# ASSESSMENT REPORT OF REGIONAL DIFFERENCES WITHIN FLORIDA



# WITHIN THE CONTEXT OF THE TRAINERS AND TOOLS PROJECT: BUILDING COASTAL FLOOD HAZARD RESILIENCY IN FLORIDA'S REGIONAL PLANNING COUNCIL COMMUNITIES

Prepared by: South Florida Regional Council

July 2016

# **Project Overview**

Projected sea level rise impacts threaten to exacerbate the vulnerability of Florida's at-risk coastal resources. Adapting to and mitigating sea level rise impacts will require that it be incorporated into all levels of hazard mitigation and land use planning in Florida. This comparative analysis provides an overview of five regional planning areas within Florida, zooming to ten regional planning councils (RPCs). The regional differences are assessed with particular respect to how each can uniquely address coastal vulnerabilities and mitigate losses appropriately aligned to local characteristics but using a statewide framework. In addition to geologic and geographic differences, there are also differences in levels of readiness and what planning and adaptation work has already been done to increase resilience. These variations will be highlighted within this report. All RPCs have completed a Regional Evacuation Study, which produced the storm surge maps for their region, but these are at different levels of being updated<sup>1</sup>.

This report uses recent research and data on Florida's vulnerability to sea level rise and coastal flooding, as well as feedback from RPC representatives within the larger project, Trainers and Tools: Building Coastal Flood Hazard Resiliency in Florida's Regional Planning Council Communities. The overarching goal of the project is creating a unified multi-region coastal resilience network for Florida to provide an iterative set of co-benefits. In developing this statewide coastal resilience structure for this project, a framework will be set in place which can be adjusted to be applied to any other resilience grant or project, from adaptation planning and vulnerability assessments, to hazard mitigation and emergency management.

The Florida Department of Economic Opportunity (DEO), in partnership with the South Florida Regional Planning Council, University of Florida, and NOAA Office for Coastal Management is undertaking this Trainers and Tools project to enhance sea-level rise resilience throughout the ten regional planning councils.

<sup>&</sup>lt;sup>1</sup> http://www.floridadisaster.org/res/

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#### Acknowledgements

This report was prepared by the following team of individuals:

#### **Department of Economic Opportunity**

#### South Florida Regional Council

Taylor Teepell, Director, Division of Community Development Adam Antony Biblo, Program Manager Sean Reiss, Project Coordinator Isabel Cosio Carballo, Executive Director Keren Bolter, Project Manager

In 2011, the Florida Department of Economic Opportunity (DEO) initiated a five-year project to integrate sea level rise (SLR) adaptation into planning, including the local comprehensive plan, hazard mitigation plan, and post-disaster redevelopment plan<sup>2</sup>. The initiative is supporting this project of special merit in piloting adaptation planning guidance in coastal communities as well as compiling lessons learned and conducting information dissemination and outreach. Through funding from the National Oceanographic and Atmospheric Administration (NOAA) and the Florida Department of Environmental Protection (DEP), DEO is working with the South Florida Regional Planning Council (SFRPC) and Florida's nine other Regional Planning Councils to create resources including regional Vulnerability Assessments and a series of trainings.



This publication was funded in part, through a grant agreement from the Florida Department of Environmental Protection, Florida Coastal Management Program, by a grant provided by the Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act of 1972, as amended, National Oceanic and Atmospheric Administration Award No. NA15NOS4190217. The views, statements, findings, conclusions and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the State of Florida, NOAA or any of their sub-agencies.

<sup>&</sup>lt;sup>2</sup> For more information on DEO's resources for Adaptation Planning, please visit http://www.floridajobs.org/adaptationplanning

#### **INTRODUCTION**

Vulnerability must be considered in three dimensions: likelihood, exposure, and adaptive capacity. First, vulnerability to sea level rise is based on physical characteristics related to the likelihood of inundation. This includes elevation, aquifer characteristics, local storm surge height projections, local tidal variations, and measures to protect the coastline (including natural buffers as well as hardened shorelines and flood mitigation processes. These and other factors influence the probability that a certain area will experience inundation during extreme events such as king tides and hurricanes. However, if inundation occurs in an area that is undeveloped and robust to rebound from saltwater flooding, the impacts are minimal. This indicates a low level of exposure, even when there is a high level of risk. Therefore, exposure is directly related to populations and assets that are impacted by inundation at various heights, timings, and frequencies. Exposure can be measure by variables including property value, low-income populations, and ecosystems impacted. Adaptive capacity is defined by the Intergovernmental Panel on Climate Change (IPCC) as "Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behavior and in resources and technologies."<sup>3</sup> Adaptive capacity enables stakeholders to find opportunities within the community development and policy structures to take actions which increase the ability of the area to recover from extreme events. Vulnerability assessments currently provide a breadth of understanding of where adaptive capacity comes from. Communities who have completed vulnerability assessments and engaged the residents are more likely to have considered their risks and planned for chosen sea level rise planning horizons.



The principal tools utilized in this report for analyzing each region's likelihood of risk are LIDAR elevation modelling and suge modelling (Which uses the Sea, Lake and Overland Surges from Hurricane (SLOSH) numerical storm surge prediction model). The assets, demographics, unique features, and adaptation planning actions are described to paint a picture of exposure and adaptive capacity. The following sections describe the regional differences in this context. The relative populations exposed can also be compared by viewing the census maps on Appendices B and C. Data and maps for storm surge zones for each coastal county can be found at <a href="http://www.floridadisaster.org/gis/data/index.htm#stormsurge">http://www.floridadisaster.org/gis/data/index.htm#stormsurge</a>. Statewide evacuation zones can be explored interactively at

http://floridadisaster.maps.arcgis.com/apps/webappviewer/index.html?id=c788060028cb43809a25744 ead39c0d6.

<sup>&</sup>lt;sup>3</sup> https://www.ipcc.ch/publications\_and\_data/ar4/wg2/en/ch17s17-3.html

#### LOCAL SEA LEVEL RISE RATES

Local sea level rise rates throughout Florida are very similar to the Global rate of sea level rise. National Oceanographic and Atmospheric Administration's (NOAA's) Center for Operational Oceanographic Products and Services has been measuring sea level for over 150 years, with 14 tide gauges in Florida<sup>4</sup>. Figure 1 illustrates that most of the trends within Florida have been an increase which is below 3mm/yr (1ft/century) (indicated in green), however, there are three locations, indicated in yellow, which which this is exceeded. Figure 1 is a screenshot of an interactive tool in which the arrows can be clicked to get more precise rates, as well as average seasonal cycles and interannual variations. For example, in Vaca Key, the mean sea level trend is 3.53 mm/year with a 95% confidence interval of +/- 0.48 mm/year based on monthly mean sea level data from 1971 to 2015 which is equivalent to a change of 1.16 feet in 100 years. These statistics can be viewed for each of the 14 gauges.



Sea Level Trends mm/yr (feet/century)

15 to 21 (5 to 7)	6 to 9 (2 to 3)	-3 to 0 (-1 to 0)	-12 to -9 (-4 to -3)
12 to 15 (4 to 5)	3 to 6 (1 to 2)	-6 to -3 (-2 to -1)	-15 to -12 (-5 to -4)
9 to 12 (3 to 4)	0 to 3 (0 to 1)	-9 to -6 (-3 to -2)	-18 to -15 (-6 to -5)

Figure 1: Long term sea level trends in Florida. Source http://tidesandcurrents.noaa.gov/sltrends

<sup>&</sup>lt;sup>4</sup> http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

Figure 2 illustrates the variation in elevation throughout Florida. The variation in elevation ranges throughout the state, with coastal areas having elevations below 4 feet, and inland areas going up to 346 feet NAVD88.



Figure 2: Composite Digital Elevation Model (DEM) created from combining the best available sources, listed in the metadata (Appendix A).

#### WEST FLORIDA

The West Florida Region includes Bay, Escambia, Holmes, Okaloosa, Santa Rosa, Walton and Washington counties and their respective municipalities. The westernmost region in the State has three transportation planning organizations and a relatively low but growing population among the regions. Priority planning issues in West Florida are centered around issues related to economy, environment, land-use, and transportation. Figures 3 and 4 illustrate the regions vulnerability to extreme tides and surge. According to the Statewide Regional Evacuation Study for the West Florida Region (SRES), the lower five coastal counties have extensive coastline and low-lying areas which have relatively dense populations<sup>5</sup>. Figure 4 shows that a category 3 hurricane at high tide would produce a maximum surge of 14.1 feet above ground. The surge height increases moving west throughout the region. Figure 5 shows the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation. There are three areas with extensive inundation for a category 1 storm, include two areas northeast of Pensacola and one areas near Freeport.

The region is a unique part of the state that encompasses many hundreds of miles of coastline. The environment is a substantial driver of the economy as a healthy environment promotes a healthy economy. For example, for the economy to grow, the resources that surround business and industry must be able to sustain. There has been a disconnect in the past regarding this correlation. However, in recent years this correlation has been brought to the forefront of policy discussion within the region.

The region has conducted a vulnerability assessment which notes the exposure of military installations, transportation infrastructure, utility infrastructure, and rare coastal features to sea-level rise. The West Florida Regional Planning Council (WFRPC) has also partnered with various regional stakeholders to providing outreach and workshops to educated decision makers and county governments about the importance of community resiliency as it is tied to natural disasters.

However, participants in the Trainers project stated that the counties were not as engaged in the sea level rise conversation as would be ideal, and that there were many outreach opportunities on increase awareness. The recent flooding which had occurred in Pensacola did bring attention to the vulnerability of region.

<sup>&</sup>lt;sup>5</sup> http://www.wfrpc.org/pdfs/2%20-%20Executive%20Summary%20West%20Florida.pdf



Figure 3: Elevation ranges in West Florida



Figure 4: Pensacola Bay SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide



Figure 5: West Florida Region Storm Tide Map with Pensacola Bay SLOSH compared against elevation

#### APALACHEE

The Apalachee Region includes Calhoun, Franklin, Gadsden, Gulf, Jackson, Jefferson, Liberty, Leon and Wakulla Counties, with 28 incorporated municipalities. With 10% of the State's land and 2.4% of the State's population, the region is predominantly rural<sup>6</sup>. The priorities in Apalachee vary from county to county, but the overarching theme is economic stability for the rural counties. The economy is centered on natural resources based industries including forestry, fishing and agriculture. In addition, with the State Capital in Leon County, Tallahassee, there is a significant government services sectors within this area of the region. Tourism and recreation are an immense asset within the region, as the Apalachicola River and Bay are lush biologically productive estuarine systems providing valuable ecosystem services as well as locations for state parks, recreational areas, wilderness preserves, wildlife management areas, aquatic preserves and many designated recreational trails<sup>7</sup>. Over 30% of the regions land area is either publicly owned or is a conservation easement.

The Apalachee Regional Planning Council sees potential in working with Local community development and stormwater management type planners on resiliency issues, and has already worked with one coastal community on a private sector resiliency project. Compared to the rest of Florida, the Apalachee Region has a relatively small population living on their 900 miles of coastline. However, that population represents the majority of the county populations, particularly within Franklin, Gulf and Wakulla counties. The coastline is very susceptible to storm surge, and there is heightened awareness and perceived risk within the region to hurricane threats.

Figure 6 shows the variations in elevation within the Region. Figure 7 illustrates a category 3 hurricane at high tide, which would produce a maximum surge of 22.7 feet above ground. The surge height increases moving east throughout the region. The Statewide Regional Evacuation Study for the Apalachee Region (SRES) identifies key threats to the region as inland flooding, coastal flooding, wildfires, and hazardous materials. Figure 8 shows the SRES results with inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation and table 1 quantifies these height ranges. Figure 9 shows the 100-Year Flood Plain in the Apalachee Region in blue. More than half of the region's areas is within the Flood Plain.

<sup>&</sup>lt;sup>6</sup> http://thearpc.com/about-the-region/

<sup>&</sup>lt;sup>7</sup> http://thearpc.com/about-the-region/



Figure 6: Elevation ranges in the Apalachee Region



Figure 7: Apalachicola Bay SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide in the Apalachee Region



Figure 8: Apalachee Region Storm Tide Map

Table 1: Potential Storm Tide heights (Source http://thearpc.com/wpcontent/uploads/2015/11/VolumeIChapter4VulnerabilityandPopulationAssessment.pdf)

# Potential Storm Tide Height(s)\*\* by County (In Feet above NAVD88)

*Storm Strength	Franklin	Gulf	Jefferson	Leon	Wakulla
Category 1	up to 10'	up to 6'	up to 11'	N/A	up to 11'
Category 2	up to 14'	up to 11'	up to 18'	up to 16'	up to 18'
Category 3	up to 21'	up to 13'	up to 24'	up to 24'	up to 24'
Category 4	up to 24'	up to 17'	up to 37'	up to 34'	up to 33'
Category 5	up to 28'	up to 20'	up to 39'	up to 35'	up to 39'

\*Based on the category of storm on the Saffir-Simpson Hurricane Wind Scale \*\* Surge heights represent the maximum values from selected SLOSH MOMs



Figure 9: 100-Year Flood Plain in the Apalachee Region (Source http://thearpc.com/wp-content/uploads/2015/11/VolumeIChapter4VulnerabilityandPopulationAssessment.pdf)

#### NORTH CENTRAL FLORIDA

The North Central Florida Region includes Alachua, Bradford, Columbia, Dixie, Gilchrist, Hamilton, Lafayette, Madison, Suwannee, Taylor, Union, Levy and Marion counties in the north central portion of Florida. The region has a relatively low population of under 900,000 residents, many of which reside in the inland Alachua County. The region has plentiful natural resources including the Suwannee River, the marshes of the Gulf Coast, cypress swamps, upland forests, a large number of clear turquoise springs, and other physical features<sup>8</sup>. The region houses University of Florida in Gainesville, which provides a major portion of the government employment, and the city is the regional retail shopping center. Levy and Marion counties were recently added to the region, with Levy adding significantly to the county's coastal area. However, with less than 40,000 residents, there is less risk than if the county were densely populated.

As the region is relatively rural and unpopulated, economics of areas highly dependent on environmental considerations. Economic development is a large priority throughout the region. There has been little stakeholder engagement on issues related to coastal resilience. Stakeholders have seemed unsure about the issues and reluctant to plan for adaptation. Within this social context, the North Central Florida Regional Planning Council sees opportunities in using state and national resources to provide emergency management and local governments useful information about resilience.

According to the Statewide Regional Evacuation Study for North Central Florida Region (SRES), most of the coastal areas within the region are set aside for conservation<sup>9</sup>. This again indicates that there are less vulnerable populations, infrastructure, and assets, but there is likely more emphasis needed on resilience with natural systems and reducing barriers to ecosystem migration as sea level rises.

Figure 10 indicates the low-lying areas within Taylor, Dixie, and Levy Counties in red. Figure 11 shows that a category 3 hurricane at high tide would produce a maximum surge of 25.4 feet above ground. The surge height increases moving west throughout the region. Figure 2 shows the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation. This map was created for the SRES prior to the addition of Levy and Marion counties to the region and thus does not include them.

<sup>&</sup>lt;sup>8</sup> http://ncfrpc.org/region.html

<sup>&</sup>lt;sup>9</sup> http://ncfrpc.org/northcentraldisaster/sres2010/docs/Vol\_1/Chapter\_II\_Regional\_Hazards\_Analysis.pdf



Figure 10: Elevation ranges in the North Central Florida Region



Figure 11: Cedar Key SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide MOM Shapefile AboveGroundLevel)(Source:Source:slosh.nws.noaa.gov/sdp/momShp\_AGL.php?L=6)



Figure 12: North Central Florida Region Storm Tide Map

#### NORTHEAST FLORIDA

The Northeast Florida Region is comprised of seven counties (Baker, Clay, Duval, Flagler, Nassau, Putnam, and St. Johns) and 27 municipalities. The Region is characterized by natural resources including the lower St. Johns River, 140 miles of coastline, and five barrier islands<sup>10</sup>. Dubbed "Florida's First Coast," the region is experiencing increasing rates of urbanization and developing economic diversity. Jacksonville has the largest population (as an incorporated place) in Florida, and is land area is the largest in the U.S. Jacksonville has conducted a community resiliency assessment process entitled *Sea Level Rise - A Community Resiliency Assessment for the City of Jacksonville*<sup>11</sup>. Additionally, the City of Jacksonville was named as one of the Rockefeller's 100 Resilient Cities and the program looks at all aspects of climate change and resiliency.

The Northeast Florida region has an *Action Plan on Sea Level Rise*<sup>12</sup>. The local governments took a step back as the community took the initiative to create a business approach plan which includes 12 actions. The plan was organized by a private, business focused committee formed to focus on the policies and action items within the plan. The Northeast Florida Regional Council (NFERC) has engaged the business community, stakeholders and the community in the completion of action items<sup>13</sup>. As efforts are currently business focused, economic issues are being stressed. Environmental aspects are in view as well, due to the number of environmental groups that champion this cause (USGBC, Matanzas Basin, North Florida Land Trust).

By 2016, the committee hopes all Action items will be achieved, with the exception of a robust, Northeast Florida specific, vulnerability assessment. For the creation of the plan, multiple stakeholders were involved. For example, vulnerable population participated in rebuild by design in case of disaster. The plan has a focus on Community Rating System (CRS) participation and the committee is exploring the possibility of creating state priority- maps of future flood risk to gain CRS points.

The NEFRC created and hosts the Northeast Florida CRS Users Group in order to facilitation discussion among our local communities on CRS issues. NEFRC strives to promote CRS among communities and encourages those who do not participate to do so. They are actively looking for better ways of understanding how to make better use of limited data and how tools and toolsets can have an impact on CRS ratings in communities. NEFRC is working to draft basic comprehensive plan policies that can be used to satisfy the sea level rise adaptation requirement in recent legislation.

<sup>&</sup>lt;sup>10</sup> http://www.nefrc.org/Regional%20Information.htm

<sup>&</sup>lt;sup>11</sup> http://www.coj.net/departments/regulatory-compliance/docs/epb/jacksonville-sea-level-rise-community-resiliency-a.aspx

<sup>&</sup>lt;sup>12</sup> www.nefrc.org/pdfs/Regional%20Action%20Plan.pdf

<sup>&</sup>lt;sup>13</sup> http://www.rcinef.org/P2R2.html

According to the Statewide Regional Evacuation Study for the Northeast Florida Region (SRES), indicates that both coastal and inland counties have extensive low-lying areas<sup>14</sup>. Figure 13 indicates the low-lying areas within the region in red. Figure 14 shows that a category 3 hurricane at high tide would produce a maximum surge of 16 feet above ground. The surge height increases moving north throughout the region. Figure 15 shows the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation.



Figure 13: Elevation ranges in Northeast Florida

<sup>&</sup>lt;sup>14</sup> http://www.nefrc.org/NE-FL-SRESP.htm



Figure 14: Jacksonville SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide MOM Shapefile Above Ground Level) (Source: Source: slosh.nws.noaa.gov/sdp/momShp\_AGL.php?L=6 )



Figure 15: Northeast Florida Region Storm Tide Map with Jacksonville SLOSH compared against elevation

#### EAST CENTRAL FLORIDA

The East Central Florida Region includes six counties: Brevard, Lake, Orange, Osceola, Seminole, and Volusia. Bay, The region has several major cities including Orlando, Daytona Beach, Deland, Melbourne, Kissimmee, Leesburg, and Sanford. The region had an estimated April 2012 population of 3,267,931 people<sup>15</sup>. Priority planning issues in East Central Florida are centered around balancing conservation with transportation and development. Volusia County is tackling transportation issues and progressing environmental priorities by using sales tax to purchase conservation lands.

The East Central Florida Regional Council (ECFRC) has looked at resiliency and marsh migration, and how sea level rise will impact the future of conservation lands. A Volusia County Floodplain Management Plan (FMP) has been completed, incorporating a full risk analysis from a land use, financial, population, and critical facility perspective. A flood risk analysis was completed for the two coastal counties in the region: Volusia County Local Mitigation Strategy (LMS) and Brevard County Local Mitigation Strategy. ECFRC also worked with the City of Satellite Beach, as they were awarded a grant from the Florida Department of Environmental Protection to conduct a pilot on storm surge and sea level rise. The overarching goal was to bring more education to region.

According to the Statewide Regional Evacuation Study for the West Florida Region (SRES), the two counties have extensive coastline and low-lying areas<sup>16</sup>. Figure 16 indicates the low-lying areas within the East Central Florida Region in red. Many of these areas extent to inland counties. Figure 17 shows that a category 3 hurricane at high tide would produce a maximum surge of 13 feet above ground. Throughout the region, the surge height decreases dramatically as it moves west of the barrier islands. Figures 18 and 19 show SRES results for the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation. The storm tide atlas was only completed for the two coastal counties, Brevard and Volusia.

<sup>&</sup>lt;sup>15</sup> http://www.ecfrpc.org/About.aspx

<sup>&</sup>lt;sup>16</sup> http://www.ecfrpc.org/getdoc/d546bd93-7686-46f3-84fb-1cb3cbc42a41/SRES.aspx



Figure 16: Elevation ranges in East Central Florida



Figure 17: Cape Canaveral SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide MOM Shapefile Above Ground Level) (Source: Source: slosh.nws.noaa.gov/sdp/momShp\_AGL.php?L=6 )



Figure 18: Volusia County East Central Florida Region Storm Tide Map with Cape Canaveral SLOSH compared against elevation



Figure 19: Brevard County East Central Florida Region Storm Tide Map with Cape Canaveral SLOSH compared against elevation

#### TAMPA BAY

The Tampa Bay Region includes Citrus, Hernando, Hillsborough, Manatee, Pasco and Pinellas Counties. The region has a high amount of coastal exposure with large population near vulnerable areas<sup>17</sup>. Transportation is a paramount issue within the region. Port Tampa Bay is a huge part of the industry, handling nearly one-third of all cargo moving in and out of the state of Florida<sup>18</sup>. The Tampa Bay Regional Planning Council (TBRPC) is interested in creating a "Your port's resiliency tool" which looks at different aspects (economic, business and infrastructure) of ports to rate resiliency. TBRCP works with county staff in issues including planning, transportation, and emergency management. The Tampa Bay estuary program has used SLAMM (sea levels affecting marshes model) and other tools to evaluate risks to the Tampa Bay Estuary. There is a shift in focus towards keeping up to date with community.

The Tampa Bay Region has had meetings with policy makers and coastal resource agencies and stewards for the past two years on the subject of coastal flooding and sea level rise. This effort under the heading of "One-Bay Resilient Communities"<sup>19</sup> came away with three recommendations among other things, regarding sea level rise in the Tampa Bay area:

1. Projections of SLR should be "regionally corrected" using the St. Petersburg tide gauge.

2. Projections of SLR should be consistent with NCA (NOAA) estimates and methods.

3. Adaptation planning should employ a scenario-based approach that considers, at a minimum, location, time horizon and risk tolerance.

This culminated with the Tampa Bay Regional Council formally accepting the Tampa Bay Climate Science Advisory Panel (CSAP) report entitled "Recommended Projection of Sea Level Rise in the Tampa Bay Region" on October 12, 2015.

According to the Statewide Regional Evacuation Study for the Tampa Bay Region (SRES), the coastal counties have extensive coastline and low-lying areas which have relatively dense populations<sup>20</sup>. Figure 20 indicates the low-lying areas within the Tampa Bay Region in red showing extensive areas to the north, but also many areas along the coast of Tampa Bay and the barrier islands. Figure 21 shows that a category 3 hurricane at high tide would produce a maximum surge of 21.1 feet above ground, with the most extreme surge heights occurring in the northern counties as well as the eastern portion of Tampa Bay. Throughout the region, the surge height is higher than heights modeled on the east coast or to the south. Figure 22 shows SRES results for the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation.

<sup>&</sup>lt;sup>17</sup> http://www.tbrpc.org/

<sup>&</sup>lt;sup>18</sup> https://www.tampaport.com/About-Port-Tampa-Bay

<sup>&</sup>lt;sup>19</sup> http://www.tbrpc.org/onebay/working\_group.shtml

<sup>&</sup>lt;sup>20</sup> http://www.tbrpc.org/tampabaydisaster/sres2010/index.shtml



Figure 20: Elevation ranges in Tampa Bay Region, Florida



Figure 21: Tampa Bay SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide



Figure 22: Tampa Bay Region Storm Tide Map with Tampa Bay SLOSH compared against

#### elevation

#### **CENTRAL FLORIDA**

The Central Florida Region includes DeSoto, Hardee, Highlands, Okeechobee, and Polk counties and their respective municipalities and unincorporated areas. Priority planning issues in Central Florida are centered around issues related to potable water facilities planning, transportation, economic development, land use, and conservation. The agricultural community is the largest stakeholder to be impacted by issues related to climate change. The region is home to Lake Okeechobee, the largest lake in Florida, and the 2nd largest freshwater lake in the United States. The Central Florida Region experienced a large growth rate recently which slowed with the economic downturn<sup>21</sup>.

The Central Florida Regional Council (CFRPC) is the only RPC without a coastal county. Therefore, coastal vulnerability is something that has not discussed in much detail. There are possibilities to explore inland population migration and the impacts this will have on the agricultural community. Availability of resources would also be the greatest potential issue related to coastal sea level rise that may affect the region. However, CFRPC is still eager to learn more about coastal resiliency and conducting vulnerability assessments.

According to the Statewide Regional Evacuation Study for the West Florida Region (SRES), the five counties have populations within evacuation zones<sup>22</sup>. This is due to potential risk from lake flooding. Figure 23 indicates there are not many low-lying areas within the Central Florida Region. There are also no coastal counties, so the storm tide atlas analysis was not completed for the SRES.

<sup>&</sup>lt;sup>21</sup> http://www.cfrpc.org/programs/statewide-regional-evacuation-study/

<sup>&</sup>lt;sup>22</sup> http://www.cfrpc.org/programs/statewide-regional-evacuation-study/



Figure 23: Elevation ranges in Central Florida

#### SOUTHWEST FLORIDA

The Southwest Florida Region includes Charlotte, Collier, Glades, Hendry, Lee and Sarasota Counties. Four of the counties border the Gulf of Mexico, with a total shoreline of 4,515 miles, and comprise a large portion of the Region's urban area. Two counties are bounded by Lake Okeechobee, the second largest freshwater lake in the United States<sup>23</sup>. The top ten priority planning issues with respect to coastal vulnerability in Southwest Florida were identified and ranked

<sup>&</sup>lt;sup>23</sup> http://www.swfrpc.org/who\_we\_are.html

- 1) Public buildings and infrastructure
- 2) Fish and wildlife habitat degradation
- 3) Policy aimed towards resiliency strategies
- 4) Public water supply
- 5) Coastal erosion

- 6) Current Flooding events
- 7) Sea level rise
- 8) Unmanaged Coastal Growth
- 9) Emergency and hazard planning
- 10) Water Quality

The Southwest Florida Regional Planning Council (SWFRPC) worked with Charlotte Harbor National Estuary Program to compile a Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment. The social, economic and environmental context of coastal vulnerability in the southwest Florida region are identified and specified in the Technical Report. The natural setting of southwest Florida coupled with extensive overinvestment in the areas closest to the coast have placed the region at the forefront of coastal flooding. More severe tropical storms and hurricanes with increased wind speeds and storm surges have already severely damaged both coastal and interior communities of southwest Florida. Significant losses of mature mangrove forest, salt marsh migration, water quality degradation, and barrier island geomorphic changes have already occurred. Longer, more severe dry season droughts coupled with shorter duration wet seasons consisting of higher volume precipitation have generated a pattern of drought and flood impacting both natural and man-made ecosystems.

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.

The City of Punta Gorda has been very active as a leader in coastal resilience. This progressive municipality had already included climate change planning in their Comprehensive Plan, and it has an Adaptation Plan and 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.

The Adaptation plan 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. 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.

On January 12, 2010 Lee County contracted the SWFRPC to develop the Lee County Climate Change Resiliency Strategy (CCRS). The CCRS includes a process for identifying potential climate change resiliency strategies through coordination and consultation with local government leadership in 39 Lee County departments and divisions. Identification of resiliency strategies that could be utilized by Lee County to reduce the negative effects of climate change will also help in positioning the County to take advantage of potential climate prosperity opportunities. The CCRS is a toolbox that contains a wide variety of ideas and opportunities for the County to employ in climate change planning, energy savings, and cost savings. The CCRS informs the County of options and opportunities but it does not prioritize those actions or direct County policy.

According to the Statewide Regional Evacuation Study for the West Florida Region (SRES), the lower five coastal counties have extensive coastline and low-lying areas which have relatively dense populations<sup>24</sup>. Figure 24 indicates the low-lying areas within the Southwest Florida Region in red showing extensive areas in the Everglades to the south, but also in many areas along the coast of Charlotte Harbor, the Caloosahatchee River and the barrier islands. Figure 25 shows that a category 3 hurricane at high tide would produce a maximum surge of 16.1 feet above ground. Figure 26 shows SRES results for the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation.

<sup>&</sup>lt;sup>24</sup> http://www.swfrpc.org/emergency\_mgmt.html



Figure 24: Elevation ranges in Southwest Florida



Figure 25: Fort Myers SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide



Figure 26: Southwest Florida Region Storm Tide Map with Fort Myers SLOSH compared against elevation

#### TREASURE COAST

The Treasure Coast Region includes Indian River, Martin, Palm Beach and St. Lucie Counties. Treasure Coast is one of the smallest of the eleven planning regions in Florida in terms of area, in area, but it is the State's fourth most populous region. With strict growth management and inland conservation or agricultural lands, the coastal areas have been the location of most of the urban development. Agricultural land areas are dominant, providing citrus production, and unique agricultural areas such as the Glades (sugar cane) and the Agricultural Reserve (winter vegetables), both in Palm Beach County. Approximately, twenty percent of the Region's land area is in wetlands<sup>25</sup>.

A chapter of the *The Likelihood of Shore Protection along the Atlantic Coast of the United States* study was based on a report conducted for the Treasure Coast in 2010<sup>26,27</sup>. This report creates maps of the Treasure Coast Region that distinguish the shores that are likely to be protected from erosion, inundation, and flooding from those where natural shoreline retreat is likely to take place. The results show high likelihoods of protection in developed areas, and lower likelihoods with rural and natural spaces. The Seven50 project involved another comprehensive coastal resilience project within the Treasure Coast. The Analysis of the Vulnerability to Sea Level Rise of the Northern SE FL Counties provides an inventory of assets that are vulnerable to 1, 2, and 3 feet of sea level rise<sup>28</sup>.

According to the Statewide Regional Evacuation Study for the Treasure Coast Region (SRES), the coastal counties have extensive coastline and low-lying areas which have relatively dense populations<sup>29</sup>. Figure 27 indicates the low-lying areas within the Treasure Coast Region in red showing many coastal areas near the barrier islands in red. Figure 28 shows that a category 3 hurricane at high tide would produce a maximum surge of 13.6 feet above ground. Figure 29 shows SRES results for the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation.

<sup>&</sup>lt;sup>25</sup> http://www.tcrpc.org/special\_projects/RES/Disc%201%20Text%20Documents/Volume%201%20-

<sup>%20</sup>Technical%20Data%20Report/Volume%201%20-%20CH%201%20FINAL%20Executive%20Summary.pdf <sup>26</sup> Merritt, Peter. 2010. "Treasure Coast." In James G. Titus, Daniel L. Trescott, and Daniel E. Hudgens (editors). The Likelihood of Shore Protection along the Atlantic Coast of the United States. Volume 2: New England and the Southeast. Report to the U.S. Environmental Protection Agency. Washington, D.C.

<sup>&</sup>lt;sup>27</sup> http://risingsea.net/ERL/FL.html

<sup>&</sup>lt;sup>28</sup> https://assets.documentcloud.org/documents/2800019/Final-Northern-SE-FL-County-SLR-Vulnerability.pdf

<sup>&</sup>lt;sup>29</sup> http://www.tcrpc.org/special\_projects/RES/RES\_Home.html



Figure 27: Elevation ranges in Treasure Coast Region



Figure 28: Palm Beach SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide



Figure 29: Treasure Coast Region Storm Tide Map with Palm Beach SLOSH compared against elevation

(Source:

http://www.tcrpc.org/special\_projects/RES/Disc%201%20Text%20Documents/Volume%201%2 0-%20Technical%20Data%20Report/Volume%201%20-

%20CH%20II%20FINAL%20Regional%20Hazards%20Analysis.pdf)

#### SOUTH FLORIDA

The South Florida Region includes Broward, Miami-Dade and Monroe Counties. Miami-Dade is the state's most populous County and Broward County is ranked second. South Florida is highly urbanized and trade oriented. At the center of an international region, it serves as a network between the United States with Central and South America and the Caribbean. The Atlantic Ocean to the east and the Everglades system to the west create natural boundaries for the region, which is largely built-out, so future growth increasingly will take the form of infill development and redevelopment<sup>30</sup>. Even with the economic downturn, South Florida grew more rapidly (9.7%) than the nation as a whole (9.1%) during this decade.

The South Florida Region is a national leader in resilience. The Southeast Florida Regional Climate Change Compact (The Compact) has been given global attention for its local adaptation planning achievements. The Compact's efforts are recognized internationally as a pathway to a long-term solution. Fort Lauderdale, Broward County, and SFRPC have been key players in the ongoing efforts of the Compact<sup>31</sup>.

The Compact has been successful in amending Florida planning legislation to incorporate efforts to address sea level rise, and prioritize funding for this purpose. The Compact hosts an annual summit to bring key partners together to learn about new projects, ideas, and research relating to regional impacts for the Four County Regional Climate Action Plan. In addition to this plan, the Compact has produced several key documents to guide local governments including a Mayors' Climate Action Pledge, Climate Action Plan Implementation Guide, A Unified Sea Level Rise Projection for Southeast Florida, A Regional Greenhouse Gas Emissions Inventory: Baseline Period 2005 -2009, and a Comprehensive Analysis of the Vulnerability of Southeast Florida to Sea Level Rise.

According to the Statewide Regional Evacuation Study for the South Florida Region (SRES), the three counties have extensive coastline and low-lying areas which have relatively dense populations<sup>32</sup>. Figure 30 indicates the low-lying areas within the South Florida Region in red showing extensive areas in the Everglades to the south and west, but also in many areas along the barrier islands. Figure 31 shows that a category 3 hurricane at high tide would produce a maximum surge of 11.4 feet above ground. This surge is punctuated to a small area of south Miami-Dade County, and most other areas have a lower value, closer to 5 feet. Figure 27 shows SRES results for the inundated areas for all five hurricane categories, by comparing surge heights to LIDAR ground elevation.

planning/crdp/aaaguidebook2015.pdf?sfvrsn=2

<sup>&</sup>lt;sup>30</sup> http://www.sfrpc.com/SRESP%20Web/Vol1-11\_FrontMatter.pdf

<sup>&</sup>lt;sup>31</sup> http://www.floridajobs.org/docs/default-source/2015-community-development/community-

<sup>&</sup>lt;sup>32</sup> http://www.sfrpc.com/sresp.htm



Figure 30: Elevation ranges in South Florida



Figure 31: Biscayne Bay SLOSH Grid showing maximum wave heights above ground for a category 3 hurricane at high tide



Figure 32: South Florida Region Storm Tide Map with Biscayne Bay SLOSH compared againstelevation(Source: http://www.sfrpc.com/SRESP%20Web/Vol1-11\_ChII.pdf)

#### FLORIDA DIGITAL ELEVATION MODEL (DEM) MOSAIC METADATA

This data is a Composite DEM created from combining the best available sources. No smoothing was done where DEMs intersect. The DEM can be downloaded from FGDL in 9.3.1 File Geodatabase format. GeoPlan creating this data for use with sea level rise studies being performed for FDOT, as well as, for use in the Environmental Screening Tool (EST), however, data included herein may be useful for a variety of applications and uses. The following source DEMs were used to create a statewide DEM. The sources are listed in order of priority:

#### 1) Northwest Florida Water Management District (NWFWMD) DEM

description: Received from NWFWMD district in 2012. This DEM was created from a variety of different sources, metadata from each source used by NWFWMD is included with the FGDL download and is located in the following folder: ...\meta\nwfwmd cell size: 2, 2 (meters) pixel type: floating point elevation units: feet elevation datum: NAVD88

#### 2) NOAA FLIDAR Coastal DEM

description: This DEM is based on coastal Lidar data sourced from the NOAA Coastal Services Center. Metadata from each source used by NOAA is included with the FGDL download and is located in the following folder: ...\meta\noaa cell size: 5.4329891, 5.4329891 (meters) pixel type: unsigned integer elevation units: inches elevation datum: NAVD88

- 3) Florida Fish and Wildlife Conservation Commission (FWC) Florida Statewide 5-Meter DEM description: this is a statewide DEM that has some gaps. The DEM was received from FWC in 2012. Note: the source vertical datum was NGVD29, which was converted to NAVD88. Original metadata for this source DEM is included with the FGDL download and is located in the following folder: ...\meta\fwc cell size: 5.4329891, 5.4329891 (meters) pixel type: floating point elevation units: meters elevation datum: NGVD29
- 4) Contour Derived DEM description: This DEM is based on 2ft contours from the coastal LiDAR

project. The biggest portion of this source data is around Lake Okeechobee, where data was from Merrick. For more information on the contour data please see FGDL layers prefixed with "TOPO2FT\_". cell size: 5.4329891, 5.4329891 (meters) pixel type: unsigned integer elevation units: inches elevation datum: NAVD88

### Appendix B: 2010 Census Population Totals by County



Source: U.S. Census Bureau, 2010 Census Redistricting Data Summary File For more information visit www.census.gov.

### Appendix C: 2010 Census Population Change by County



Source: U.S. Census Bureau, Census 2000 and 2010 Census Redistricting Data Summary File For more information visit www.census.gov.