project design stage, climate risk assessment), but also on M&E in the implementation and post-implementation stages. Neglecting these important steps can prevent the adaptation process from being an effective management tool. On a larger scale, it could cause the City to miss important opportunities to correct past mistakes and improve current practices.

The following Table 70 indicates the recommended initial primary adaptation actions, the physical measure(s) that would be monitoring to indicate progress to success or lack thereof and the candidate entity that would collect the data for evaluation in the monitoring. Most of these parameters are currently being collected for other ongoing purposes and would be available in the habitat monitoring and water quality assessment associated with the normal Charlotte harbor National Estuary Program monitoring or are utilized as part of the periodic Evaluation and Appraisal Report (EAR) process for reviewing the City of Punta Gorda Comprehensive Plane. Clearly this monitoring is mainstreamed with ongoing evaluation processes of Charlotte Harbor and the land uses of the City.

Table 70: Adaptation Plan Monitoring Summary for the Primary Initial Adaptation Actions

Adaptation	Proximal Monitoring Physical Measure	Secondary Measure	Responsible Entity Collecting Data	Primary Target Goal
Seagrass protection and restoration	Acres of seagrass in the Tidal Peace River segment	Quality of seagrass	SWFWMD/ CHNEP	CHNEP seagrass target (951 acres) for Tidal Peace River segment
Xeriscaping and native plant landscaping.	Percent of City responsible landscape in xeriscape	Percent of citizen responsible landscape in xeriscape	City of Punta Gorda	25% by 2025
Explicitly indicating in the comprehensive plan which areas will retain natural shorelines.	% natural shoreline	% natural shoreline restored	City of Punta Gorda	50%
Constraining locations for certain high risk infrastructure.	Amount of TDR transferred Out of Environmental Sending Locations	amount of high risk infrastructure remaining in the Tropical Storm and Category 1 Storm Surge Zones	City of Punta Gorda	No high risk infrastructure remaining in the Tropical Storm and Category 1 Storm Surge Zones
Restrict fertilizer use.	Nitrogen concentrations and loads in River and Harbor	Reduction in nitrogen levels and loads in City canals	SWFWMD, Charlotte County, FMRI	Reduction in nitrogen in River and Harbor to achieve non-impairment per TMDL

Adaptation	Proximal Monitoring Physical Measure	Secondary Measure	Responsible Entity Collecting Data	Primary Target Goal
Promote green building alternatives through education, taxing incentives, green lending.	Number of green buildings constructed	Estimated change in energy use in dollars and by energy audit methods	City of Punta Gorda	25% increase for building, 25% decrease for energy use by 2025
Drought preparedness planning.	Number of planning steps completed.	Number of use water restriction events	City of Punta Gorda	completed and implemented plan

Summary Conclusion

This Climate Change Adaptation Plan utilizes and identifies the key elements of climate change adaptation planning for the City of Punta Gorda, and provides some resources that the City and the CHNEP can use in climate change adaptation.

The plan included:

- An assessment of climate vulnerabilities for the City of Punta Gorda;
- A summary of the considerations and public participation processes used to set priorities and select vulnerabilities and implementation actions
- Communication with stakeholders and decision makers.
- How the plan affects existing goals of the City of Punta Gorda as expressed in the existing 2025 Comprehensive Plan;
- Additional climate change-induced goals and objectives beyond the existing management goals to the period of the year 2200;
- Adaptation management actions associated with achieving those goals and objectives;
- Description of specific implementation actions for the priority adaptations with the highest level of consensus (including some of the associated tools and resources that can be employed to implement the priority adaptations).
- Plans for monitoring and evaluation of results if the adaptations are implemented

This plan will need to be a "living document," utilizing adaptive management techniques that allows for updating in response to changing conditions and lessons learned from monitoring and evaluation of results.

During the public workshops with the citizens of the City of Punta Gorda identified 54 climate change vulnerabilities. Eight climate change vulnerabilities were identified including, in order of priority:

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.

During the public workshops, participants generated potential adaptations. The public then individually selected adaptations for inclusion or exclusion in the plan. A total of 104 acceptable and 34 unacceptable potential adaptations were identified and prioritized by level of agreement.

The top consensus adaptations for each area of vulnerability include:

- 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.

These are the recommended first adaptations for development of implementation plans by the City of Punta Gorda. The recommended priority adaptation implementations do not constitute an institutional or cultural change for the City but rather a continuation of a general progressive approach undertaken by the City to improve and enhance its resource base and standard of living. As the implementation and monitoring of these actions are undertaken it is recommended that the plan be revisited to reexamine the success of implementation and to select/verify the next set of priority climate change adaptations.

The methods developed in this project can be used as a framework to develop climate change adaptation plans for other coastal cities in Florida and around the Gulf Coast. Interest has already been expressed from other jurisdictions within the CHNEP area and outside of it to employ this Public Participation-Local Condition procedure for their unique adaptation plans.

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Appendix I: April 9, 2009 Public Meeting in Punta Gorda, Agenda

Developing a Weather Adaptation Plan for the City of Punta Gorda

Thursday, April 9, 2009

8:30 Registration and refreshments. Participants are asked to complete a questionnaire.

9:10 Welcome: Maran Hilgendorf, CHNEP

9:15 CHNEP Climate-Ready Estuaries: Lisa Beever, CHNEP

9:30 Overview of actions taken by the City of Punta Gorda: Joan LeBeau, City of Punta Gorda

9:45 Adaption Study Overview: Jim Beever, Southwest Florida Regional Planning Council

10:00 Break

10:15 Results of Survey: Maran Hilgendorf and Whitney Gray, Southwest Florida Regional Planning Council

10:20 Vulnerability Game, a facilitated exercise to determine perceptions of vulnerability to weather change: Lisa Beever

10:45 "Adaption Game", a facilitated exercise on perceptions about how to adapt, minimize or avoid items generated during earlier exercise: Lisa Beever

11:15 Break

11:30 Acceptability game "Thumbs"

11:45 *Thank you* for participating in the workshop today!

As a thank you, CHNEP is pleased to provide you with a poster of a local scene by either well-known artist Clyde Butcher or Diane Pierce.

Results of the workshop today will be available in approximately a month and the full report will be available by the next public workshop. An email message will be sent to all who provided one once the results and report are available.

Please attend . . . Tuesday, June 2 for a morning workshop to review various adaptation strategy scenarios that are developed with input from the results of the April 9 workshop

Thursday, September 3 for a morning workshop to review the draft adaptation plan.

Thanks to the City of Punta Gorda and to PGI Civic Association for hosting these workshops.

Survey

Developing a Weather Adaptation Plan for the City of Punta Gorda

Answer Tracking Sheet

Please complete this questionnaire at the start of the workshop.

Return it to the table where you registered. *Thank you.*

1) Do you live in Florida ______25______________ year round or ________3__________ seasonally? **Tally**

2) How many years have you lived in or visited Florida? **Average years** Lived 21, visit 32, greater 26

3) What is your local zip code? **Tally**

33927	33938	33946 **1**	33947	33948
33949	33950 **16**	33951	33952 **2**	33953
33954	33955 **1**	33980	33981	33982 **1**
33983 **1**	34224 **1**	**33990 1**	**34234 1**	**34269 2**

4) If you live in Florida seasonally, what is the zip code of your other home? **List**

47905 55337 49684

5) If you work, what zip code do you work in locally? **Tally**

33927	33938	33946	33947	33948
33949	33950 **5**	33951	33952	33953
33954	33955	33980 **2**	33981	33982 **1**
33983	34224 **1**	**34223 1**	**33901 1**	**34234 1**

Please circle your responses.

6) Winter in Florida is typically the dry, cool season. (a) Do you think winters have been wetter, drier, the same since you began living/visiting here or are you not sure? (b) Have they been cooler, warmer, or the same or not sure? **Tally**

Wetter **1**	Drier **21**	Same **2**	Not sure **4**
Cooler **11**	Warmer **6**	Same **4**	Not sure **2**

7) Summer here is typically the warm, rainy season. (a) Do you think summers have been wetter, drier, the same since you began living/visiting here or are you not sure? (b) Have they been cooler, warmer, the same or are you not sure? **Tally**

Wetter	Drier **18**	Same **1**	Not sure **5**
Cooler **1**	Warmer **9**	Same **8**	Not sure **5**

8) Is fishing around Charlotte Harbor improving, declining, about the same or are you not sure? **Tally**

Improving **3**	Declining **7**	Same **3**	Not sure **14**`

9) Is water quality in Charlotte Harbor improving, declining, about the same or are you not sure? **Tally**

Improving **3**	Declining **14**	Same **4**	Not sure **6**

10) Is water quality in the canals of Punta Gorda improving, declining, about the same or are you not sure? **Tally**

Improving **3**	Declining **9**	Same **4**	Not sure **11**

11) Is the presence of wildlife in Punta Gorda increasing, decreasing, about the same or are you not sure? **Tally**

Increasing **4**	Decreasing **9**	Same **4**	Not sure **8**

Please answer briefly.

12) Have you noticed any changes in the weather (in addition to or other than what was noted above) in the time you've lived in or visited Punta Gorda? **List**

None **17**	Variable **2**	Drought **2**	Fire danger **1**	Charley **2**

More wind **2**	Change in summer rain patterns **1**	Seasons blurring **1**	Less rain **1**	Winter low tides much more frequent than 5 years ago **1**

13) Do you think storms are getting more severe or frequent? **Tally/list**

Yes **7**	No **11**	More Severe **3**	More Frequent **0**

Don't know 3

No answer 2

Hurricane cycle upswing, less winter rain

14) Do you expect the weather to be better, worse or about the same in the future? **Tally**

Better **0**	Worse **12**	Same **9**	Not sure **3**

15) Did your local property sustain any damage as a result of Hurricane Charley? If so, what? **List**

Vegetation
Structural
Roof
Lanai/screen
Windows
Interior
Insulation
Garage

16) What changes have you made as a result of Hurricane Charley (or other storm event) to be better prepared for the next storm? **List**

Generator
Shutters/plywood
Improved/replaced roof
Improved/replaced windows
Improved/replaced doors
Purchased storm supplies
Improved/replaced lanai
Rainwater harvesting
Stormscaping
Bring house up to code
MySafeFloridaHome survey
Improve/replace garage door
Multiple
Better evacuation plan
None

17) What additional changes to your property would you like to make? **List**

Moving truck
Better protection for lanai/screen
Evaluate and harden home
Storm shutters
Rainwater harvesting
Stronger garage door
Improve windows
Improve roof
Stormscaping
Improve lake shoreline
None

18) What have been the obstacles to making those changes? **List**

Money/cost
Finding contractors
Getting permits
Knowing alternatives
Time
No obstacles

19) What should government do differently to be better prepared for the next hurricane? The next drought? The next flood? **List**

Intelligent growth/limit development
Water resource planning/water use restrictions
More/better planning
More/better education
Improve evacuation routes
Restore wetlands/improve protection
Rainwater collection

Improve forecasting
Improve communication
Remove FEMA from Homeland Security
Raise Aqui Esta and Olympia
Improve storm sewers
Government is well prepared.
Better governmental coordination

20) Please let us know of any other concerns you have regarding weather changes in Punta Gorda.

Drought
Less wildlife
Sea level rise
Downtown flooding
Insurance
Complacency
None
Not sure

Four surveys had completely blank back page.

Appendix II. Climate Change Adaptations Identified in the First Public Workshop

Economy Adaptations

- Acquire sensitive lands and lands for retreat of habitat
- Create out-of-area coalitions for mutual aid
- Solve environmentally related problems which affect recreational activities
- Create recovery plans for short and long terms
- Solve insurance problem to encourage business to thrive, including tourism business
- Diversify economy
- Improve overall natural resource management to increase habitat resilience
- Expect there will be less food, both to import and export
- Plan for agricultural impacts affecting local food providers, rising transportation costs for food grown outside Florida
- Promotion of local food providers and community gardens
- Promote green bldg alts thru education, taxing incentives, green-lending
- Alter timing of reproductive cycles for livestock
- Anticipate changes in forest productivity/species
- Beach nourishment
- Allow shoreline hardening where appropriate
- Sell carbon offsets
- Create a regional sediment management plan
- Determine how climate change will affect exercise and recreation
- Develop resilience in agricultural systems
- Drought-resistant crops
- Install groins to control beach erosion
- Prevent subsidence

Education Adaptations

- Funding for programs at all levels
- Better distribution of information
- Use pure science/proven information
- Look at causes
- Require new residents to attend local environment school
- Identify critical coastlines, wetlands, species, and water supplies
- Identify conflicting policies between programs
- Incorporate consideration of climate change impacts into planning
- Establish early warning sites & gather baseline data
- Consider temperature when choosing building materials
- Identify vulnerable populations
- Develop heat wave response plans
- Increase public awareness

- Increase research & formulate action plans for tropical diseases
- Research asthma increases due to climate change & id resulting impacts to human health
- Partner with utility companies to educate the public on energy efficiency
- Hold public information workshops
- Identify barriers to adaptation
- Promote green bldg alts thru education, taxing incentives, green-lending
- Educate homeowners associations regarding xeriscaping

Financial Adaptations

- Obtain state/federal grants/funding
- Redirect revenues to these issues/make funding a government priority
- Stop avulsion
- Stop dredging
- Raise taxes for living nearer the coast
- Invest in alternative energy (not nuclear)
- Invest in alternative energy
- Improve risk modeling methods
- Reuse of foundations
- Establish funds for purchase of lands
- Fund and perform long-term research
- Plan for regional relocation and displacement
- Subsidize retrofitting buildings for energy efficiency
- Free/low cost loans for photovoltaic systems, net metering, solar panels
- Create more energy- & cost-effective communities thru community design& green bldg
- Create water markets
- Implement land exchange programs
- Purchase coastal land that is damaged or prone to damage for conservation
- Incorporate drastically increased fees/rates for high water consumption
- Consider congestion zone tolls in larger cities
- Eliminate flat rate water billing and re-price water on a sliding scale
- Public purchase of private development rights
- Provide rebates for installation of low flow technology
- Additional insulation in buildings
- Change to energy efficient buses and taxis

Fire Adaptations

- Better and faster response times
- 30 foot buffer in residential landscaping
- Improved system of retaining rainwater
- Evict smokers
- Increase drought preparedness planning
- Build xeriscaping into codes and educate homeowners

- Require municipal use of xeriscaping
- Consider risks associated with roofing materials and other flammable building materials
- Control sprawl
- Control invasive exotic plant species
- Monitor & determine trends in wildfire

Flooding Adaptations

- Design new coastal drainage systems
- Increase bridge clearances
- Increase stormwater capacity
- Improved roof drainage capacity
- Complete downtown flooding study
- Emulate Venice, Italy/rely on boat transportation
- Raise elevation of streets
- Raise elevation of buildings
- Establish no-rebuild zones
- Land acquisition for retreat/relocation
- Improve weather response plans
- Shoreline hardening
- Relocate structures
- Increase vegetation
- Restore natural accretion processes
- Incorporate wetland protection into infrastructure planning
- Explicitly indicate in local master plans which areas will retain natural shorelines
- Allow coastal wetlands to migrate inland in areas explicitly indicated
- Remove hard protection or other barriers to shoreline retreat and protections
- Establish rolling easements
- Retreat
- Purchase upland development rights/property rights
- Adaptive stormwater management
- Constrain location of certain infrastructure such as landfills, hazardous waste, sewer
- Redefine flood hazard zones
- Restricting/prohibiting development in erosion/flood/damage prone areas
- Increase shoreline setbacks and exchange/purchase/acquisition
- Improved flood pain management/regulation
- Protection of barrier islands that shelter beaches
- Build “deconstructable” buildings which can be taken apart and easily moved to higher ground
- Modify stormwater conveyance systems and control elevations
- Limit development
- Construct stormwater infrastructure improvements
- Build roads & sidewalks of porous materials
- Improve building codes

- Replace shoreline armoring with living shoreline
- Fortify dikes
- Move health facilities out of vulnerable areas
- Regulate pumping near shorelines

Growth Adaptations

- Infill incentives
- Control building with zoning and permitting
- Redefine impacted land use
- Insist on "greening" measures
- Strict enforcement of existing codes
- Reduce/eliminate development in sensitive areas/coast
- Use flexible planning
- Better regulation for industry
- Urban growth boundaries
- Acquire/protect critical habitat areas
- Consider sea level rise in site design
- Constrain locations for certain high risk infrastructure
- Ensure appropriate foundations for buildings
- Use coastal management in land planning
- Use LEED standards in building
- Use LID principles in development
- Redefine flood hazard zones
- Ensure that master plans explicitly indicate which areas will retain natural shorelines
- Establish rolling easements
- Purchase upland development rights/property rights
- Expand planning horizons
- Identifying conflicting policies between programs
- Provide alternative transportation
- Consider congestion zone tolls in larger cities
- Change building codes to promote energy efficient building
- Create more energy- & cost-effective communities thru comm. Design & green building
- Increase use of alternative and renewable energy
- Promote green roofs through building codes
- Subsidize retrofitting buildings for energy efficiency
- Increase shoreline setbacks
- Plan for regional relocation & displacement
- Change minimum parking requirements
- Consider climate change in infrastructure planning
- Consider climate effects in choice of building materials
- Consider immigration to SWF due to SLR impacts to the Bahamas & the Keys
- Adopt bldg design criteria that consider more severe hurricanes

- Don’t allow development or engineering solutions to block migration of wetlands
- Elevate land surfaces
- Establish living shorelines
- Adopt bldg design criteria that consider sea level rise
- Improve land use management
- Increase bridge clearances
- Remove unnecessary/inundated infrastructure

Habitat Adaptations

- Do nothing
- Conservation land acquisition
- Establish migration routes for wildlife
- Habitat protection/retention
- Establish strong laws to protect habitat
- Good law enforcement
- More rigorous agency review of development
- Controls/restrictions on growth
- Mangrove restoration
- Seagrass restoration
- Landscape with exotics
- Stop unchecked commercial fishing
- Build fish hatcheries
- Stop fishing tournaments
- Monitor fish catches & adjust limits
- Promote catch and release fishing
- Reduce carbon footprint
- Restore natural inlets and accretion
- Collect data on and mapping existing conditions
- Establish early warning sites and gather baseline data
- Develop GIS-based decision making/visualization tools
- Establish funds for land purchase
- Establish and use land exchange programs
- Adapt protections of critical biogeochemical zones
- Allow coastal wetlands to migrate inland
- Plan for vertical accretion of wetlands/marshes
- Establish seed banks
- Create dunes
- Create marsh
- Establish living shorelines
- Design estuaries with dynamic boundaries and buffers
- Plant submerged aquatic vegetation
- Remove of barriers to dispersal
- Remove invasive species and restore native species

- Strengthen rules that prevent the introduction of invasive species
- Replicate habitat in multiple areas to spread risks
- Selectively move vulnerable ecosystems north
- Reduce CO_2 emissions to reduce ocean acidification
- Fertilizer regulation
- Incorporate wetland protection into transportation planning
- Explicitly indicate in local master plans which areas will retain natural shorelines
- Use CLIP, FNAI, etc to prioritize land purchases
- Artificial vertical build-up of tidal wetlands
- Improve marine/reef management
- Incorporate wetland protection into infrastructure planning
- Prohibit bulkheads
- Reduce CO_2 emissions to reduce ocean acidification
- Regulate import of exotics

Insurance Adaptations

- "Call out" most vulnerable properties
- No rebuild laws in vulnerable areas
- Socialize insurance
- Stop providing government subsidized insurance in high-risk areas
- Retrofit program for existing structures
- Review, update and improve building and zoning standards and codes
- Harden homes
- Control costs so that homeowners are not taken advantage of
- Stronger enforceable laws re: insurance coverage and faster remediation of claims
- Link sale of other forms of ins. to offering property ins. as a req. of doing business in Fla.
- Insurance coverage should reflect risk vs. actual loss
- Improve risk modeling methods
- Raise insurance prices
- Make insurance unavailable after storms
- Flood insurance rate maps should take climate change into account
- Require structures to meet National Flood Insurance Program requirements or local flood ordinance requirements, whichever are stricter
- Prohibit federal subsidies and flood insurance
- Climate policy integration where fed, state & local governments work collaboratively
- Adapt protections to changing climates & conditions
- Establish climate archives for baseline & tracking data
- Heat health planning
- Redefine flood hazard zones

Water Quality Adaptations

- Restrict fertilizer use

- Control flow of pollutants into harbor
- Stop coal burning
- Watershed/basin protection
- Stormwater retention
- Boater education
- Establish early warning sites and increase data collection on existing conditions
- Carbon offsets
- Reduce atmospheric carbon dioxide
- Develop adaptive stormwater management
- Create regional sediment management plan
- Fertilizer regulation
- Proper consideration of hazardous materials disposal
- Plug drainage canals
- Reduce impervious surface allowed
- Integrated Coastal Zone Management
- Modify wetland conservation/restoration plans
- Conservation land acquisition
- Design new coastal drainage system
- Improved site drainage designs and improved water penetration barriers
- Create marsh
- Change regulations that affect other causes of algae blooms

Water Supply Adaptations

- Comprehensive planning
- Cisterns/rain barrels
- Use of grey water for irrigation
- Use of reclaimed water for irrigation
- Conservation education
- Desalinization
- Conservation
- Restriction on uses
- Reservoir(s)
- Create redundancy in supply
- Reinforce existing infrastructure
- Identify alternate sources
- Charge more for certain uses
- Limit development
- Acquire land for recharge
- Cap and trade water
- Stop fertilizer use
- Reduce runoff into streams
- Stabilize upland development sites
- Don’t lower drinking water standards

- Use native plants in landscaping
- Restore natural accretion processes
- Change ordinances that require vegetation such as turf grass
- Increase tree cover to reduce evaporation from ground
- Encourage composting and mulching to reduce irrigation
- Minimize impervious surfaces to increase recharge
- Channel water from impervious to pervious areas
- Install rainfall sensors to reduce automatic irrigation
- Require municipal use of xeriscaping
- Charge impact fees for non-drought-tolerant lawns
- Consider climate change in water supply planning
- Protect groundwater sources
- Increase stormwater management capacity
- Identify conflicting policies between programs
- Build xeriscaping into codes
- Agricultural water reuse
- Drought preparedness planning
- Create water markets
- Re-price water on a sliding scale

Appendix III. Results From the Second Public Workshop

<u>Unchecked</u> <u>or</u> <u>Unmanaged</u> <u>Growth</u>

City-Wide Adaptations

✓✓✓✓	Constrain locations for certain high risk infrastructure
✓✓✓✓	Urban growth boundaries
✓✓✓✓	Consider climate change in infrastructure planning
✓✓✓✓	Change building codes to promote energy efficient building
✓✓✓✓	Don't allow development or engineering solutions to block migration of wetlands
✓✓✓✓	Consider sea level rise in site design
✓✓✓	Reduce/eliminate development in sensitive areas/coast
✓✓✓	Strict enforcement of existing codes
✓✓✓	Improve land use management
✓✓✓	Adopt building design criteria that consider sea level rise
✓✓✓	Provide alternative transportation
✓✓✓	Control building with zoning and permitting
✓✓	Insist on "greening" measures
✓✓	Use coastal management in land planning
✓✓	Infill incentives
✓✓	Acquire/protect critical habitat areas
✓✓	Ensure that master plans explicitly indicate which areas will retain natural shorelines
✓✓	Adopt building design criteria that consider more severe hurricanes
✓✓	Promote green roofs through building codes
✓✓	Infill incentives
✓✓	Create more energy- & cost-effective communities through community design and green building
✓✓	Establish rolling easements
✓✓	Consider climate effects in choice of building materials
✓✓	Subsidize retrofitting buildings for energy efficiency
✓	Purchase upland development rights/property rights
✓	Increase use of alternative and renewable energy
✓	Identify conflicting policies between programs
	All measures to reduce local GHG emissions
	Integrate carrying capacity principles into comprehensive planning
	Elevate land surfaces
	Establish living shorelines
	Increase shoreline setbacks
	Adopt building design criteria that consider all adaptation requirements
	Redefine flood hazard zones

Use LED standards in building
Use flexible planning
Ensure appropriate foundations for buildings
Plan for regional relocation & displacement
Remove unnecessary/inundated infrastructure
Use LID principles in development

Unchecked or Unmanaged Growth

Recommended Against

- ✔ ✔ Insist on "greening" measures
- ✔ Increase bridge clearances
- ✔ Consider congestion zone tolls in larger cities
- Consider immigration to SWF due to sea level rise impac5s to the Bahamas and the Keys

Flooding

City-Wide Adaptations

- ✔ ✔ ✔ Explicitly indicate in local master plans which areas will retain natural shorelines
- ✔ ✔ Build roads and sidewalks of porous materials
- ✔ ✔ Incorporate wetland protection into infrastructure planning
- ✔ ✔ Complete downtown flooding study
- ✔ Improved flood plain management/regulation
- ✔ Increase stormwater capacity
- ✔ Modify stormwater conveyance systems and control elevation
- ✔ Improve building codes
- ✔ Constrain location of certain infrastructure such as landfills, hazardous waste, sewer
- ✔ Remove hard protection or other barriers to shoreline retreat and protections
- ✔ Retreat
- ✔ Establish no-rebuild zones
- ✔ Land acquisition for retreat/relocation
- ✔ Increase shoreline setbacks and exchange/purchase/acquisition
- Construct stormwater infrastructure improvements
- Increase vegetation
- Raise elevation of streets
- Adaptive stormwater management
- Regulate pumping near shorelines
- Improved roof drainage capacity

Replace shoreline armoring with living shoreline
Allow coastal wetlands to migrate inland in areas explicitly indicated
Increase bridge clearances
Undertake a long-term study of the need to raise infrastructure
Design new coastal drainage systems
Restrict/prohibit development in erosion/flood/damage prone areas
Limit development
Improve weather response plans
Build "deconstructable" buildings which can be taken apart and easily moved to higher ground
Establish rolling easements
All measures to reduce local GHG emissions

Flooding

Recommended Against

✔ Shoreline hardening
Fortify dikes
Raise elevation of buildings
Relocate structures
Retreat

Education and Economy

City-Wide Adaptations

✔✔✔✔ Promote green building alternatives through education, taxing incentives, green lending
✔✔✔✔ Partner with utility companies to educate the public on energy efficiency
✔✔✔ Increase public awareness
✔✔✔ Hold public information workshops
✔✔✔ Educate homeowners associations regarding xeriscaping
✔✔ Identify critical coastlines, wetlands, species, and water supplies
✔✔ Identify vulnerable populations
✔✔ Incorporate consideration of climate change impacts into planning
✔✔ Change to energy efficient buses and taxis
✔✔ Invest in alternative energy
✔✔ Improve overall natural resource management to increase habitat resilience
✔✔ Acquire sensitive lands for retreat of habitat
✔✔ Stop providing government subsidized insurance in high-risk areas
✔ Better distribution of information

- ✔ Use pure science/proven information
- ✔ Identify conflicting policies between programs
- ✔ Establish climate archives for baseline and tracking data
- ✔ Provide rebates for installation of low flow technology
- ✔ Create more energy- and cost-effective communities through community design and green building
- ✔ Fund and perform long-term research
- ✔ Install groins to control beach erosion
- ✔ Solve insurance problem to encourage business to thrive, including tourism business
- ✔ Drought resistant corps
- ✔ Prohibit federal subsidies and flood insurance in high risk areas
- ✔ Eliminate flat-rate billing and re-price water on a sliding scale
- ✔ Raise taxes for living near the coast
- ✔ Establish funds for purchase of lands
- ✔ Obtain state/federal grants/loans
- ✔ No rebuild laws in vulnerable areas
- ✔ Review, update and improve building and zoning standards and codes

Funding for (education)programs at all levels
Establish early warning sites and gather baseline data
Identify barriers to adaptation
Consider temperature when choosing building materials
Look at causes
Climate policy integration where federal, state ,and local governments work collaboratively
Redirect revenues to these issues/make funding a government priority
Implement land exchange programs
Subsidize retrofitting buildings for energy efficiency
Reuse of foundations
Require new structures to meet National Flood Insurance Program requirements or local flood ordinance requirements whichever are stricter
Control costs so that homeowners are not taken advantage of
Diversify economy
Additional insulation in buildings
Create out-of-area coalitions for mutual aid
Create a regional sediment management plan
Beach nourishment
Allow shoreline hardening where appropriate
Develop resilience in agricultural systems
Retrofit program for existing structures
Plan for regional relocation and displacement
All measures to reduce local GHG emissions
Solve environmentally related problems which affect recreational activities
Minimize dredging
Public purchase of private development rights

Free/low cost loans for photovoltaic systems, net metering, solar panels
Increase public awareness on renewable energy
Incorporate drastically increased fees/rates for high water consumption
Flood insurance rate maps should take climate change into account
Sell carbon offsets
Redefine flood hazard zones

Education and Economy

Recommended Against

Require new residents to attend local environment school
Raise insurance prices
Prohibit federal subsidies and flood insurance in high risk areas
Link sale of other forms of insurance to offering property insurance as a requirement of doing business in Florida
Insurance coverage should reflect risk vs. actual loss
Socialize insurance
Raise taxes for living nearer the coast
Eliminate flat-rate water billing and r-price water on a sliding scale
Stop dredging
Incorporate drastically increased fees/rates for high water consumption
Consider congestion zone tolls in larger cities
Sell carbon offsets

Water Quality Degradation

City-Wide Adaptations

✔ ✔ ✔ ✔ Restrict fertilizer use
✔ ✔ ✔ ✔ Conservation land acquisition
✔ ✔ ✔ Control flow of pollutants into harbor
✔ ✔ ✔ Improved site drainage designs and improved water penetration
✔ ✔ ✔ Proper consideration of hazardous materials disposal
✔ ✔ ✔ Develop adaptive stormwater management
✔ ✔ Watershed/basin protection
✔ ✔ Stormwater retention
✔ ✔ Fertilizer regulation
✔ ✔ Modify wetland conservation/restoration plans

- ✔ ✔ Reduce impervious surface allowed
- ✔ Create marsh
- ✔ Design new coastal drainage system
- ✔ Boater education
- ✔ Establish early warning sites and increase data collection on existing conditions
- ✔ Create regional sediment management plan
- Reduce atmospheric carbon dioxide
- *Stop flow of pollutants into harbor*
- Carbon offsets
- *All measures to reduce local GHG emissions*
- Integrated Coastal Zone Management
- *Replace septic tanks with sewers with government subsidies for homeowners*
- *Control runoff through improved land grading techniques*

Water Quality Degradation

Recommended Against

- ✔ Carbon offsets

Inadequate Water Supply and Fire

City-Wide Adaptations

- ✔ ✔ ✔ ✔ ✔ ✔ ✔ Require municipal use of xeriscaping
- ✔ ✔ ✔ ✔ ✔ Build xeriscaping into codes and educate homeowners
- ✔ ✔ ✔ ✔ ✔ Use native plants in landscaping
- ✔ ✔ ✔ ✔ Comprehensive planning
- ✔ ✔ ✔ ✔ Consider climate change in water supply planning
- ✔ ✔ ✔ ✔ Improved system of retaining rainwater
- ✔ ✔ ✔ ✔ Cisterns/rain barrels - *now allowed under 2008 LDRs*
- ✔ ✔ ✔ ✔ Drought preparedness planning
- ✔ ✔ ✔ ✔ Conservation education
- ✔ ✔ ✔ Minimize impervious surfaces to increase recharge
- ✔ ✔ ✔ Use of grey water for irrigation

✔	✔	Conservation
✔	✔	Re-price water on a sliding scale
✔	✔	Reservoir(s)
✔	✔	Use of reclaimed water for irrigation
✔	✔	Protect groundwater sources
✔	✔	Control invasive exotic species
✔	✔	Increase tree cover to reduce evaporation from ground
✔	✔	Acquire land for recharge
✔	✔	Increase stormwater management capacity
✔	✔	Install rainfall sensors to reduce automatic irrigation
✔		Create redundancy in supply
✔		Encourage composting and mulching to reduce irrigation
✔		Limit development
✔		Identify alternative sources
✔		Charge more for certain uses
✔		Restore natural accretion processes
✔		Reduce runoff into streams
✔		Control sprawl
		Look at possibility of desalinization
		Change ordinances that require vegetation such as turf grass
		Control fertilizer use
		Restrict fertilizer use
		All measures to reduce local GHG emissions
		Reinforce existing infrastructure
		Acquire land for flood/water supply
		Restriction on uses
		Require use of xeriscaping
		Water reuse replace irrigation on public land
		Charge more for treated water similar to Sarasota
		Minimize use of potable water for irrigation
		Desalinization
		Identify conflicting policies between programs

Channel water from impervious to pervious areas

Don't lower drinking water standards

Agricultural water reuse

30 foot buffer in residential landscaping
Consider risks associated with roofing materials and other flammable building materials

Inadequate Water Supply and Fire

Recommended Against

- ✔ Build xeriscaping into codes
- Desalinization *energy requirements*
- Stop fertilizer use
- Charge impact fees for non-drought-tolerant lawns
- Stabilize upland development sites
- Change ordinances that require vegetation such as turf grass
- Re-price water on a sliding scale
- Cap and trade water
- Evict smokers

Fish and Wildlife Habitat Degradation

City-Wide Adaptations

- ✔ ✔ ✔ ✔ Seagrass restoration
- ✔ ✔ ✔ Remove invasive species and restore native species
- ✔ ✔ ✔ Mangrove restoration
- ✔ ✔ ✔ Incorporate wetland protection into infrastructure planning
- ✔ ✔ ✔ Explicitly indicated in local master plans which areas will retain natural shorelines
- ✔ ✔ Habitat protection/retention
- ✔ ✔ Regulate import of exotics
- ✔ ✔ Establish funds for land purchase
- ✔ ✔ Collect data on and map exiting conditions

- ✔ ✔ Fertilizer regulation
- ✔ ✔ Conservation land acquisition
- ✔ ✔ Incorporate wetland protection into transportation planning
- ✔ Establish early warning sites and gather baseline data
- ✔ Develop GIS-based decision-making/visualization tools
- ✔ Monitor fish catches and adjust limits
- ✔ Establish migration routes for wildlife
- ✔ Improve reef/marine management
- ✔ Design estuaries with dynamic boundaries and buffers
- ✔ Establish living shorelines
- ✔ Restore natural inlets and accretion
- ✔ Controls/restrictions on growth
- ✔ Establish and use land exchange programs
- ✔ Strengthen rules that prevent the introduction of invasive species
- Prohibit *new* bulkheads
- Build fish hatcheries
- Use of CLIP. FNAI, etc to prioritize land purchases
- Allow coastal wetlands to migrate inland
- *Improve site planning controls*
- *Minimize habitat alteration*
- Plant submerged aquatic vegetation
- *All measures to reduce local GHG emissions*
- *Promote catch and release fishing*
- Adapt protections of critical biogeochemical zones
- Establish seed banks
- Establish strong laws to protect habitat
- Create dunes
- Stopped unchecked commercial fishing

Fish and Wildlife Habitat Degradation

Recommended Against

- ✔ ✔ ✔ Landscape with exotics
- ✔ ✔ ✔ Stop fishing tournaments
- ✔ ✔ ✔ Do nothing
- Stop unchecked commercial fishing

Appendix IV. City of Punta Gorda Critical Facilities

Description	Address
Adult Living Facility	450 Shreve St
Adult Living Facility	2295 Shreve St
Adult Living Facility	509 Berry St
Adult Living Facility	250 Bal Harbor Blvd
Airport	Not Addressed
Auditorium	75 Taylor St
Auditorium	210 Maud St
Auditorium	11200 First St
Bridge	Hwy 17 @ Orange Cr
Bridge	Riverside@Broad Cr
Bridge	Riverside @ ???
Bridge	Riverside @ ???
Bridge	Riverside @ ???
Bridge	Riverside @ Shell Cr
Bridge	Aqui Esta @ Venice
Bridge	Rio Villa @ Venice
Bridge	I75 @ Airport Rd
Bridge	Hwy 765 @ Clarks Cana
Bridge	Us 41 @ Peace River
Bridge	Us 41 @ Peace River
Bridge	I-75 @ Peace River
Bridge	I-75 @ Peace River
Bridge	I-75 @ Riverside Dr
Bridge	I-75 @ Riverside Dr
Bridge	I75 @ Sr17
Bridge	I75 @ Sr17
Bridge	I75@Henry
Bridge	I75 @ Jones Loop
Bridge	I75 @ Jones Loop
Bridge	I-75 @ Alligator
Bridge	I-75 @ Alligator
Bridge	I75 @ Jones Loop
Bridge	I75 @ Carmalita
Bridge	I75 @ Tuckers Grade

Bridge	I75 @ Tuckers Grade
Bridge	Hwy 17 @ Florida St
Bridge	Hwy 17 @ Florida St
Bridge	Sr 17 @ Shell Creek
Bridge	Sr 17 @ Shell Creek
Bridge	Sr 17 @ Shell Creek
Bridge	Jones Lp @ Alligator
Bridge	I-75 @ Clarks Canal
Bridge	Us 41 @ Alligator Cre
Bridge	Us 41 @ Alligator Cre
Bridge	Washington Lp @ Shell
Bridge	Washington Lp @ Shell
Bridge	Washington Lp@Myrtle
Bridge	Cr74@Small Cr
Bridge	Cr74@Myrtle Sl
Bridge	Cr74@Myrtle Cr
Bridge	Cr74@Babcock Dr
Bridge	Marion @ Bass Inlet
Bridge	Marion @ Sailfish
Bridge	Marion @ Tarpon
Bridge	Hwy 765a @ Alligator
Bridge	765 @ Alligator
Bridge	Jones Lp @ Alligator
Bridge	Hwy 765a @ Alligator
Bridge	Washington Loop @ ???
Bridge	Hwy 74 @ ???
Bridge	Not Addressed
Bridge	I75@???
Bridge	I75@???
Bridge	I75@Oilwell Rd
Bridge	Not Addressed
Bridge	Not Addressed
Bridge	Hwy765@???
Bridge	Hwy41@Rock Canal
Bridge	Hwy41@Rock Canal
Bridge	Cr74@Shell Cr
Bridge	Farabee@Unnamed
Bridge	Farabee@Prarie Cr
Bridge	Sr31@Prarie Br
Bridge	Sr31@Shell Cr
Bridge	Sr17@Cleveland Cr

Clinic	100 Madrid Blvd
Clinic	1401 Tamiami Tr
Clinic	227 Taylor Rd
Communications Tower	17200 Burnt Store Rd
Communications Tower	17400 Burnt Store Rd
Communications Tower	25590 Technology Blvd
Communications Tower	25510 Airport Rd
Communications Tower	5445 Williamsburg Dr
Communications Tower	31091 Oilwell Rd
Communications Tower	39631 Cook Brown Rd
Communications Tower	40000 Horseshoe Rd
Communications Tower	Not Addressed
Communications Tower	Not Addressed
Communications Tower	Not Addressed
Communications Tower	11011 Sr 31
Communications Tower	Not Addressed
Communications Tower	2380 Sandy Pine Dr
Communications Tower	Not Addressed
Communications Tower	Not Addressed
Communications Tower	408 Cooper St
Communications Tower	408 Cooper St
Communications Tower	Not Addressed
Communications Tower	25641 Technology Blvd
Communications Tower	Not Addressed
Communications Tower	3151 Cooper St
Communications Tower	4810 Deltona Dr
Communications Tower	12211 Sr31
Communications Tower	12931 Sr 31
Communications Tower	13100 Tamiami Tr
Communications Tower	28425 Morningside Dr
Communications Tower	142 Evergreen Ave
Communications Tower	39241 Washington Loop
Communications Tower	30283 Holly Rd
Communications Tower	28500 Tuckers Grade Rd
Communications Tower	Not Addressed
Communications Tower	Not Addressed
Communications Tower	Not Addressed
Communications Tower	Not Addressed
Communications Tower	Not Addressed

Communications Tower	13600 Tamiami Tr
Community Center	3125 Baynard Dr
Community Center	1139 Bal Harbor Blvd
Community Center	3950 Tamiami Tr
Community Center	317 Nesbit St
Community Center	3941 Tamiami Tr
Community Center	105 Taylor St
Electrical Facility	122 E Charlotte Av
Electrical Facility	391 Tamiami Tr
Electrical Facility	11501 Burnt Store Rd
Electrical Facility	5444 Sabal Palm Ln
Electrical Facility	6855 Cleveland Dr
Electrical Facility	Not Addressed
Fire/Ems	3941 Tamiami Tr
Fire/Ems	1501 Tamiami Tr
Fire/Ems	26287 Notre Dame Blvd
Fire/Ems	27589 Disston Av
Fire/Ems	3624 Ash St
Fire/Ems	12931 Sr 31
Government Complex	1501 Cooper St
Government Complex	750 W Retta Esplanade
Government Complex	512 E Grace St
Government Complex	**1410 Tamiami Tr**
Government Complex	6900 Florida St
Government Complex	350 E Marion Av
Government Complex	719 W Henry St
Government Complex	900 W Henry St
Government Complex	7451 Golf Course Blvd
Government Complex	118 W Olympia Av
Government Complex	802 W Retta Esplanade
Government Complex	126 Harvey St
Government Complex	Not Addressed
Government Complex	1500 Carmalita St
Government Complex	130 E Marion Av
Hazardous Sites	6400 Taylor Rd
Hazardous Sites	301 Madrid Blvd

Hazardous Sites	825 Carmalita St
Hazardous Sites	29751 Zemel Rd
Hazardous Sites	30999 Bermont Rd
Hazardous Sites	38100 Washington Loop Rd
Hazardous Sites	33123 Oil Well Rd
Hazardous Sites	53500 Bermont Rd
Hazardous Sites	6100 Duncan Rd
Hazardous Sites	17430 Burnt Store Rd
Hazardous Sites	17100 Tamiami Tr
Hospital	809 E Marion Av
Landfill	29751 Zemel Rd
Lock	Alligator Creek
Police-Sheriff	1410 Tamiami Tr
Police-Sheriff	27377 Mooney Av
Police-Sheriff	7474 Utilities Rd
Prison	26601 Airport Rd
Prison	33127 Oilwell Rd
Ramp	125 Nesbit St
Ramp	5408 Sea Edge Dr
Refuge	1250 Cooper St
Refuge	12275 Paramount Dr
Refuge	825 Carmalita St
Refuge	1221 Cooper St
Refuge	27110 Jones Loop Rd
School	311 Charlotte Av
Sewer Lift Or Treatment	25161 Olympia Av
Sewer Lift Or Treatment	3310 Adeline St
Sewer Lift Or Treatment	26560 Jones Loop Rd
Sewer Lift Or Treatment	26001 Airport Rd
Sewer Lift Or Treatment	Not Addressed
Sewer Lift Or Treatment	14920 Tamiami Tr
Sewer Lift Or Treatment	280 Balsam

Sewer Lift Or Treatment	4010 Michigan Dr
Sewer Lift Or Treatment	Not Addressed
Sewer Lift Or Treatment	3101 Bayside Pkwy
Sewer Lift Or Treatment	27406 Cleveland Ave
Sewer Lift Or Treatment	420 Anderson St
Sewer Lift Or Treatment	17430 Burnt Store Rd
Sewer Lift Or Treatment	24310 Cabana Rd
Sewer Lift Or Treatment	16184 San Edmundo Rd
Sewer Lift Or Treatment	24284 Balearic Ln
Sewer Lift Or Treatment	24316 San Ciprian Rd
Sewer Lift Or Treatment	1702 Monza Rd
Sewer Lift Or Treatment	33139 Oilwell Rd
Sewer Lift Or Treatment	30206 Oilwell Rd
Sewer Lift Or Treatment	9300 Knights Dr
Sewer Lift Or Treatment	26950 Jones Loop
Sewer Lift Or Treatment	26800 Airport Rd
Sewer Lift Or Treatment	7807 Skylane Wy
Sewer Lift Or Treatment	24289 Airport Rd
Sewer Lift Or Treatment	Not Addressed
Sewer Lift Or Treatment	Not Addressed
Sewer Lift Or Treatment	15450 Burnt Store Rd
Sewer Lift Or Treatment	15450 Burnt Store Rd
Sewer Lift Or Treatment	16115 Badalona Dr
Sewer Lift Or Treatment	16015 Minorca Dr
Sewer Lift Or Treatment	25418 Alicante Dr
Sewer Lift Or Treatment	16406 Minorca Dr
Sewer Lift Or Treatment	25360 Doredo Dr
Sewer Lift Or Treatment	25303 Doredo Dr
Sewer Lift Or Treatment	25642 Prada Dr
Sewer Lift Or Treatment	25142 Doredo Dr
Sewer Lift Or Treatment	25090 Harborside Blvd
Sewer Lift Or Treatment	16281 Quesa Dr
Sewer Lift Or Treatment	24038 Santa Inez Rd
Sewer Lift Or Treatment	24046 Vincent Av
Sewer Lift Or Treatment	Not Addressed
Sewer Lift Or Treatment	7541 Coral Tree
Sewer Lift Or Treatment	641 Royal Poinciana
Sewer Lift Or Treatment	448 Scarlet Sage
Sewer Lift Or Treatment	Not Addressed
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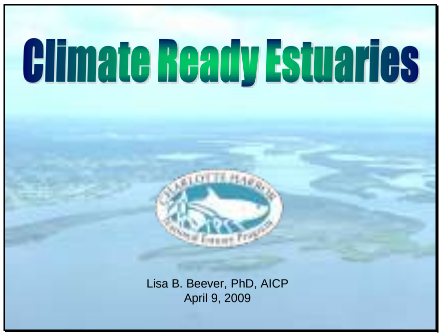
Sewer Lift Or Treatment	Not Addressed
Sewer Lift Or Treatment	Not Addressed
Telephone Switching Station	113 W Olympia Av
University-College	7405 Florida St
Water Tower	10501 Burnt Store Rd
Water Tower	10401 Burnt Store Rd

Appendix V. Presentations

Presentation 1 by Dr. Lisa Beever

Slide 1



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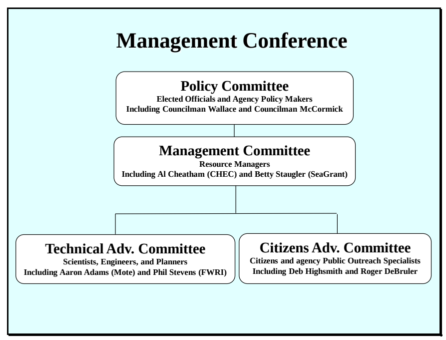

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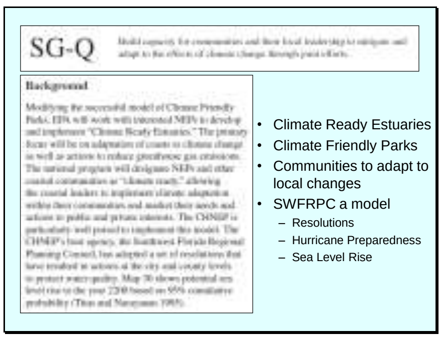

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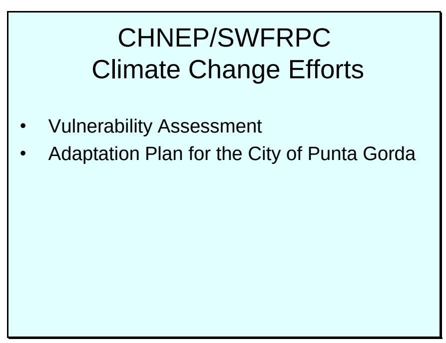

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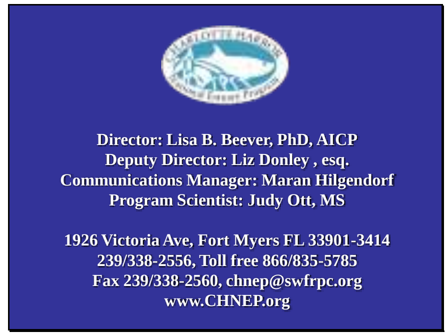

Presentation 3 by Jim Beever

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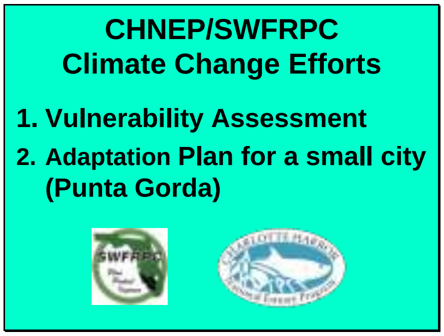

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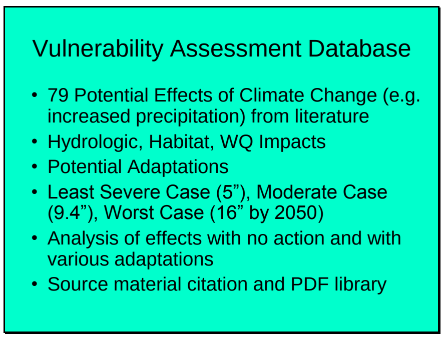

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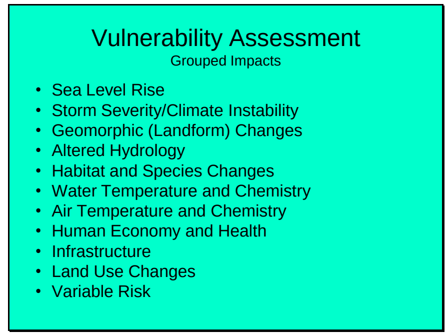

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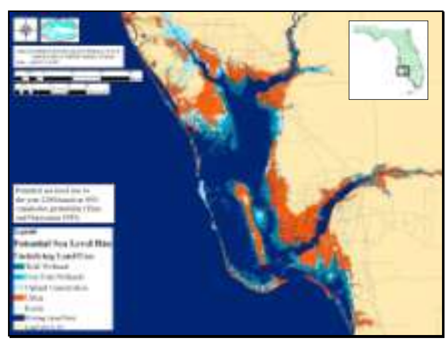

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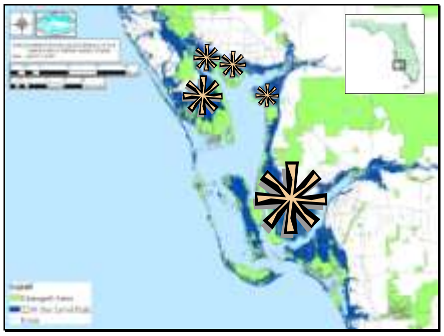

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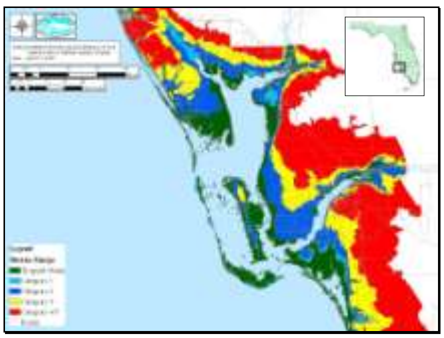

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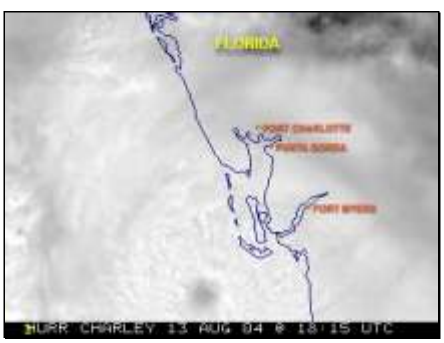

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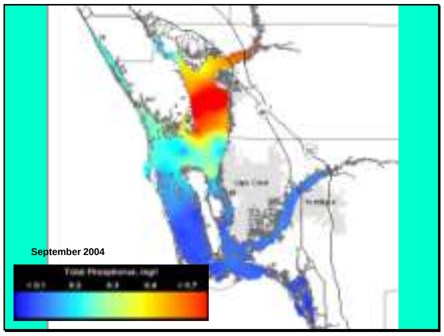

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Geomorphic Changes

- Landform migration to maintain relative position within the coastal energy gradient (Pethick 2001)
- Mangrove ability to accrete sediment (in absence of killing storms or human impacts)
- "Mangroves cannot persist with relative sea level rise above 12 cm/100 years" (Singh 2003)
- Habitat migration with landform changes

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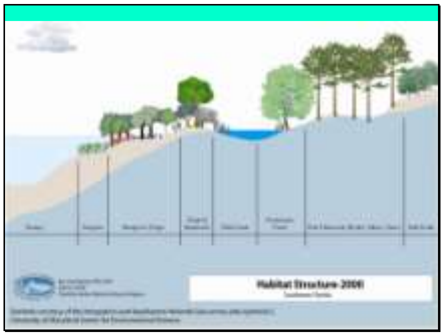

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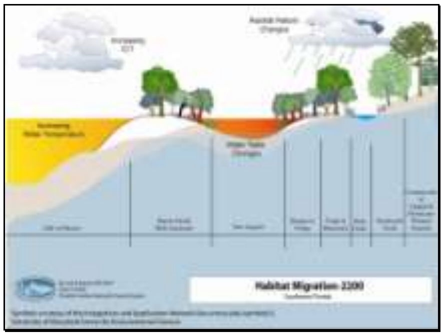

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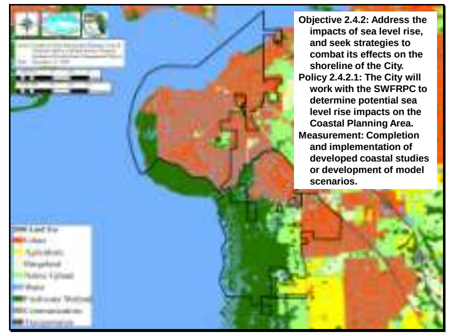

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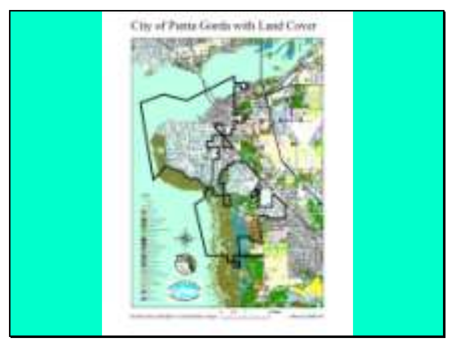

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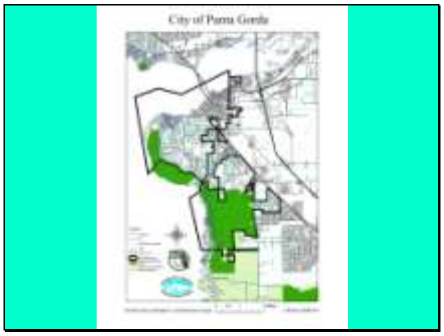

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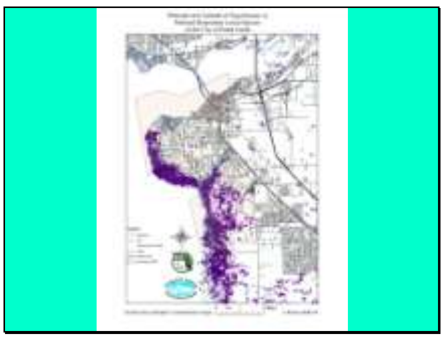

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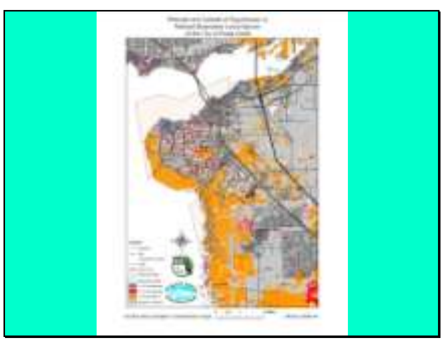

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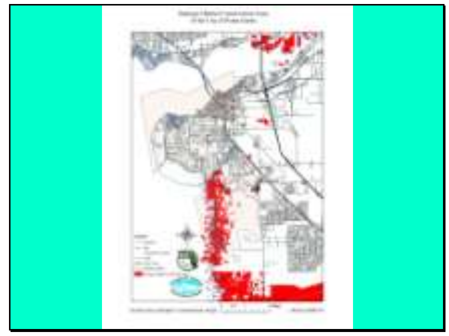

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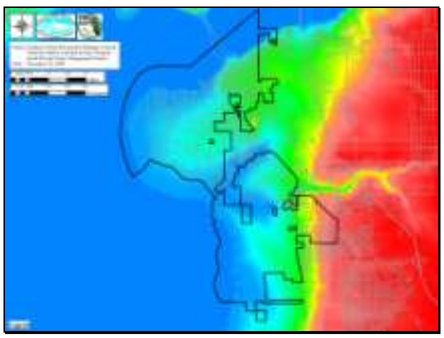

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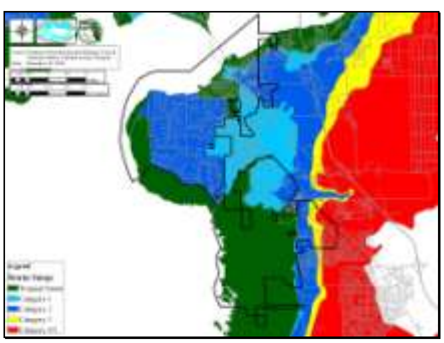

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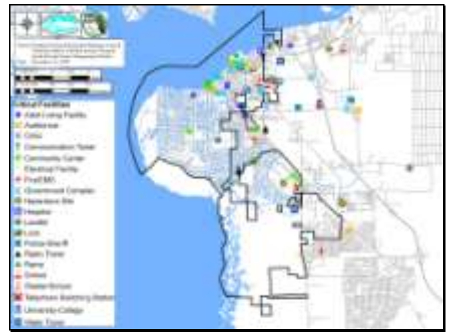

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Project Manager and Senior Planner: Jim Beever

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Fax 239/338-2560, jbeever@swfrpc.org
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Appendix VI: Adaptations List from the Regional Adaptations Review (Beever et al. 2009)

Adaptation Option	*Stressor Addressed*	*Other Management Goals Addressed*
A comprehensive climate policy integration where federal government, states & localities work collaboratively	Variable Risk	Human Economy
Adapt protections of important biogeographical zones & critical habitat as the locations of these areas change w/climate	Species and Habitats	Land Use
Adapt protections to changing climates and conditions	Variable Risk	Climate Instability, Sea Level Rise
Adaptive Management	Variable Risk	Land Use
Adaptive stormwater management	Water Chemistry and Temperature	Infrastructure
Add climate change health issues to state mandated Continuity of Operations Plans (COOP)	Human Health	Variable Risk
Additional insulation in buildings	Air Temperature and Chemistry	Infrastructure
After providing alternative transportation, consider congestion zone tolls in larger cities	Air Temperature and Chemistry	Land Use

Agricultural water reuse	Water Chemistry and Temperature	Human Economy
Allocate and cap increase drought preparedness plans	Climate Instability	Human Economy
Allow coastal wetlands to migrate inland	Species and Habitats	Sea Level Rise
Allow shoreline hardening where appropriate	Geomorphic Changes	Climate Instability, Sea Level Rise
Alter timing of reproductive cycles for livestock	Species and Habitats	Human Economy
Anticipating changes in species composition and productivity of forests	Species and Habitats	Variable Risk
Artificial vertical build up of tidal wetlands	Sea Level Rise	Species and Habitats
As 90% of Floridians live within 10 miles of the coast, we need to plan for regional relocation and displacement	Sea Level Rise	Land Use
Beach nourishment	Sea Level Rise	Human Economy
Build Xeriscaping into codes and educate Homeowners Associations regarding principles and benefits	Climate Instability	Water Chemistry and Temperature
Carbon offsets	Air Temperature and Chemistry	Water Chemistry and Temperature

Change building codes to promote energy efficient building good energy efficiency also aids in disaster preparedness	Air Temperature and Chemistry	Infrastructure
Change regulation that affects other causes of algae blooms	Water Chemistry and Temperature	Species and Habitats
Change to energy efficient busses and taxis, including biofuels	Air Temperature and Chemistry	Human Economy
Changing min parking requirements	Land Use	Infrastructure
Charge impact fees for St. Augustine lawns	Water Chemistry and Temperature	Land Use
Collect data on existing conditions/mapping	Variable Risk	Land Use
Combining State Policies and Measures, Federal Cap & Trade, and Federal Policies & measures through a wide variety of proven sector based action.	Variable Risk	Land Use
Connect landscapes with corridors to enable migrations	Species and Habitats	Land Use
conservation land acquisition	Species and Habitats	Land Use
conservation lands planning	Species and Habitats	Land Use
consider climate change in infrastructure planning	Variable Risk	Climate Instability, Sea Level Rise

consider climate change in water supply planning, including expanding planning horizons and adaptive stormwater management	Climate Instability	Infrastructure
consider climate effect in choice of building material	Infrastructure	Climate Instability, Sea Level Rise
Consider sea level rise impacts to the Bahamas the Keys and immigration and migration effects for Florida	Human Economy	Climate Instability, Sea Level Rise
consider sea level rise in infrastructure planning develop	Infrastructure	Climate Instability, Sea Level Rise
consider sea level rise in site design	Sea Level Rise	Infrastructure
consider sea level rise in utility siting	Sea Level Rise	Infrastructure
Consider temperature when choosing building materials	Infrastructure	Climate Instability, Sea Level Rise
constrain location of certain infrastructure such as landfills, hazardous waste, sewer	Land Use	Infrastructure
Create a regional sediment management plan	Geomorphic Changes	Climate Instability, Sea Level Rise
create dunes	Species and Habitats	Geomorphic Changes
create marsh	Species and Habitats	Climate Instability, Sea Level Rise

Create more energy cost effective communities through community design, green building and energy efficient vehicles, including public transportation	Infrastructure	Air Temperature and Chemistry
Create natural buffers against sea level rise	Species and Habitats	Climate Instability, Sea Level Rise
Create regional plans for conservation	Species and Habitats	Climate Instability, Sea Level Rise
Create water markets	Climate Instability	Human Economy
Desalination	Human Economy	Climate Instability, Sea Level Rise
design estuaries with dynamic boundaries and buffers	Geomorphic Changes	Climate Instability, Sea Level Rise
Design new coastal drainage system	Infrastructure	Climate Instability, Sea Level Rise
Determine how climate change will affect exercise and recreation	Human Health	Human Economy
develop adaptive stormwater management	Climate Instability	Water Chemistry and Temperature
Develop and adopt housing design criteria to deal with the consequences of more intense hurricanes and possible sea level rise	Infrastructure	Climate Instability, Sea Level Rise
develop GIS-based decision making/visualization tools identify conflicting policies between programs	Infrastructure	Land Use

Develop heat-health action plans	Human Health	Air Temperature and Chemistry
Develop surveillance systems for monitoring tropical diseases	Human Health	Human Economy
developing resilience in agricultural systems	Human Economy	Water Chemistry and Temperature
don't allow development or engineering "solutions" to block migration of wetlands	Species and Habitats	Climate Instability, Sea Level Rise
drought resistant crops,	Human Economy	water Chemistry and Temperature
Elevating land surfaces	Sea Level Rise	Infrastructure
Eliminate flat rate water billing and re-price water on a sliding scale	Climate Instability	Human Economy
Encourage water conservation – permanently	Climate Instability	Human Economy
Encourage/require grey water use through incentive programs	Climate Instability	Human Economy
enhancing watersheds and aquifer recharge capacity	Climate Instability	Water Chemistry and Temperature
ensure appropriate foundations for buildings	Infrastructure	Climate Instability, Sea Level Rise
enterprise change (livestock)	Human Economy	Species and Habitats
Establish baseline data	Variable Risk	Land Use
Establish early warning sites & baseline	Variable Risk	Human Economy
Establish living shorelines	Species and Habitats	Sea Level Rise

establish or broaden use containment areas to allocate and cap water withdrawal	Climate Instability	Human Economy
Establish rolling easements	Sea Level Rise	Human Economy
Establish seed banks	Species and Habitats	Human Economy
Establish/expand land purchase programs	Species and Habitats	Human Economy
establishing a Center for Climate Archives for baseline and associated data	Variable Risk	Human Economy
expand and diversify water supply for people	Climate Instability	Water Chemistry and Temperature
expand planning horizons of land use planning to incorporate longer climate predictions	Variable Risk	Land Use
Expect there will be less food, both to import and export	Variable Risk	Human Economy
extend and expand programs like CLIP	Species and Habitats	Land Use
Fertilizer regulation	Water Chemistry and Temperature	Species and Habitats
fortify dikes to protect from flooding and storm surges	Climate Instability	Sea Level Rise
grey water use of rain barrels/cisterns	Climate Instability	Water Chemistry and Temperature
groins	Geomorphic Changes	Infrastructure

Growth management and land use planning that result in a connected, ecologically functional network of conservation areas buffered by land uses consistent with land management needs	Species and Habitats	Land Use
Harden shoreline	Geomorphic Changes	Human Economy
headland control	geomorphic Changes	Climate Instability, Sea Level Rise
Heat wave response plans	Human Health	Infrastructure
ICAM	Variable Risk	Climate Instability, Sea Level Rise
ICZM	Variable Risk	Climate Instability, Sea Level Rise
ID & protect ecologically significant areas	Species and Habitats	Climate Instability, Sea Level Rise
ID barriers to adaptation	Variable Risk	Human Economy
ID conflicting policies between programs	Variable Risk	Land Use
ID ecologically significant areas	Species and Habitats	Land Use
ID vulnerable populations	Human Health	Human Economy
ID wildlife corridors	Species and Habitats	Land Use
Identification, protection and adaptation of protections of ecologically important areas/habitats	Species and Habitats	Climate Instability, Sea Level Rise
Identify conflicting policies between programs	Variable Risk	Human Economy
implement water restrictions	Climate Instability	Water Chemistry and Temperature

improve animal genetics	Human Economy	Species and Habitats
Improve risk modeling methods	Variable Risk	Human Economy
improved marine/reef management	Species and Habitats	Water Chemistry and Temperature
improved air conditioner (AC) designs	Air Temperature and Chemistry	Infrastructure
improved flood plain management/regulation	Land Use	Human Economy
improved land use and management	Land Use	Human Economy
Improved public transportation alternatives such as light rail and other methods	Air Temperature and Chemistry	Land Use
Improved roof drainage capacity	Climate Instability	Infrastructure
Improved site drainage designs	Climate Instability	Infrastructure
Improved water penetration barriers	Climate Instability	Infrastructure
include climate impacts and positive environmental services in land acquisition decisions	Variable Risk	Land Use
incorporate climate change into planning for new infrastructure	Infrastructure	Variable Risk
Incorporate consideration of climate change impacts into planning	Land Use	Variable Risk
Incorporate sea level rise into infrastructure planning/sewer system	Sea Level Rise	Infrastructure

incorporate sea level rise into planning for new infrastructure	Sea Level Rise	Infrastructure
Incorporate wetland protection into infrastructure planning	Species and Habitats	Infrastructure
incorporate wetland protection into transportation planning	Species and Habitats	Infrastructure
incorporating drastically increased cost for large consumption	Human Economy	Variable Risk
increase bridge clearances	Sea Level Rise	Infrastructure
increase capacity to manage stormwater	Climate Instability	Infrastructure
Increase data collection on existing conditions	Variable Risk	Air Temperature and Chemistry
increase maintenance	Infrastructure	Human Economy
increase public awareness	Variable Risk	Human Economy
increase shoreline setbacks and exchange/purchase/acquisition	Climate Instability	Sea Level Rise
increase stormwater management capacity	Climate Instability	Infrastructure
increased energy efficiency	Air Temperature and Chemistry	Infrastructure
increased hardening of critical facilities/building envelopes	Climate Instability	Infrastructure
increased pervious/ open space for recharge	Climate Instability	Infrastructure
increased power usage for AC	Infrastructure	Human Economy

increased shoreline setbacks	Climate Instability	Sea Level Rise
increased use of alternative and renewable energy	Human Economy	Air Temperature and Chemistry
Increased water recycling	Water Chemistry and Temperature	Climate Instability, Sea Level Rise
infrastructure investments	Infrastructure	Human Economy
Integrate climate change scenarios into water supply system	Climate Instability	Variable Risk
Integrated Coastal Zone Management (ICZM)	Climate Instability	Sea Level Rise
investigate tolerances of various infrastructure assets as to salinity tolerances	Infrastructure	Sea Level Rise
land acquisition programs	Species and Habitats	Land Use
LEED	Air Temperature and Chemistry	Infrastructure
living shorelines	Species and Habitats	Climate Instability, Sea Level Rise
Local master plans should explicitly indicate which areas will retain natural shorelines	Land Use	Sea Level Rise
long-term research	Variable Risk	Human Economy
low impact development (LID)	Land Use	Infrastructure
low-tillage and water reuse in agriculture	Water Chemistry and Temperature	Human Economy
maintain shorelines w/hard measures	Geomorphic Changes	Infrastructure

maintain shorelines w/soft measures like living shorelines	Geomorphic Changes	Sea Level Rise
manage and deliberately realign engineering structures affecting rivers, estuaries and coastlines	Geomorphic Changes	Climate Instability, Sea Level Rise
manage water demand thru reuse, recycling, rainwater harvesting, desal, etc.	Climate Instability	Human Economy
misting	Air Temperature and Chemistry	Human Economy
modify conservation and preservation plans	Variable Risk	Land Use
modify urban landscaping requirements to reduce runoff	Water Chemistry and Temperature	Infrastructure
Modify wetland conservation/restoration plans	Species and Habitats	Climate Instability, Sea Level Rise
more efficient irrigation	Climate Instability	Infrastructure
more stringent regulations that would increase energy efficiency and further control air pollutants	Air Temperature and Chemistry	Infrastructure
Move health facilities out of vulnerable zones provide distributed health services	Human Health	Land Use
Natural breakwaters to inhibit erosion	Geomorphic Changes	Climate Instability, Sea Level Rise
Need more water retention areas for aquifer recharge	Climate Instability	Infrastructure

Need research on heat waves and affects/treatments for vulnerable citizens	Human Health	Variable Risk
Need to consider climate change in long-term regional planning	Variable Risk	Land Use
New site design	Land Use	Infrastructure
nutrient limitation other than fertilizer regulation	Water Chemistry and Temperature	Species and Habitats
Ocean fertilization	Air Temperature and Chemistry	Water Chemistry and Temperature
offering incentives for structured parking	Land Use	Infrastructure
Partner with utility companies to educate the public on energy efficiency and expand and increase incentives to homeowners (free/low cost loans for photovoltaic systems, net metering, solar panels)	Air Temperature and Chemistry	Infrastructure
permitting rules re siting for landfills, hazardous waste, etc	Land Use	Human Economy
Plan for agricultural impacts affecting local food providers as well as rising transportation costs for food grown outside Florida	Human Economy	Land Use

Plan vertical accretion of wetlands/marshes	Species and Habitats	Climate Instability, Sea Level Rise
plant submerged aquatic vegetation and other vegetation	Species and Habitats	Water Chemistry and Temperature
plug canals to protect coastal land/development,	Sea Level Rise	Water Chemistry and Temperature
plug canals to protect land from flooding and prevent subsidence inducing saltwater intrusion	Water Chemistry and Temperature	Climate Instability, Sea Level Rise
Preserve and restore the structural complexity and biodiversity of vegetation in tidal marshes etc.	Species and Habitats	Water Chemistry and Temperature
preserve ecological buffers	Species and Habitats	Land Use
Prevent or limit groundwater extraction from shallow aquifers to protect coast from subsidence and saltwater intrusion	Water Chemistry and Temperature	Geomorphic Changes
preventing subsidence	Geomorphic Changes	Infrastructure
prohibit bulkheads	Sea Level Rise	Species and Habitats
prohibit development subsidies (federal flood insurance and infrastructure development grants) to estuarine & coastal shores at high risk	Human Economy	Variable Risk

prohibit shoreline hardening	Human Economy	Species and Habitats
Promote green building alternatives through education, taxing incentives, building and design standards, green-lending	Infrastructure	Human Economy
Promote green roof technology through building codes	Infrastructure	Human Economy
Promote local food providers and community gardens	Human Economy	Land Use
Promote native vegetation and storm resistant tree canopy	Species and Habitats	Human Economy
Promote wetland accretion by introducing sediment and prohibit hard shore protection	Geomorphic Changes	Climate Instability, Sea Level Rise
protect groundwater sources	Water Chemistry and Temperature	Human Economy
protect stream banks from erosion/subsidence	Geomorphic Changes	Water Chemistry and Temperature
protection of barrier islands that shelter beaches	Geomorphic Changes	Climate Instability, Sea Level Rise
protection of water quality for fisheries and reefs	Water Chemistry and Temperature	Species and Habitats
Provide rebates for installation of low flow technology along with a progressive water pricing program	Infrastructure	Water Chemistry and Temperature

purchase upland development rights expand planning horizons	Land Use	Variable Risk
purchase coastal land that is damaged or prone to damage	Variable Risk	Human Economy
Purchase of coastal land damaged by storms and sea level rise for use for conservation as wetland retreat and fishery habitats with replication of habitat types up gradient	Species and Habitats	Climate Instability, Sea Level Rise
pursue GHG control and sequestration technologies	Air Temperature and Chemistry	Water Chemistry and Temperature
redefine flood hazard zones	Land Use	Human Economy
Reduce carbon dioxide	Air Temperature and Chemistry	Water Chemistry and Temperature
reduce CO2 emissions to reduce ocean acidification	Water Chemistry and Temperature	Species and Habitats
reduce heat islands from parking by using shared parking	Air Temperature and Chemistry	Infrastructure
Reduce other greenhouse gas emissions	Air Temperature and Chemistry	Water Chemistry and Temperature
reduce urban heat islands with building codes and more trees	Air Temperature and Chemistry	Infrastructure
regulate import of exotics	Species and Habitats	Variable Risk

regulation of pumping near shorelines, especially for flood control	Geomorphic Changes	Climate Instability, Sea Level Rise
relocation/migration of seagrass beds towards new shallows	Species and Habitats	Water Chemistry and Temperature
removal of barriers to dispersal	Species and Habitats	Land Use
Remove canal walls in areas of inundation	Sea Level Rise	Species and Habitats
remove hard protection or other barriers to tidal and riverine flow	Sea Level Rise	Water Chemistry and Temperature
remove hardening structures to allow shoreline migration	Sea Level Rise	Species and Habitats
Remove invasive plants and animals and restore natives	Species and Habitats	Water Chemistry and Temperature
Remove or reconfigure hazardous building elements and utilities	Human Health	Climate Instability, Sea Level Rise
Remove unnecessary infrastructure and inundated infrastructure	Infrastructure	Human Economy
Replace and/or repair with more tolerant materials	Infrastructure	Human Economy
Replicate habitat in multiple areas to spread risks identify and protect ecologically significant areas	Species and Habitats	Variable Risk
Research an action plan for tropical diseases	Human Health	Human Economy

Research possible asthma increase due to climate change and identify resulting impacts to health	Human Health	Human Economy
Restoration of Submerged Aquatic Vegetation	Species and Habitats	Water Chemistry and Temperature
Restore native species	Species and Habitats	Land Use
restrict or prohibit development in erosion zones	Human Economy	Geomorphic Changes
retreat/abandon shore headland control	Geomorphic Changes	Human Economy
Reuse foundations	Infrastructure	Human Economy
Rolling easements	Sea Level Rise	Human Economy
select different species for livestock	Human Economy	Species and Habitats
selection of hardier livestock breeds	Human Economy	Species and Habitats
Selectively move ecosystems north	Species and Habitats	Land Use
short and long term legislation	Variable Risk	Human Economy
Strengthen rules that prevent introduction of invasive plants and animals	Species and Habitats	Variable Risk
Stricter vehicle emission standards	Human Health	Air Temperature and Chemistry
Subsidize retrofitting buildings for energy efficiency	Infrastructure	Air Temperature and Chemistry
Take into consideration climate impacts and positive environmental services when considering acquisition	Land Use	Air Temperature and Chemistry

technological improvements to reduce pollutants from vehicles,	Air Temperature and Chemistry	Human Health
tree protection/shading to prevent evaporation	Species and Habitats	Land Use
Update wind maps	Variable Risk	Climate Instability, Sea Level Rise
use artificial breakwaters to reduce wave energy	Geomorphic Changes	Climate Instability, Sea Level Rise
use CLIP, FNAI, Cooperative Conservation Blueprint, etc to prioritize land purchases	Land Use	Species and Habitats
use coastal management in land planning	Land Use	Climate Instability, Sea Level Rise
use drought resistant crops,	Human Economy	Water Chemistry and Temperature
use longer planning horizons	Variable Risk	Land Use
use of "green streets"		
Use of carbon offsets	Air Temperature and Chemistry	Water Chemistry and Temperature
use of grey water	Water Chemistry and Temperature	Infrastructure
use of LID	Infrastructure	Air Temperature and Chemistry
Use of natural breakwaters	Geomorphic Changes	Climate Instability, Sea Level Rise
use of rain barrels/cisterns	Water Chemistry and Temperature	Infrastructure
Use trees, blinds, shutters for shade	Air Temperature and Chemistry	Infrastructure

Values might change as to what constitutes “wealth” and how that relates to the economy	Human Economy	Variable Risk
ventilation	Infrastructure	Air Temperature and Chemistry
water conservation methods	Water Chemistry and Temperature	Infrastructure
Water markets	Infrastructure	Water Chemistry and Temperature
Water pressure boosters	Infrastructure	Water Chemistry and Temperature
Water reuse and rainwater harvesting	Infrastructure	Water Chemistry and Temperature
Water supply planning & regulation consider climate change in water planning	Variable Risk	Water Chemistry and Temperature
water-conserving appliances/fixtures	Infrastructure	Water Chemistry and Temperature
Work on guidelines and incentives for Homeowner’s Associations and individual homeowners for mitigation and adaptation measures	Air Temperature and Chemistry	Water Chemistry and Temperature
xeriscaping	Water Chemistry and Temperature	Species and Habitats

Appendix VII: Adopted SWFRPC Resolution #07-01

Begins on Next Page

SWFRPC Resolution #07-01

Southwest Florida Regional Planning Council Fertilizer Resolution

A RESOLUTION SUPPORTING THE REGULATED USE OF FERTILIZERS CONTAINING NITROGEN AND/OR PHOSPHORUS WITHIN SOUTHWEST FLORIDA; PROVIDING SPECIFIC RECOMMENDATIONS AND GUIDELINES TO BE CONSIDERED BY LOCAL GOVERNMENT JURISDICTIONS FOR THE REGULATION AND CONTROL OF FERTILIZER APPLICATION; PROVIDING RECOMMENDED DEFINITIONS; PROVIDING RECOMMENDATIONS RELATING TO TIMING OF FERTILIZER APPLICATION, CONTENT AND APPLICATION RATE, IMPERVIOUS SURFACES, BUFFER ZONES AND MECHANICAL APPLICATION; PROVIDING RECOMMENDED EXEMPTIONS; PROVIDING RECOMMENDATIONS FOR LICENSING OF COMMERCIAL AND INSTITUTIONAL APPLICATORS; PROVIDING RECOMMENDATIONS FOR PUBLIC EDUCATION PROGRAMS; PROVIDING RECOMMENDATIONS RELATING TO THE RETAIL SALE OF FERTILIZER; PROVIDING RECOMMENDATIONS FOR APPEALS, ADMINISTRATIVE RELIEF AND PENALTIES; PROVIDING FOR AN EFFECTIVE DATE.

WHEREAS, Southwest Florida is a region where the water quality of the bays, estuaries, rivers, lakes, wetlands, bayous and the Gulf of Mexico is critical to the region's environmental, economic, and recreational prosperity and to the health, safety and welfare of the citizens of this region;

WHEREAS, recent increased frequency and duration of red tide blooms and increased accumulation of red drift algae on local beaches and other algae and water related problems have heightened community concerns about water quality and cultural eutrophication of surrounding waters;

WHEREAS, there is a need to develop a stronger knowledge of the connection between activities in yards, streets, and stormwater systems and natural water bodies among all those who live, work and recreate in the Southwest Florida Region;

WHEREAS, this resolution is part of a multi-pronged effort by the Southwest Florida Regional Planning Council to reduce nutrient leaching and runoff problems by actions including, but not limited to, stormwater management, water conservation, septic systems, central sewage treatment, public education, restoration of surface and groundwater levels; and regional drainage of native habitats;

WHEREAS, nutrients are essential elements for plant growth and are commonly used in various forms as a Fertilizer for lawns (Turf), specialized Turf and landscape application;

WHEREAS, leaching and runoff of nutrients from improper or excess fertilization practices can contribute to nitrogen and phosphorus pollution of the Southwest Florida's water resources;

WHEREAS, the amount of Fertilizer applied should be the minimum necessary for the lawn (Turf), specialized Turf and Landscape Plants to meet initial establishment and growth needs;

WHEREAS, it has been recognized by soil science professionals that the use of slow release nitrogen sources acts to minimize harmful nitrate leaching;

WHEREAS, nitrogen from slow release sources is more likely to be used by plants and less likely to leach into groundwater or wash away in stormwater runoff;

WHEREAS, the amount of Fertilizer applied and the method of application of that Fertilizer has a great impact on the potential for creating water pollution; and

NOW, THEREFORE, BE IT RESOLVED by the Southwest Florida Regional Planning Council that the following provisions are recommended to local government jurisdictions in Southwest Florida as a basis for controlling, regulating and monitoring the use and application of Fertilizers in Southwest Florida:

SECTION 1: PURPOSE AND INTENT

A. **The Southwest Florida Regional Planning Council declares its support for the reasonable regulation and control of Fertilizers containing nitrogen and/or phosphorus and hereby provides specific management guidelines for Fertilization in order to minimize the negative environmental effects said Fertilizers have in and on Southwest Florida lakes, canals, estuaries, interior wetlands, rivers and near shore waters of the Gulf of Mexico. Collectively these water bodies are a natural asset, which are critical to the environmental, recreational, cultural and economic well being of this region and the surrounding areas and contribute to the general health and welfare of the public. Recent red tide blooms, accumulation of red drift algae on local beaches, and the freshwater releases from Lake Okeechobee via the Caloosahatchee River have heightened community concerns about water quality and eutrophication of estuary, bay, river and coastal waters. Regulation of nutrients, including both phosphorus and nitrogen contained in Fertilizer entering the water bodies in this region is a crucial step towards improving and maintaining water and habitat quality.**

B. **The purpose of this Resolution is to provide specific recommendations and guidelines to be considered by local government jurisdictions in Southwest Florida for the regulation and control of Fertilizer application containing nitrogen and/or phosphorus.**

SECTION 2: RECOMMENDED DEFINITIONS

The following are the minimum recommended definitions and the words, terms, and phrases when used in this Resolution shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

Applicator means any Person who applies, in any manner, Fertilizer to Turf and/or Landscape Plants as defined in this resolution.

Blended Fertilizer means a simple physical mixture of dry fertilizer materials. In blended fertilizers, the individual particles remain separate in the mixture, and there is a potential for segregation of the nutrients.

Commercial Fertilizer Applicator means any Person who applies Fertilizer on Turf and/or Landscape Plants in Southwest Florida in exchange for money, goods, services or other valuable consideration.

Fertilize, Fertilizing, or Fertilization means the act of applying Fertilizer to a lawn (Turf), Specialized Turf, or Landscape Plant.

Fertilizer means any substance that contains one or more recognized plant nutrients and promotes plant growth, or controls soil acidity or alkalinity, or provides other soil enrichment, or provides other corrective measures to the soil.

Granulated Fertilizer means a solid, homogenous mixture of fertilizer materials. Each uniform-size fertilizer particle contains all of the nutrients in the grade.

Institutional Applicator means any Person, other than a Non-Commercial or Commercial Applicator (unless such definitions also apply under the circumstances), that applies Fertilizer for the purpose of maintaining Turf and/or Landscape Plants. Institutional Applicators shall include, but shall not be limited to, owners and managers of public lands, schools, parks, religious institutions, utilities, industrial or business sites and any residential properties maintained in condominium and/or common ownership.

Landscape Plant means any native or exotic tree, shrub, or groundcover (excluding Turf).

Non-Commercial Fertilizer Applicator means any Person other than a Commercial Fertilizer Applicator or Institutional Applicator who applies Fertilizer on Turf and/or Landscape Plants in Southwest Florida, such as an individual owner of a single-family residential unit.

Person means any natural Person and shall also mean any business, corporation, association, club, organization, and/or any group of people acting as an organized entity.

Slow Release, Controlled Release, Timed Release, Slowly Available, or Water Insoluble Nitrogen means nitrogen in a form which delays its availability for plant uptake and use after application, or which extends its availability to the plant longer than a reference "Rapid Release Nitrogen" product. Forms of *Slow Release, Controlled Release, Slowly Available*, or *Water Insoluble Nitrogen* include:

1) Isobutylidene diurea (IBDU);
2) Resin, Polymer, or Sulpher coated urea;
3) Biosolids or residuals from domestic wastewater treatment;
4) Urea formaldehyde;
5) Composted animal manure; and
6) Others as may be designated by the appropriate governmental entities.

Slow Release Landscape Management Plan is a service specific schedule and checklist plan that includes contractor requirements, timing of service specifications including mowing, trimming, edging, fertilizing schedule that uses only slow release fertilizer, pH control, weed control, pest control, seeding, pruning, mulch management, herbicide use, and irrigation

Specialized Turf Manager means a Person responsible for fertilizing or directing the fertilization of a golf course or publicly owned ball field.

Turf means a piece of grass-covered soil held together by the roots of the grass; sod; lawn.

SECTION 3: RECOMMENDATIONS RELATING TO TIMING OF FERTILIZER APPLICATION; CONTENT AND APPLICATION RATE; IMPERVIOUS SURFACES; BUFFER ZONES; AND MECHANICAL APPLICATION

A. **Timing of Application**
No Applicator shall apply Fertilizers containing nitrogen and/or phosphorus to Turf and/or Landscape Plants during the "rainy season" (defined as July 1 through September 30 of each calendar year).

B. **Fertilizer Content and Application Rate**

1) No Fertilizer shall be applied to Turf and/or Landscape Plants within Southwest Florida that contains more than 2% phosphorous or other compounds containing phosphorous, such as phosphate, per guaranteed analysis label (as guaranteed analysis and label are defined by Chapter 576 Florida Statutes, such definition incorporated herein). The use of no phosphorus Fertilizer is strongly encouraged, as Florida soils typically contain sufficient phosphorus for a healthy native or man-made landscape

2) Fertilizer applied to Turf and/or Landscape Plants within the Southwest Florida must contain no more than 20% total nitrogen, with at least 70% as Slow Release Nitrogen per guaranteed analysis label (as guaranteed analysis and label are defined by Chapter 576 Florida Statutes, such definition incorporated herein).

3) Fertilizer applied to Turf and/or Landscape Plants within Southwest Florida must be slow release, granulated fertilizer. Blended fertilizer shall not be applied.

4) Fertilizers should be applied to Turf and/or Landscape Plants at the lowest rate necessary without exceeding the maximum weight per application. Fertilizer shall not be applied at a rate greater than one (1) pound of nitrogen per 1000 square feet per application. No more than four (4) pounds of nitrogen per one thousand (1000) square feet shall be applied to any Turf/landscape area in any calendar year.

The above provisions are also applicable to and regulate the application of pesticide/Fertilizer mixtures, including, but not limited to, "weed and feed" products.

C. **Total Yearly Applications**

While single Fertilizer applications in the fall and spring will often suffice, Fertilizers shall not be applied more than six (6) times during any one calendar year to a single area. A Controlled Release Landscape Management Plan is strongly recommended.

D. **Impervious surface**

Fertilizer shall not be applied, spilled, or otherwise deposited on any impervious surfaces. Any Fertilizer applied, spilled, or deposited, either intentionally or accidentally, on any impervious surface shall be immediately and completely removed. Fertilizer released on an impervious surface must be immediately contained and either legally applied to Turf or any other legal site, or returned to the original or other appropriate container.

E. **Buffer Zones**

No Fertilizer shall be applied within 25 feet of any pond, stream, water course, lake, retention areas, drains and drainage ditches or canal, or in any designated wetland or within 25 feet of any wetland as defined by the Florida Department of Environmental Protection (Chapter 62-340, F.A.C. defines Florida Wetland as "Those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils").

F. **Mechanical Application**

Spreader deflector shields are required when fertilizing by use of any broadcast spreaders. Deflectors must be positioned such that Fertilizer granules are deflected away from all impervious surfaces and water bodies, including wetlands.

SECTION 4: RECOMMENDED EXEMPTIONS

A. Section 3, Subsections (A)-(C) of this Resolution shall not apply to:

1) Newly established Turf and/or Landscape Plants for the first 60 days after installation or planting, provided documentation for newly established Turf and/or Landscape Plants is maintained to support this exemption;
2) Damaged Turf and/or Landscape Plants for a period of 60 days and only on the damaged areas, provided documentation for damaged Turf and/or Landscape Plants is maintained to support this exemption;
3) Areas where soil tests confirm, and such tests are confirmed and approved by the local government Natural Resources Director or designee, that phosphorous levels are below 10 parts per million. This is equivalent to a "very low" designation for phosphorus set forth in UF/IFAS Extension Soil Testing Laboratory Analytical Procedures Training Manual (Circular 1248, September 2002);
4) Vegetable gardens, provided they are not within 25 feet of any water body and/or wetland;
5) Yard waste compost, mulches, or other similar materials that are primarily organic in nature and are applied to improve the physical condition of the soil; and
6) Reclaimed water used for irrigation provided it is not used within 25 feet of any water body and/or wetland.

B. For all golf courses, the provisions of the Florida Department of Environmental Protection document, *"Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses" January 2007*, as updated, shall be followed when applying Fertilizer to golf course practice and play areas. This document can be accessed on-line on the Florida Department of Environmental Protection website at http://www.dep.state.fl.us. All other Specialized Turf Managers shall use their best professional judgment to apply the concepts and principles embodied in the "*Florida Green Industries Best Management Practices for Protection of Water Resources in Florida, June 2002*" while maintaining the health and function of their Specialized Turf areas. The Florida Department of Agriculture and Consumer Services, division of agricultural and Environmental

Services is in the process of developing Rule 5E-1.003 providing clarification of existing language and establishing labeling criteria for urban lawn or Turf Fertilizer products and adoption of Best Management Practices for Nitrogen applications for the Green Industry and the Golf Course Industry, under the authority of 576.181 F.S. and implemented in 576.021 F.S.

C. All commercial agricultural activities as defined by the Florida Department of Agriculture and Consumer Services, Division of Agriculture and Environmental Sciences are exempt from the recommendations of this resolution. The use of fertilizer and the Best Management Practices (BMP) for commercial agriculture activities is regulated and managed under the authority of the Florida Department of Agriculture and Consumer Services, Division of Agriculture and Environmental Sciences shall be followed when applying fertilizer to agricultural areas.

SECTION 5: RECOMMENDATION FOR LICENSING OF COMMERCIAL AND INSTITUTIONAL APPLICATORS.

A. In the absence of any uniform licensing requirements by the State government for Commercial and Institutional Fertilizer Applicators, it is recommended that, in addition to any current or future training or education requirements mandated by the State or local governments, that each local government jurisdiction establish a licensing procedure that will provide for the regulation and monitoring of Fertilizer use by Commercial and Institutional Applicators. After the implementation of such licensing procedure, no Commercial Fertilizer Applicator or Institutional Fertilizer Applicator shall apply Fertilizer without obtaining a license from the appropriate governmental licensing entity (hereinafter such Person referred to as "Licensee"). Persons working as employees under the direct supervision of landscapers or other contractors who hold a License shall be exempt, provided that such landscaper or other contractor holds a current, valid license.

B. Upon compliance with the requirements set forth in this section, and upon payment of any local government application fee established to recover the application costs of the governmental entity, the applicant would be issued a Commercial/Institutional Applicator License. Thereafter, as continuing conditions and requirements of such Commercial/Institutional Applicator License, such Person, and all Persons working or providing services under the authority granted to such Licensee:

1) Shall apply Fertilizer to Turf and/or Landscape Plants in accordance with all provisions of this Resolution.

2) Shall be responsible for maintaining a record of the pounds of nitrogen, expressed as pounds per 1,000 square feet of land, applied to each site by the Licensee during the year. If applying Fertilizer under any exemption or administrative variance, the Licensee shall also maintain documentation to support said exemption(s) or variance. If applying Fertilizer in accordance with Section 4(A)(3) of this Resolution, the Licensee shall also possess a record of the soil test indicating the amount of phosphorus present and a copy of the approved exemption. Said records shall be kept in the Licensee's possession or vehicle(s) and available for inspection by local staff during all business hours or while the Licensee is at a customer's site.

3) Shall permit the local government to obtain a sample of any Fertilizer applied or to be applied within the jurisdiction of the local government. If the sample analysis shows that nitrogen and/or phosphorus content does not comply with the levels permitted by this Resolution, enforcement may be taken in accordance with the terms of this regulation, and the cost of analyzing Fertilizer samples taken from Commercial Fertilizer Applicators or Institutional Applicators shall be reimbursed by said Applicator to the local government within thirty (30) days after invoicing.

4) A Licensee with a Commercial/Institutional Fertilizer Applicator License shall be on-site at all times when Fertilizers are being applied.

After the initial Commercial/Institutional Fertilizer Applicator License is received, renewal of the Commercial/Institutional Fertilizer Applicator License shall be renewed on an annual basis. Failure of a Licensee to comply with the provisions of the applicable Regulation or Ordinance shall constitute grounds to suspend a license, or to deny renewal of such license.

SECTION 6: RECOMMENDED PUBLIC EDUCATION PROGRAM

A. Public Education is highly recommended regarding the appropriate use of Fertilizers. Local governments will work with the IFAS Cooperative Extension staff to offer "Fertilizer Application" courses to all current and future Applicators wishing to obtain the Commercial/Institutional Fertilizer Applicator License.

B. A general education program will be coordinated with local media to advise the public on the proper use of Fertilizer and the environmental and health problem associated with mis-use. Such education program will be based upon and utilize materials form the Florida Yards and Neighborhoods Program (FY&N).

The objectives of the FY&N program are to:

- reduce stormwater runoff
- decrease non-point source pollution
- conserve water
- enhance wildlife habitat
- create beautiful landscapes

FY&N encourages homeowners to water efficiently, mulch, recycle, select the least toxic pest control measures, put the right plant in the right spot, Fertilize only when necessary, provide food, water and shelter for wildlife, protect surface water bodies (i.e., bays, rivers, streams, ponds, etc.) and minimize stormwater runoff.

SECTION 7: RECOMMENDATIONS RELATING TO THE RETAIL SALE OF FERTILIZER

Retail businesses within the jurisdiction selling Fertilizer shall post a notice in a conspicuous location near the Fertilizer notifying customers of the limitation on the use of Fertilizer containing greater than 2% phosphorus and/or greater than the 20% total nitrogen with a 70% minimum Slow Release nitrogen requirement.

SECTION 8: RECOMMENDATIONS FOR APPEALS, ADMINISTRATIVE RELIEF AND PENALTIES.

Each local government jurisdiction should establish provisions for appeals of administrative decisions and/or denials, provisions for administrative relief in the event of unique circumstances not addressed by local government Fertilizer regulations, and penalty and enforcement provisions necessary to accomplish the goals and objectives of the local jurisdiction's Fertilizer regulations.

NOTE: **Please note that these provisions do not address farming operations or tree/plant nurseries. (Although the definition of "Fertilize" refers to lawn, Specialized Turf or Landscape Plant).**

PASSED AND DULY ADOPTED BY THE SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL this 15th day of March, 2007.

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

Jim Coletta, Chairman

ATTEST:

David Burr, Executive Director

Appendix VIII.

September 3, 2009 Public Meeting in Punta Gorda

Developing a Climate Adaptation Plan

for the City of Punta Gorda

Agenda

Tuesday, September 3, 2009

8:30 Registration and refreshments. Participants are asked to complete a questionnaire.

9:10 Welcome: Maran Hilgendorf, CHNEP

9:05 CHNEP Climate-Ready Estuaries: Lisa Beever, CHNEP

9:20 The Draft City of Punta Gorda Adaptation Plan

10:00 Break

10:15 Public comments and recommendations

11:55 *Thank you* for participating in the workshop today!

Draft vulnerability and adaptation reports will be available at the CHNEP website. An email message will be sent to all who provided one with the links to these reports.

Please attend . . .

Thanks to the City of Punta Gorda and to PGI Civic Association for hosting these workshops.